MECHANIC TWO & THREE WHEELER

NSQF LEVEL - 3

TRADE THEORY

SECTOR : AUTOMOTIVE

(As per revised syllabus July 2022 - 1200 Hrs)

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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

Sector : **Automotive**

Duration : **1 Year**

Trade : **Mechanic Two & Three Wheeler - Trade Theory - NSQF LEVEL - 3 (Revised 2022)**

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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 has now come up with instructional material to suit the revised curriculum for **Mechanic Two & Three Wheeler - Trade Theory- NSQF Level - 3 (Revised 2022) in Automotive Sector under Annual Pattern.** The NSQF Level - 3 (Revised 2022). Trade Practical 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 - 3 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 3 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

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

Secretary

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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.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

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.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

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 Two & Three Wheeler - NSQF Level - 3 (Revised 2022)** under **Automotive** 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 PRACTICAL

The trade practical manual is intented to be used in practical workshop . It consists of a series of practical exercises to be completed by the trainees during the Course of the **Mechanic Two and Three Wheeler under Automotive Sector.** Trade 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 - 3 (Revised 2022) syllabus are covered. This manual is divided into Ten modules.

Module 1	Workshop Safety Practice
Module 2	Basic Workshop Practice
Module 3	Basic Electrical and Electronics
Module 4	Manufacturing Process
Module 5	Hydraulics and Pneumatics
Module 6	Engine Overview
Module 7	Steering and Suspension System
Module 8	Brake and Transmission System
Module 9	Ignition and Lighting System
Module 10	Emission Control and Electrical Vehicle

The skill training in the shop floor is planned through a series of practical exercises centred 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.

TRADE THEORY

The manual of trade theory consists of theoretical information for the Course of the **Mechanic Two and Three Wheeler** trade. The contents are sequenced according to the practical exercise contained in NSQF Level - 3 (Revised 2022) 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 the trade theory connected to each exercise atleast 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.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No.	Learning Outcome	Ref. Ex.No
1	Comply environment regulations and housekeeping in the workshop following safety precautions.	1.1.01 - 08
2	Check & perform Measuring & marking by using various Measuring & Marking tools.	1.2.09 - 13
3	Plan & perform basic fastening & fitting operation by using correct hand tools, Machine tools & equipments.	1.2.14 - 22
4	Construct electrical circuits and test its parameters by using electrical measuring instrument.	1.3.23 - 26
5	Perform basic electrical testing in two and three wheelers.	1.3.27 - 28
6	Perform battery testing and charging operation.	1.3.29 - 31
7	Construct basic electronic circuits and testing.	1.3.32 - 35
8	Join components by using Arc & Gas welding.	1.4.36
9	Check & Interpret Vehicle Specification data and VIN, Select & operate various Service Station Equipments.	1.5.37 - 39
10	Carry out the general servicing of two & three wheelers.	1.6.40 - 43
11	Carryout engine overhaul of two wheeler& three wheelers.	1.6.44 - 46
12	Overhauling of cylinder head assembly.	1.6.47 - 50
13	Diagnose and troubleshoot for excessive smoke, engine overheating and abnormal noise.	1.6.51 - 55
14	Carry out servicing of fuel tank.	1.6.56 - 58
15	Carryout overhauling of steering and suspension system.	1.7.59 to 1.8.74
16	Overhaul automatic/manual transmission of two and three wheelers.	1.8.75 - 82
17	Overhaul AC generator.	1.9.83 - 91
18	Check ignition circuit for proper functioning.	1.9.92 - 97
19	Overhaul the LPG/CNG fuel system and check exhausts smoke.	1.10.98 - 99
20	Carryout servicing and maintenance of electric two and three wheelers.	1.10.100 to 1.10.105

SYLLABUS FOR MECHANIC TWO & THREE WHEELER

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
Professional Skill 50Hrs; Professional Knowledge 10 Hrs.	Comply environment regulations and housekeeping in the workshop following safety precautions.	1 Demonstration of Machinery used in the trade. (09 hrs.) 2 Identification to safety equipment and their use etc. (05 hrs.) 3 Importance of maintenance and cleanliness of Workshop. (05 hrs.) 4 Demonstration on safe handling and Periodic testing of lifting equipment, and Safety disposal of used engine oil. (10 hrs.) 5 Demonstration with health centre. (05 hrs.) 6 Demonstration fire service station to provide demo on First aid and Fire safety. (05 hrs.) 7 Perform use of fire extinguishers. (05 hrs.) 8 Energy saving Tips of ITI electricity Usage. (06 hrs.)	- Importance of trade Training. - General discipline in the - Institute - Elementary First Aid. - Importance of Mechanic 2 & 3 wheelers in Industry - Safety precautions to be followed while in handling machineries. - Energy conservation - Safety disposal of used engine oil, Electrical safety tips. - Safe handling of Fuel Spillage. - Fire extinguishers used for different types of fire. - Safe disposal of toxic dust, - Safe handling and Periodic testing of lifting equipment - Authorization of Moving & road testing vehicles. (10 Hrs.)
Professional Skill 100 Hrs; Professional Knowledge 20 Hrs.	Check & perform Measuring & marking by using various Measuring & Marking tools.	9 Perform practice using all marking aids, like steel rule with spring calipers, dividers, scriber, punches, Chisel etc. (25 hrs.) 10 Perform layout a work piece- for line, circle, arcs and circles. (15 hrs.) 11 Perform to measure a wheel base of bike & auto with measuring tape. (20 hrs.) 12 Perform to remove wheel lug nuts with use of an air impact wrench. (20 hrs.) 13 Perform Practice on General workshop tools & power tools. (20 hrs.)	Hand & Power Tools: - Marking scheme, marking material-chalk, Prussian blue. - Cleaning tools- Scraper, wire brush, Emery paper, - Description, care and use of Surface plates, steel rule, measuring tape, try square. Calipers-inside and outside. Dividers, surface gauges, scriber, - Punches-prick punch, centre punch, pin punch, hollow punch, number and letter punch. - Chisel-flat, cross-cut. Hammer-ball pein, lump, mallet. Screwdrivers blade screwdriver, Phillips screw driver, Ratchet screwdriver. - Allen key, bench vice & C clamps, - Spanners- ring spanner, open end spanner & the combination spanner, universal adjustable open end spanner. - Sockets & accessories, - Pliers ,Combination pliers, multi grip, long nose, flat-nose,

			- Air impact wrench, air ratchet, wrenches- Torque wrenches, pipe wrenches, car jet washers Pipe flaring & cutting tool, pullers - Gear and bearing. (10 Hrs.) Systems of measurement, Description, care & use of - Micrometers - Outside and depth micrometer, - Micrometer adjustments, - Vernier calipers, Telescope gauges - Dial bore gauges, Dial indicators, straightedge, feeler gauge, thread pitch gauge, - Vacuum gauge, tire pressure gauge. (10 Hrs.)
Professional Skill 120 Hrs.; Professional Knowledge 10 Hrs.	Plan & perform basic fastening & fitting operation by using correct hand tools, Machine tools & equipments.	14 Perform general cleaning, checking and use of nut, bolts, & studs etc. (10 hrs.) 15 Perform of removal of stud/bolt from blind hole. (10 hrs.) 16 Perform cutting tools like Hacksaw, file, chisel, Sharpening of Chisels, center punch, safety precautions while grinding. (15 hrs.) 17 Perform hacksawing and filing to given dimensions. (25 hrs.)	- Fasteners- Study of different types of screws, nuts, studs & bolts, locking devices, such as lock nuts, cotter, split pins, keys, circlips, lock rings, lock washers and locating where they are used. - Washers& chemical compounds can be used to help secure these fasteners. Function of Gaskets - Selection of materials for gaskets and packing, oil seals. - Cutting tools:- Study of different type of cutting tools like Hacksaw, File- Definition, parts of a file, specification, Grade, shape, different type of cut and uses., - OFF-hand grinding with sander, bench and pedestal grinders, safety precautions while grinding. - Limits, Fits &tolerances:-Definition of limits, fits &tolerances with examples used in auto components (05 Hrs.)
		18 Perform marking and drilling clear and Blind Holes, Sharpening of Twist Drills. (10 hrs.) 19 Check safety precautions to be observed while using a drilling machine. (05 hrs.) 20 Perform tapping a Clear and Blind Hole, Selection of tape drill Size. (15 hrs.) 21 Use of stud-extractor. Cutting Threads on a Bolt/ Stud. (15 hrs.) 22 Adjustment of two piece Die, Reaming a hole/ Bush to suit the given pin/ shaft, scraping a given machined surface.(15 hrs.)	Drilling machine - Description and study of Bench type drilling machine, Portable electrical Drilling machine, drill holding devices, - Work Holding devices, Drill bits. Taps and Dies: Hand Taps and wrenches, Calculation of Tap drill sizes for metric and inch taps. Different type of Die and Die stock. - Screw extractors. Hand Reamers, different Type of hand reamers, Drill size for reaming, Lapping, Lapping abrasives and type of Laps. (05 Hrs.)

Professional Skill 25 Hrs.; Professional Knowledge 07 Hrs.	Construct electrical circuits and test its parameters by using electrical measuring instrument.	23 Perform joining wires using soldering Iron. (05 hrs..) 24 Construction of simple electrical circuits. (05 hrs.) 25 Perform measure of current, voltage and resistance using digital multimeter. (05 hrs.) 26 Perform continuity test for fuses, jumper wires, fusible links and circuit breakers. (10 hrs.)	- Voltmeter, ammeter, Ohmmeter Mulitmeter, Conductors & insulators, Wires, Shielding, Resistor ratings. (07 Hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 07 Hrs.	Perform basic electrical testing in two and three wheelers.	27 Perform series, parallel, series parallel circuits using Ohm's law, (10 hrs..) 28 Check electrical circuit with a test lamp, perform voltage drop test in circuits using multimeter, measure current flow using multimeter /ammeter, use of service manual wiring diagram for troubleshooting. (15 hrs.)	- Fuses & circuit breakers, Ballast resistor, - Stripping wire insulation, cable colour codes and sizes, Resistors in Series circuits , - Capacitors and its applications, Capacitors in seriesand parallel. (07 Hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 07 Hrs.	Perform battery testing and charging operation.	29 Cleaning and topping up of a lead acid battery, testing battery with hydrometer. (05 hrs.) 30 Perform connection battery to a charger for battery charging, Inspecting & testing a battery after charging. (10 hrs.) 31 Measure and troubleshoot the cause(s) of excessive Key-off battery drain (parasitic draw) and do corrective action. Testing of relay and solenoids and its circuit. (10 hrs.)	- Batteries & cells, Lead acid batteries & Stay Maintenance Free (SMF) batteries, - Thermistors, Thermo couples, - Relays, Solenoids, Primary & Secondary windings, - Transformers, stator and rotor coils. (07 Hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 07 Hrs.	Construct basic electronic circuits and testing.	32 Identify and test power and signal connectors for continuity. (05 hrs.) 33 Identify and test different type of Diodes. (05 hrs.) 34 Perform regulator /rectifier, inspection, and assembling. (05 hrs.) 35 Check NPN&PNP Transistors for its functionality, Construct and test simple logic circuits OR, AND & NOT Logic gates using as switches. (10 hrs.)	- Basic electronics: Description of Semiconductors, - Solid state devices- Diodes, transistors, Thyristors, Uni Junction Transistors (UJT), Metal Oxide Field Effect Transistors (MOSFETs), - Logic gates-OR, AND & NOT and Logic gates using switches. (07 Hrs.)
Professional Skill 16 Hrs.; Professional Knowledge 04 Hrs.	Join components by using Arc & Gas welding.	36 Setting of Gas welding flames, practice to make a straight beads and joints Oxy- Acetylene welding. (16hrs.)	- Introduction to welding and - Oxy - Acetylene welding, principles, equipment, welding parameters, edge preparation & fit up and welding techniques. - Heat Treatment Process (04 Hrs.)

Professional Skill 20 Hrs.; Professional Knowledge 04 Hrs.	Check & Interpret Vehicle Specification data and VIN, Select & operate various Service Station Equipments.	37 Identify of different type of Vehicle. (05 hrs.) 38 Demonstrate of vehicle specification data; Identification of vehicle information Number (VIN). (05 hrs.) 39 Demonstrate of Garage, Service station equipments.- (10 hrs.)	- Auto Industry - history, leading manufacturers, development in automobile industry, trends, new product. Brief about Ministry of Road transport &Highways, - The Automotive Research Association of India (ARAI), National Automotive Testing and R&D Infrastructure Project (NATRIP), & Automobile - Association. Definition: - Classification of vehicles on the basis of load as per central motor vehicle rule, wheels, final drive, and fuel used, axles, position of engine and steering transmission, body and load. - Brief description and uses of Vehicle hoists (04 Hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 06 Hrs.	Carry out the general servicing of two & three wheelers.	40 Identify the parts &general servicing of Two Wheeler and Three wheeler, washing, cleaning, oiling, greasing and lubricating. (05 hrs.) 41 Dismantle the two wheeler SI engine, cleaning and inspecting the parts, checking engine bore, piston rings, connecting rod, bearings, crankshaft. (05 hrs.) 42 Assemble all the parts after assembling inspect Engine oil level, clutch cable free play. (08 hrs.) 43 Adjust Drive chain tension, check performance of electrical system. (07 hrs.)	- Two wheelers and three wheelers auto Industry in India - Leading manufacturers, new product. Introduction to Engine: - Description of internal & external combustion engines, Classification of IC engines, Principle & working of 2&4-strokediesel engine Compression ignition Engine(C.I), - Principle of Spark Ignition Engine(SI), differentiate between 2-strokeand 4 stroke, C.I engine and S.I Engine, - Direct injection and Indirect injection, - Technical terms used in engine, Engine specification. - Study of various gauges/instrument on a dash board of a vehicle-Speedometer, Tachometer, Odometer and Fuel gauge, and Indicators such as gearshift position. (06 hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 06 Hrs.	Carryout engine overhaul of two wheeler& three wheelers.	44 Perform dismantling three wheeler engine and inspection of cylinder head, piston, piston ring, connecting rod. (05 hrs.) 45 Perform measurement of piston ring gap, the piston ring to groove clearance, piston OD, cylinder to piston clearance, piston pin OD, piston pin hole ID in an X and Y axis, piston to pin clearance connecting rod small end ID, connecting rod small end to piston pin clearance and compare the measurements with service manual. (10 hrs.) 46 Perform trouble shooting of low compression, High compression, Excessive noise, and poor idling. (10 hrs.)	- Basic engine components Engine cams & Description & functions of pistons, piston rings, connecting rod and piston pins and materials. Used recommended clearances for the rings and its necessity, precautions while fitting rings, common troubles and remedies of piston. - Description and function of Crank shaft, Engine bearings. - Trouble shooting procedure for low compression, High compression, Excessive noise, and poor idling. (06 hrs.)

Professional Skill 25 Hrs.; Professional Knowledge 06 Hrs	Overhauling of cylinder head assembly.	47 Identify valves and condition of valve and seat. Inspection of rocker arm and rocker arm shaft, camshaft, valve spring, valve guide, valve guide replacement, valve seat inspection and replacing. (05 hrs.) 48 Perform cylinder head assembly. (05hrs.) 49 Perform inspection of valve clearance and Ignition timing and setting. (05 hrs.) 50 Perform trouble shooting of Excessive smoke, overheating, knocking or abnormal noise. Troubleshooting of cam chain noise and cam chain slack excessively. (10 hrs.)	Valves & Valve Trains - Function of Engine Valves, different types, materials, Type of valve operating mechanism, Importance of Valve seats, Valve-timing setting. - Description of Camshafts & drives, importance of Cam lobes, Timing belts &chains. - Trouble shooting procedure for Excessive smoke, overheating, knocking or abnormal noise. Troubleshooting procedure for cam chain noise, and cam chain slack excessively. (06 hrs.)
Professional Skill 28 Hrs.; Professional Knowledge 10 Hrs.	Diagnose and troubleshoot for excessive smoke, engine overheating and abnormal noise.	51 Perform checking the throttle cable for deterioration, damage or kinks, measure the throttle grip free play, and adjustments. Check the carburetor idle speed and adjust as per manual. (05 hrs.) 52 Perform compression test. Practice on throttle valve disassembly, check the throttle valve and jet needle surfaces for presence of dirt, scratches or wear and assemble the throttle valve. (06 hrs.) 53 Perform removal of carburetor, float, float valve, jet clean, inspect and adjust the flat level as per manual and assemble the carburetor. (10 hrs.) 54 Adjust the throttle grip free play and carburetor as per manual. (02 hrs.) 55 Perform removing and cleaning of air cleaner, Checking of Engine oil level, oil filter screen cleaning. Inspection of fuel lines, Spark plug. (05 hrs.)	Intake & exhaust systems - Carbureted systems, - Principle of Carburetor, type of carburetor working of constant velocity type carburetor, - Carburetor operation-Carburetion, carburetor systems, - Metering jets, Accelerating, Carburetor barrels, Carburetor filter Diesel fuel Injection system, Tanks & lines, Fuel lines. Idle speed circuit, slow speed circuit, high speed circuit, air cleaners, Intake manifolds. Importance of Cooling systems & Lubrication system. Cooling system and lubrication system overview. - Function of engine oil, Grades of oil, Lubrication points. - Trouble shooting procedure for Oil level too low and Oil contamination. - Liquid cooling system description and its working - Pressure oil system description and working. (10 hrs.)
Professional Skill 25 Hrs; Professional Knowledge 05 Hrs.	Carry out servicing of fuel tank.	56 Perform removal of fuel tank; check that fuel flow freely from the petrol tap. (05 hr.s) 57 Perform removal of petrol tap and clean the strainer and assemble. (05 hrs) 58 Diagnose - causes and remedy for engine not starting, high fuel consumption, Practice on engine tune. (15 hrs..)	Gasoline Fuel Systems: - Gasoline fuel characteristics, Difference between Gasoline. - Controlling fuel burn, Stoichiometric ratio (air-fuel ratio), Air density, Fuel supply system, Pressure & vacuum. - Trouble shooting procedure for Engine cranks but would not start, Lean mixture, Engine idles roughly, stalls or turns poorly, and Rich mixture. (05 hrs.)

Professional Skill 50 Hrs.; Professional Knowledge 10 Hrs.	Carryout overhauling of steering and suspension system.	59 Identify steering system components in two and three wheelers. (05 hrs.) 60 Practice on handle bar removal, inspection and assembling of handlebar. (05 hrs.) 61 Perform removal of front fork, inspection of front fork spring, fork tube, piston, slider and assembling of front fork. (5hrs) 62 Practice on steering stem removal, steering stem adjustment. (05 hrs.) 63 Inspect condition of fork and adjust rake of front fork, dismantle trailing link, adjust and service of heavy duty thrust races. (05 hrs..)	- Introduction to steering Principles of steering: Description of different types of steering & handle, fork mounted over races. - Description, construction and function of steering stem. - Troubleshooting Procedure for Hard steering Steers to one side or does not track strain, front wheel wobbling, Soft suspension, Hard suspension, Front suspension noise. (05 hrs.)
		64 Identify suspension system components in two and three wheelers. (05 hrs.) 65 Practice on rear shock absorber removal, inspection of shock absorber spring and assembling of shock absorber. (05 hrs.) 66 Perform removal of swing arm, inspection of pivot bolt, swing arm. (10 hrs.) 67 Inspect condition of shock absorbers. Servicing of suspension, changing bush. (05 hrs.)	Suspension Systems - Principles of suspension, Suspension force, Description, location, suspension-description, construction and working principle of telescopic front suspension, suspension oil, oil seal installation, Shock absorber types - Hydraulic shock absorbers, Gas-pressurized shock absorbers, Load-adjustable shock absorbers, - Manual adjustable rate shock absorbers, Electronic adjustable-rate shock absorbers, Automatic load-adjustable shock absorbers. (05 hrs.)
		68 Perform removal of front wheel from vehicle, inspection of front wheel axle run-out, front wheel bearing inspection, front wheel rim run-out, brake drum inspection, and assembling of front wheel. (10 hrs.) 69 Practice on removing rear wheel from vehicle, inspection of rear wheel axle run-out, rear wheel bearing inspection, rear wheel rim run-out, brake drum inspection, driven sprocket inspection, driven sprocket removal, and assembling of rear wheel, driven sprocket installation. Check the chains lack and adjust as per manual. (10 hrs.) 70 Dismantle tyres and tubes checking puncture. Assembling inflating to correct pressure. Checking & adjusting tire pressure by use of air or by Nitrogen Wheel truing, alignment. (10 hrs.)	Wheels &Tyres - Function of wheel and construction, Wheel types-spoke, cast wheel& sizes, Wheel balancing, Rim sizes &designations, Tyre function and structure, size and designation, Radial ply tyres, Tubeless tyre, Center of gravity, Relation between tyre pressure and life, Tube size, TUFFUP tube. Aspect ratio of tyre, - Puncture procedure, Repair of TUFFUP tube. Tyre construction - Types of tyre construction, Tyre materials, Tyre sizes &designations, Tyre information, Tyre tread designs, Effects of air pressure and uneven wear pattern. - Descriptions Tire wear Patterns and causes, Nitrogen vs atmospheric air in tyres. (07 hrs.)

		71 Analyze tyre wear patterns. Checking the wheel bearings and greasing. (07 hrs.)	
		72 Perform following practical on Two and three wheelers.- Measure the front brake lever free play and adjust as per manual, Measure the rear brake pedal free play and adjust as per manual. (10 hrs.) 73 Perform Servicing of brake system, cleaning, checking, greasing and assembling. (10 hrs.) 74 Inspect the shoes and wheel drums, changing of brake lining. Repairing and maintenance of hydraulic disc brake used in Motorcycles. (15 hrs.)	Braking Systems - Braking fundamentals Principles of braking, description, construction and operation of Drum & disc brakes, advantage over drum brake, - Description and working principle of master cylinder, Hydraulic pressure & force, Brake fade - Braking system components- Brake pedal/lever , Brake fluid hose, Brake fluid, - Bleeding, Applying brakes, Brake force, Brake light switch - Disc brakes & components -Disc brake system, Disc brake operation, Disc brake rotors, Disc brake pads, Disc brake calipers, Brake friction materials, - Comparison of Drum brake and Disc brake. ABS Drum brakes & components. (07 hrs.)
Professional Skill 50 Hrs.; Professional Knowledge 10 Hrs.	Overhaul automatic/ manual transmission of two and three wheelers.	75 Adjust clutch lever free play and adjust as per manual, removing clutch assembly from Two-wheeler & three wheeler cleaning and inspecting parts. (05 hrs.) 76 Replace defective parts. Fitting clutch assembly. (05 hrs.) 77 Inspect and repair work of Automatic clutch and automatic transmission used in two wheeler & three wheeler. (10 hrs.) 78 Practice on removal of crankshaft, inspection of crank shaft, timing sprocket replacement & installation, (05 hrs.) 79 Practice on kick starter disassembly, inspection and assembly. (05 hrs.) 80 Perform disassembly of transmission, inspection of main shaft, counter shaft, gearshift drum, shift fork, guide pin and gears and assembly of transmission. (10 hrs.) 81 Removal of oil pump and inspection and assembly of oil pump. (05 hrs.) 82 Gearshift linkage disassembly, inspection and assembly of gearshift linkage. (05 hrs.)	Clutches & Transmission:- - Clutch principles, Wet & dry clutches Single plate clutches, Multi-plate clutches, Operating mechanisms, Description of cam chain mechanism. Automatic clutch - Gearbox layout & operation Gearbox layouts, description of gear shift mechanism, gear ratio, Gearbox operation, Gear drive position - Neutral, 1st to 5thposition. - Trouble shooting procedure for Clutch slip when accelerating, clutch will not disengage, motor cycle creeps with clutch disengaged, - Excessive lever pressure, clutch lever pressure, clutch operation feels rough, Hard to shift, Gearshift pedal does not return, and Transmission jumps out of gears. - Automatic transmission used in two wheeler and three wheeler. (10 hrs.)

Professional Skill 50 Hrs.; Professional Knowledge 11 Hrs.	Overhaul AC generator.	83 Practice on A.C. Generator removal, inspection and installation. (05 hrs.) 84 Perform removal of cam chain tensioner, inspection of tensioner spring and pushrod, installation. (10 hrs.) 85 Trace the A.C /D.C electrical circuit in a two wheeler and three wheeler. (05 hrs.) 86 Perform measurement of Resistance, DC voltage measurement, DC Current measurement, pulse generator, (5hrs.) 87 Inspect leakage current, measurement of charging voltage. (05 hrs.) 88 Practice on headlight removal, headlight bulb replacement and installation. (05 hrs.) 89 Practice on removal of speedometer, indicator lamp replacement. (05 hrs.) 90 Check horn, head light and indicator and rectify the circuit. (05 hrs.) 91 Practice on adjusting head light focus. Identifying wiring harness. (05 hrs.)	Auto electrical - Thermistor, Description and function of ignition switch, alternator, Regulator/ rectifier, Ignition principles, Ignition components, - Battery power source, Ignition coil, DC/ ACCDI, TCI Contact breaker, capacitor /condenser, Distributors, Distributor types, - High-tension leads, Spark plugs, Spark plug components, Principal of electronic ignition, advantage of electronic ignition. - Starter motor, Fuse, throttle position switch, source coil & pulser coil Power relay, Silicon rectifier, - Description of Charging system, starting system, Lighting system, Lamps/light bulbs, Lamp/light bulb information, Indicators, Headlights, Circuit diagrams. (11 hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 04 Hrs.	Check ignition circuit for proper functioning.	92 Inspection of spark plug gap and adjustments. (05 hrs) 93 Measurement the resistance of the ignition primary and secondary coil. (02 hrs.) 94 Perform checking the performance of ignition coil, (03 hrs.) 95 Inspect of A.C generator, practice on removal of C.D.I unit (Capacitive Discharge Ignition), inspection of C.D.I unit & assembling.(05 hrs.) 96 Servicing of electronic Ignition system, Inspection of ignition timing and adjustment. (05hrs.) 97 Inspect ignition switch, handlebar switches, front brake & rear brake stoplight light switch. (05 hrs.)	Troubleshooting procedure - for No sparks at plugs, Engine starts but runs poorly, - No lights come on when ignition switch is turned ON, - All lights come on but dimly when ignition switch is turned ON - Headlight beams do not shift when HI-LO switch is operated. Misfiring. (04 hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 07 Hrs.	Overhaul the LPG/CNG fuel system and check exhausts smoke.	98 Identify the various parts of LPG/ CNG kit and Troubleshooting of the same. (10 hrs.) 99 Practice on Starting engine, tuning for slow speed, perform exhaust emission test using gas analyzer/smoke tester and tuning the vehicle for recommended emission levels. (15 hrs.)	- Study about LPG / CNG powered engines used in Three Wheelers. Safety while handling gas units. Emission Control - Sources of emission, Combustion, Hydrocarbons, Hydrocarbons in exhaust gases, Oxides of nitrogen, Particulates, Carbon monoxide, Carbon dioxide, Sulphur content in fuels, crankcase emission control system, Evaporative emission control, - Catalytic converter Regulated emissions standard. (07 hrs.)

Professional Skill 34 Hrs.; Professional Knowledge 07 Hrs.	Carryout servicing and maintenance of electric two and three wheelers.	100 Electric 2 & 3 Wheler Maintenance Operate equipment according to safety protocols and identify tools, tests equipment and service procedures used in the servicing of EV . (07 hrs.) 101 Identify basic propulsion systems and power transfer systems including AC and DC motor technology used in EV (0 7 hrs.) 102 Diagnose, repair, and test power electronic circuitry for electric drive systems. (05hrs.) 103 Diagnose, repair, and test motor control electronic hardware. (05hrs.) 104 Diagnose, repair, and test high voltage battery systems. (05hrs.) 105 Perform safe storage, handle, and dispose of high voltage battery systems and Check Inverter Assembly variable voltage system. (05hrs.)	Introduction: Electric Vehicle Electric Vehicle Architecture Design Electric Drive and controller Energy Storage Solutions (ESS) Battery Management System (BMS)/ Energy Management System (EMS) Control Unit: Function of CU, Development Process. (07 hrs.)

Importance of trade training

Objective: At the end of this lesson you shall be able to
- **importance and scope of the trade training.**

Scan the QR code to view the video for this exercise

Scope of the Mechanic two and three wheeler training: Mechanic two and three wheeler trade under craftsmen training scheme (CTS) is one of the most popular trade delivered nation wide through the network of ITI. This trade duration is one year.

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 two & three wheeler can join in central and state government establishments, like railway, airport, marine, military and automobile industry.
- employment opportunities in overseas.

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 garage.

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

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 bad habits.

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 interfere in other's activities.

Attention and listen to the lecture carefully during the theory class and practical demonstration given by the instructor.

Give respect to your trainer and all other staffs and co-trainees in your institute.

Be interested in all the training activities.

Do not make noise and play while undergoing training.

Keep the institute premises neat and clean avoid polluting 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 practical.

Time-table

Practical and theory class hours are schedulated in advance and working hours is generally 8 hrs including lunch hours. There are two shifts are provided for training in the ITI generally 1st shift working hours 7.30 AM to 4.00 PM and 2nd shift working hours 9.00 AM to 5.30 PM.

Course Content in the syllabus

Engine, cooling, lubrication intake & exhaust, fuel emission, charging and starting systems.

- Identify the various types of tools equipment, raw materials, spares used in the 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 petrol and diesel engines.

Practice to emission control and electric vehicle

Facilities in I.T.I

Hostel facilities, first aid kit, visiting doctor's and also libraries are available in mandatory of the I.T.I's

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 the 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 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

1	Physical Hazards	2	Chemical Hazards
3	Biological Hazards	4	Physiological Hazards
5	Psychological Hazards	6	Mechanical Hazards
7	Electrical Hazards	8	Ergonomic Hazards

1 Physical Hazards
- Noise
- Heat and cold stress
- Vibration
- Radiation (ironising & Nonironising)
- 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
  - absertecism
  - disobedience
  - aggressive behaviours
- Accident proneness etc,
- Emotional disturbances
  - violence
  - 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

Objectives: At the end of this lesson you shall be able to
- **state the causes for accidents in general terms**
- **state the safe attitudes**
- **list out the four basic categories of safety signs.**

Causes for accidents: Normally accidents do not just happen. They are caused.

Causes for accidents are many. Some of the important causes are listed below.

- Unawareness of danger
- Disregard for safety
- Negligence
- Lack of understanding of proper safety procedures
- Untidy condition of workplace
- Inadequate light and ventilation
- Improper use of tools
- Unsafe conditions

Safe attitudes: People's attitudes govern what they do or fail to do. In most cases where someone is working with unsafe equipment or in an unsafe situation, somebody has allowed that state of affairs to come about by something they have done or failed to do.

Most accidents don't just happen; they are caused by people who (for example) damage equipment or see it is faulty but don't report it, or leave tools and equipment lying about for other people to trip over.

Responsibilities: Safety doesn't just happen - it has to be organised and achieved like the work-process of which it forms a part. The law states that both an employer and his employees have a responsibility in this behalf.

Employer's responsibilities: The effort a firm puts into planning and organising work, into training people, into engaging skilled and competent workers, maintaining plant and equipment, and checking, inspecting and keeping records- all of this contributes to the safety in the workplace.

The employer will be responsible for the equipment provided, the working conditions, what employees are asked to do, and the training given.

Employee's responsibilities: You will be responsible for the way you use the equipment, how you do your job, the use you make of your training, and your general attitude to safety.

A great deal is done by employers and other people to make your working life safer; but always remember you are responsible for your own actions and the effect they have on others. You must not take that responsibility lightly.

Rules and procedures at work: What you must do, by law, is often included in the various rules and procedures laid down by your employer. They may be written down, but more often than not, are just the way a firm does things - you will learn these from other workers as you do your job. They may govern the issue and use of tools, protective clothing and equipment, reporting procedures, emergency drills, access to restricted areas, and many other matters. Such rules are essential; they contribute to the efficiency and safety of the job.

Safety signs: As you go about your work on a construction site you will see a variety of signs and notices. Some of these will be familiar to you - a 'no smoking' sign for example; others you may not have seen before. It is up to you to learn what they mean - and to take notice of them. They warn of the possible danger, and must not be ignored.

Safety signs fall into four separate categories. These can be recognised by their shape and colour. Sometimes they may be just a symbol; other signs may include letters or figures and provide extra information such as the clearance height of an obstacle or the safe working load of a crane.

The four basic categories of signs are as follows. (Fig 1)

- Prohibition signs
- Mandatory signs
- Warning signs
- Information signs

Prohibition signs

Shape Circular.
Colour Red border and cross bar. Black symbol on white background.
Meaning Shows it must not be done.
Example No smoking.

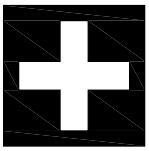
Mandatory signs

Shape Circular.
Colour White symbol on blue background.
Meaning Shows what must be done.
Example Wear hand protection.

Warning signs

Shape Triangular.
Colour Yellow background with black border and symbol.
Meaning Warns of hazard or danger.
Example Caution, risk of electric shock.

Information signs



Shape Square or oblong.
Colour White symbols on green background.
Meaning Indicates or gives information of safety provision.
Example First aid point.

Prohibition signs (Fig 2)

Fig 2

Mandatory signs (Fig 3)

Fig 3

Warning signs (Fig 4)

Fig 4

Questions about your safety

Do you know the general safety rules that cover your place of work?

Are you familiar with the safety laws that cover your particular job?

Do you know how to do your work without causing danger to yourself, your workmates and the general public?

Are the plant, machinery and tools that you use really

safe? Do you know how to use them safely and keep them in a safe condition?

Do you wear all the right protective clothing, and have you been issued with all the necessary safety equipment?

Have you been given all the necessary safety information about the materials used?

Have you been given training and instruction to enable you to do your job safely?

Do you know who is responsible for safety at your place of work?

Do you know who are the appointed `Safety Representatives'?

- Stop the machine before changing the speed.
- Disengage the automatic feeds before switching off.
- Check the oil level before starting the machine.
- Before starting the machine, move the ram by hand to ensure that the ram or tool-handler does not strike the workpiece or table.
- Never start a machine unless all the safety guards are in position.
- Take measurements only after stopping the machine.
- Use wooden planks over the bed while loading and unloading heavy jobs.
- Do not stop the machine before the finish of the cutting stroke.

Safety is a concept, understand it.

Safety is a habit, cultivate it.

Knowledge of personal safety and general precautions observed in the shop

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.

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.

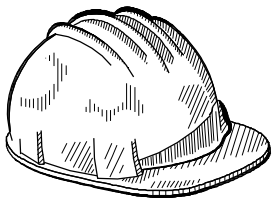
They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

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

Fig 1



HELMET

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Fig 2

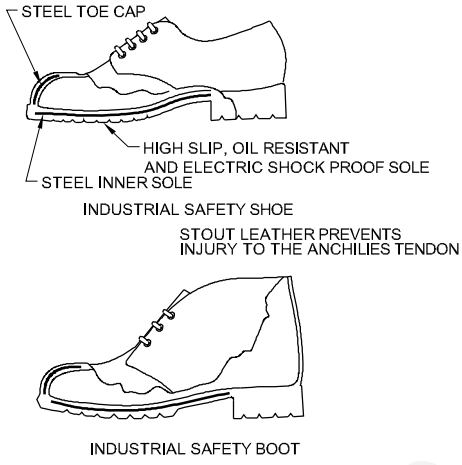

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Fig 3

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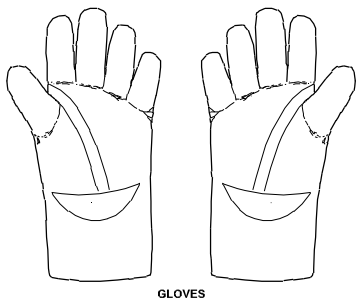
Common type of personal protective equipments and their uses and hazards are as follows

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 protection (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 4



GLOVES

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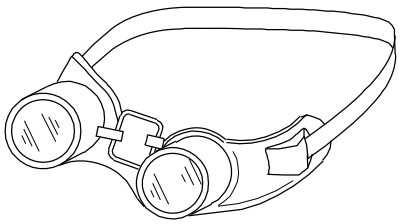
Fig 5



GOGGLES

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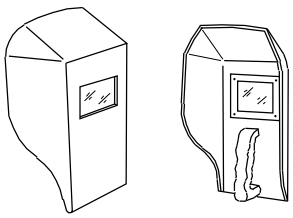
Fig 6



HAND SCREEN

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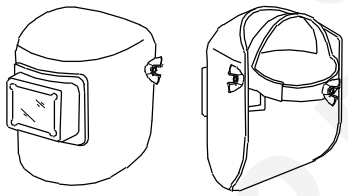
Fig 7



WELDING HELMET

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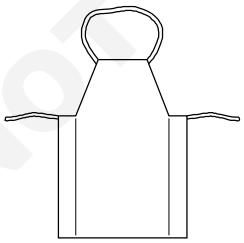
Fig 8



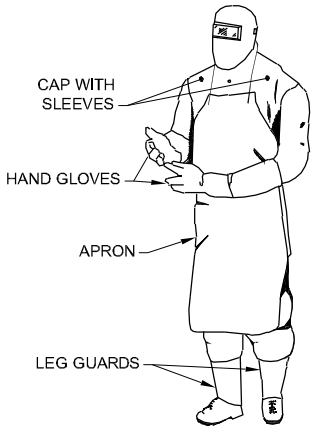
APRON

MTN110128

Safety precaution in handling diesel machine

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.

Fig 9



LEG GUARDS

MTN110129

The following precautions are to be observed to keep a 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 fill in to the fuel tank.
- Keep the empty diesel/ lubricant cans away from the machine.
- Ensure the 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.
- Maintain 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 leakage
- 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 leakage of lubricant and coolant in the engine and rectify the leakages.
- Ensure free air circulation in engine operating place.

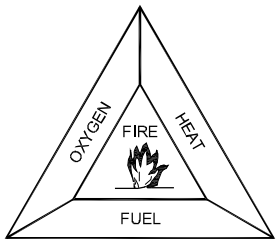
Safety practice - fire extinguishers

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 conditions required for combustion relevant to fire prevention**
- **state the general precautionary measures to be taken for prevention of fire.**

Fire is the burning of combustible material. It might injure people, and sometimes cause loss of life as well. Hence, every effort must be made to prevent 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°C, 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, over loaded 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.

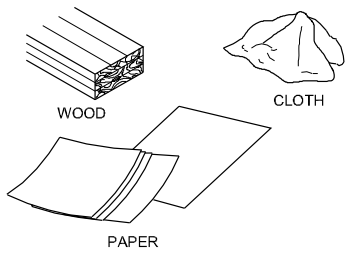
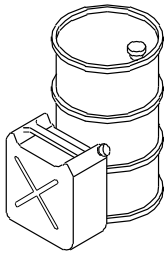
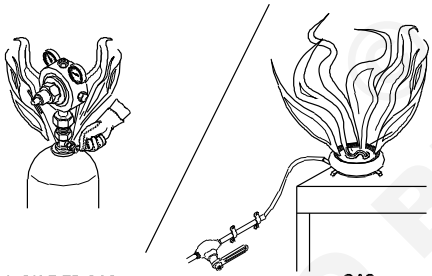
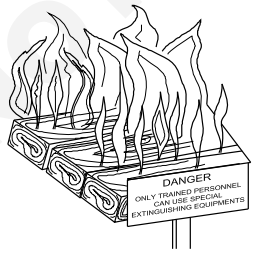
Blow lamps and torches must not be left burning when they are not in use.

Extinguishing fires: Fires are classified into four types in terms of the nature of fuel.

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.

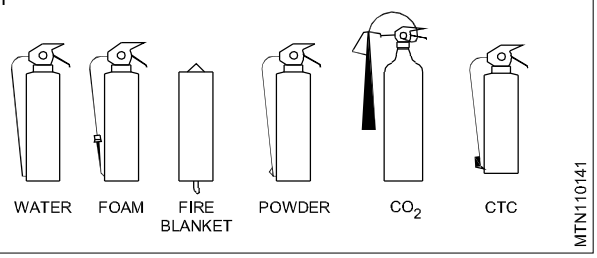
Fuel	Extinguishing
Fig 2 CLASS 'A' FIRE  MTN110132	Most effective ie. cooling with water. Jets of water should be sprayed on the base of the fire and then gradually upwards.
Fig 3 CLASS 'B' FIRE  FLAMMABLE LIQUIDS AND LIQUIFIABLE SOLIDS MTN110133	Should be smothered. The aim is to cover the entire surface 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 CO_2 may be used on this type of fire.
Fig 4 CLASS 'C' FIRE  MTN110134	Extreme caution is necessary in dealing with liquefied gases. There is a risk of explosion and sudden out break 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 MTN110135	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.

Types of fire extinguishers

Objectives: At the end of this lesson you shall be able to
- **distinguish different types of fire extinguishers**
- **determine the correct type of fire extinguisher to be used based on the class of fire**
- **describe the general procedure to be adopted in the event of a fire.**

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

Fig 1

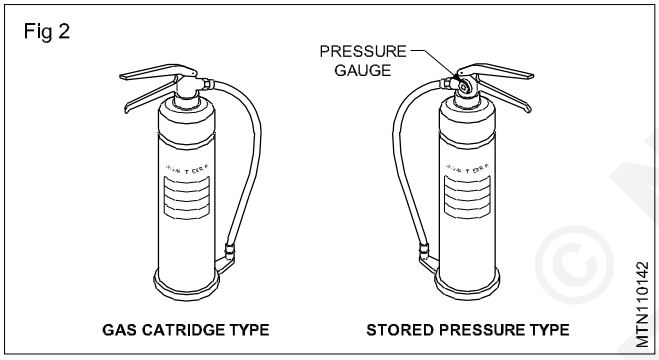


Water-filled extinguishers

There are two methods of operation (Fig 2).

- Gas cartridge type
- Stored pressure type

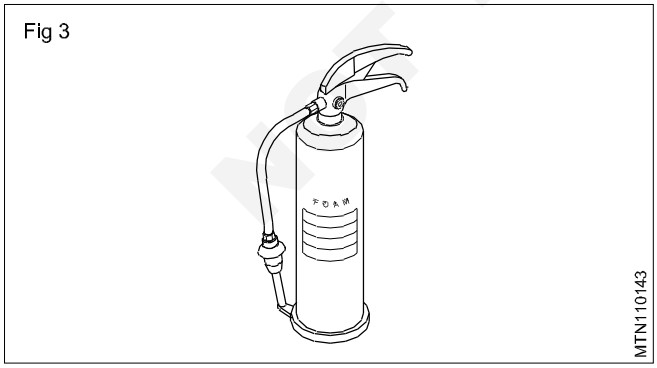
Fig 2



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

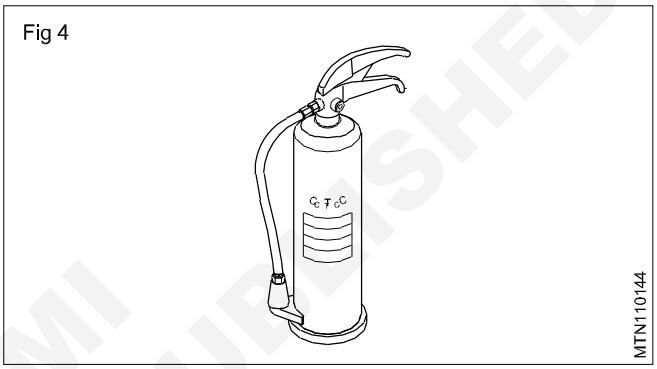
- Flammable liquid fires
- Running liquid fires

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.

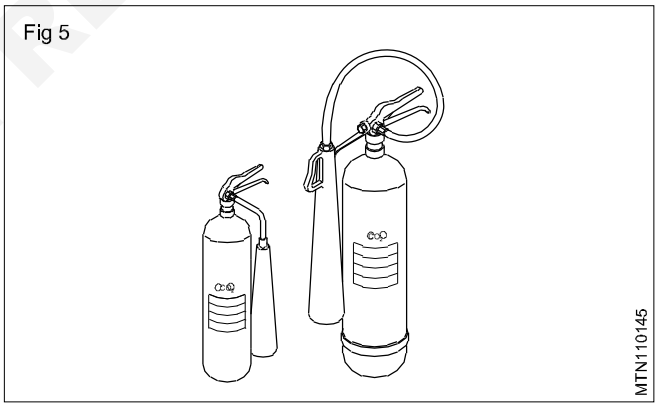
Fig 4



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)

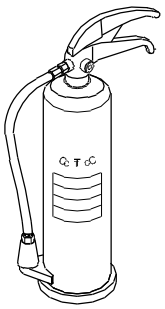
These extinguishers may be filled with carbon-tetrachloride and Bromochlorodifluoro methene (BCF). They may be either gas cartridge or stored pressure type.

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.

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

Fig 6



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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 fed 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.

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,

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 learnt over on their side, which also has the effect of clearing the tongue from the pharynx. 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 his head.

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.

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 ventilation 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.

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.

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 may be 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 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 handling and periodic testing of lifting equipments

Objective: At the end of this lesson you shall be able to
- **state the periodic testing 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 overhauled 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.

Authorization moving of road testing vehicles

Objectives: At the end of this lesson you shall be able to
- **state the function of regional transport office**
- **state road safety**
- **issue of fitness certificate and vehicle permits.**

Ministry of road transport & highways

Regional transport office is responsible, for registration monitoring controlling authoring of any automobiles our country.

Responsibility of regional transport office

Issue of license

- Testing and insurance of learning license
- Issue of renewal of driving license
- Issue of international driving license
- Addition of a new class of vehicle to driving license
- Issue of renewal of license for the establishment of a motor driving school
- Issue of renewal of driving instruction license
- Issue of conductor's license

Revenue collection for the government

- Tax on motor vehicle
- Collection of IMV fees
- Departmental action cases
- Inspection of vehicles at check posts

Environmental upgradation

- CNG/LPG conversion
- PUC testing (Pollution Control testing)
- Road safety measures

Registration of vehicle

- Issue of renewal of registration certificate for motor vehicles
- Transfer of ownership in registration certificate of motor vehicle
- Entirely termination of hire-purchase/lease/ hypothecation in R.C to book
- Recording of changes in registration certificate
- Issue of certificate of temporary registration
- Issue of no objection certificate(NOC)
- Issue and renewal of trade certificate
- Issue of fitness certificate and vehicle permits.

Road safety precautions

The biggest responsibility lies on the driver while using the road. The vehicle being a fast moving object it can do a lot of damage, if carelessly driven. In order to promote safety, the following general precautions should be observed by every road user.

Always keep to your left; while overtaking it should be done on the right side.

When passing stationary vehicles, keep a watch on pedestrians who may come out suddenly from the front of the stationary vehicle.

Drive slowly on narrow winding road.

When the traffic is held up, never try to force your way by encroaching on the off-side of the road.

Do not overtake on bends

Overtake only when a driver in front of you gives the signal to do so, and always overtake on the right side.

Always keep a good distance between your vehicle and the others. Too close a driving is dangerous.

Always park the vehicle at specified places.

Always give the signal when turning.

Drive slowly and carefully on a road where a school or hospital is situated.

Reversing the vehicle

In driving the vehicle backwards, reverse it into a limited opening either to the left or right under control and with reasonable accuracy. Reverse lights can be used at nights to indicate to the other road users who are coming at the back of the vehicle being reversed.

Problem with automotive emissions

The emissions given off by the burning of gasoline hake shown to be toxic to people and animals when breathes. But they also contribute to the ugly hare called smog, which hangs around the atmosphere causing problems long after the car has moved on. Here are the major pollutants.

Hydrocarbon (HC), Carbon Monoxide (CO) Nitrogen Oxide (NO_2), Volatile organic compounds (VOCs) particulate matter (diesel vehicle), Sulphur Oxide (SOx).

Energy conservation process

Objective: 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.

Definition 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.

Electrical safety tips

Many injuries occur as the result of contact with electrical equipment or appliances. If the part of the body comes in contact with the electrical circuit, a shock will occur. The current will enter the body at one point and leave at another and this passage of electricity can cause severe pain, burning of skin at the point of contact, and even death. So it is need safe and free from electrical hazards.

Safety tips

1 Use only properly grounded or double insulated items/ equipments.

2 Do not overload outlets.

3 Do not plug multi-outlet bars to other multioutlet bars.

4 Only use equipment that has been approved by national testing laboratory.

5 Minimize the use of extension cards.

6 Do not cover power cords with rugs or mats.

7 Do not run electrical cord through pedestrian aisles.

8 Disconnect the power before servicing the equipment.

9 Do not ignore warning signs.

10 Replace the defective cords immediately.

11 Cover or guard any exposed electrical components or wire.

12 Don’t use electrical equipment when your hands or equipments are wet and don’t use it near wet surface/ water.

13 Don’t pull the power cord from a distance.

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

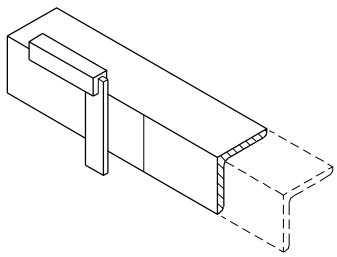
Chalk mixed with methylated spirit

White lead powder mixed with turpentine

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

White wash is not recommended for workpieces of high accuracy.

Fig 1



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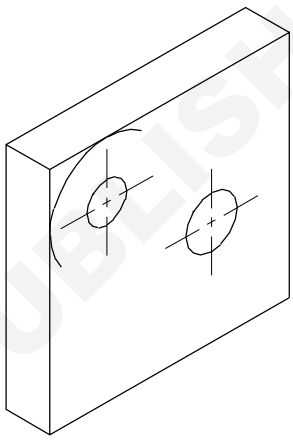
Cellulose Lacquer: This is a commercially available marking medium. It is made in different colours, and dries very quickly.

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



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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

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.

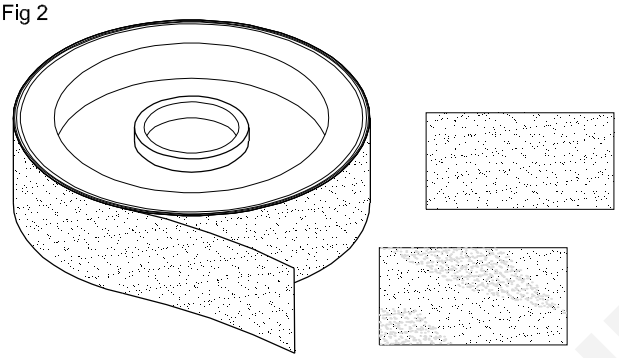
It should not make any scratches on the finished surface.

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.

Fig 2



EMERY SHEET

MTN120922

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

MTN120921

Scraper

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

- **name the different type of scrapers**
- **state the features of each type of scraper**
- **state the precaution to be observed while uses scraper.**

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 Scraper

Special scraper is available for scraping and finishing curved surfaces. They are:

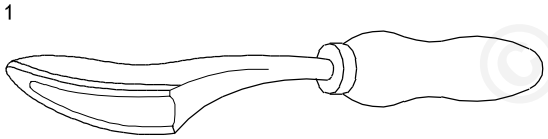
- Half round scraper
- Three-square scraper
- Bull nose scraper

Half round scraper

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

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

Fig 1



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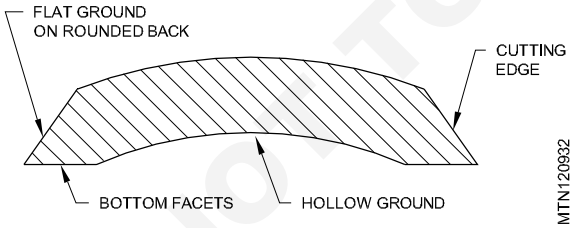
The bottom facet and the flat surfaces are ground along the edge to form the cutting edge. (Fig 2)

Fig 2



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

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

Three- square scraper (Fig 4)

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

Fig 3

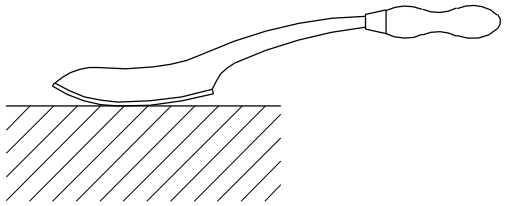

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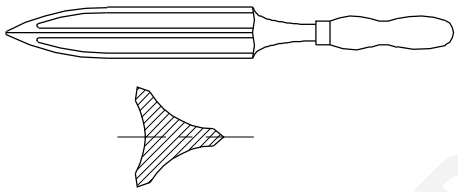
Fig 4



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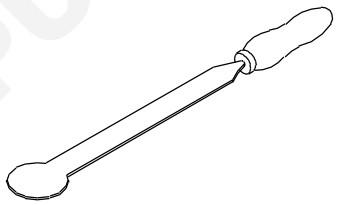
The cross-section of this is triangular. This has more number of cutting edges and the hollow portion between the cutting edges helps in re-sharpening easily.

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



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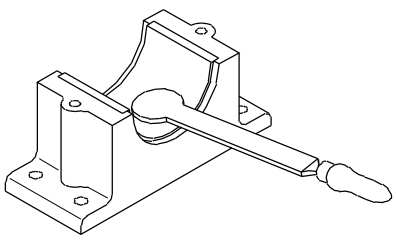
It is useful for scraping large bearings (Fig 6). This scraper can be used in a longitudinal direction like a flat scraper or with a circumferential movement like a half round scraper. This dual action helps to prevent ridges on the scraped surfaces.

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 in use.

Fig 6



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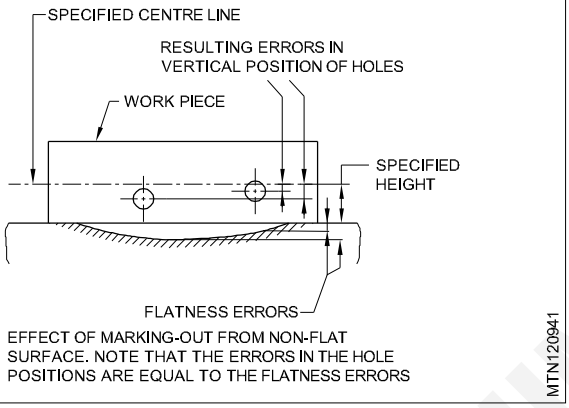
Surface plates

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 and 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

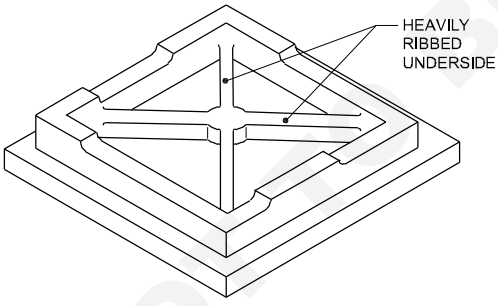


EFFECT OF MARKING-OUT FROM NON-FLAT SURFACE. NOTE THAT THE ERRORS IN THE HOLE POSITIONS ARE EQUAL TO THE FLATNESS ERRORS

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

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

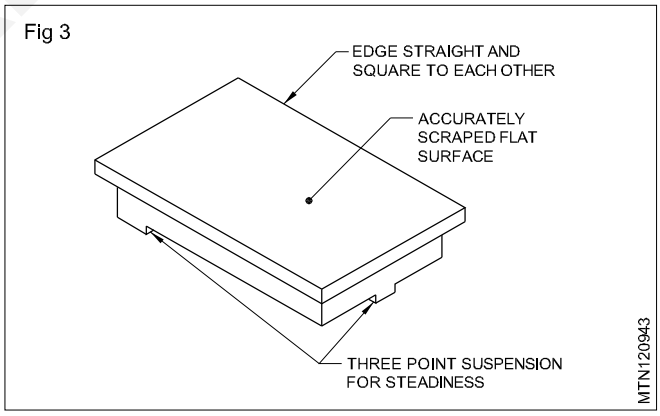
Cast iron surface plates are designated by their length, breadth, grade and the Indian Standard number.

Example

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

Marking-off tables (Fig 3)

Fig 3



Wheelbase, wheel track and measuring tape

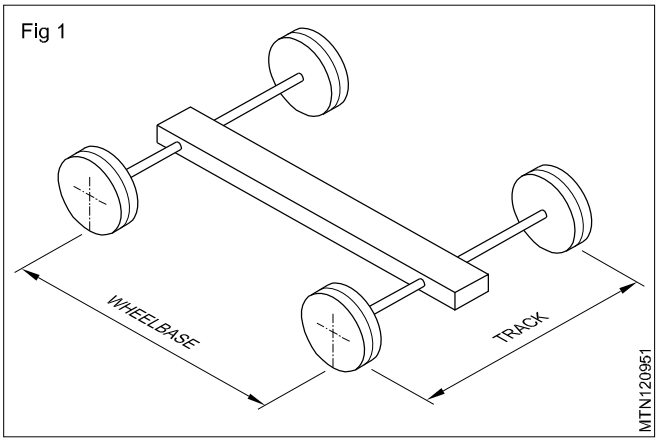
Objectives: At the end of this lesson you shall be able to
- **define wheelbase**
- **define wheel track**
- **state measuring tape and its types and uses.**

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

Wheel/Track: The wheel track of a vehicle equals the center distance between its front wheels. As shown in the diagram (Fig 4) and (Fig 1).

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.

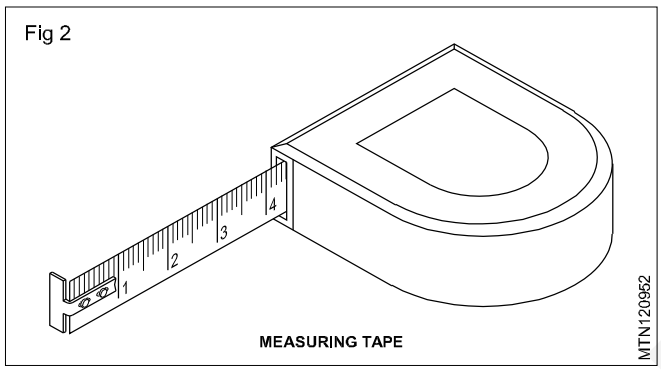
Fig 1



Types

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

Fig 2



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

Fig 3

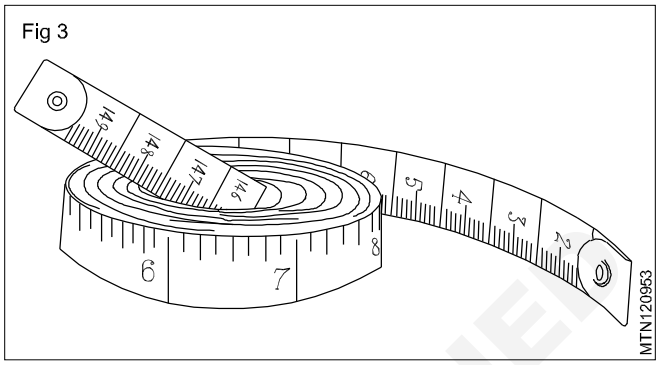
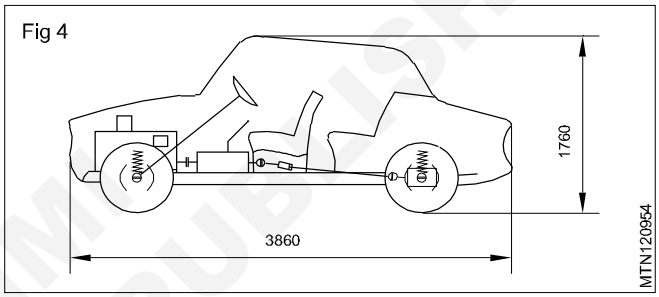


Fig 4



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)

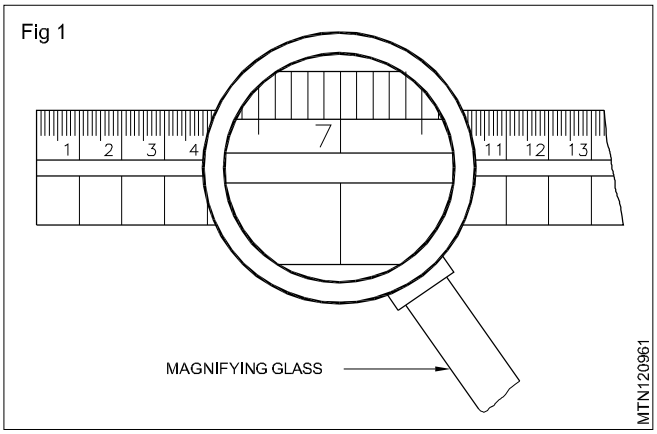
Both large and small dimensions are stated in millimetres

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 with corresponding vernier scales.

Fig 1



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 length, 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.

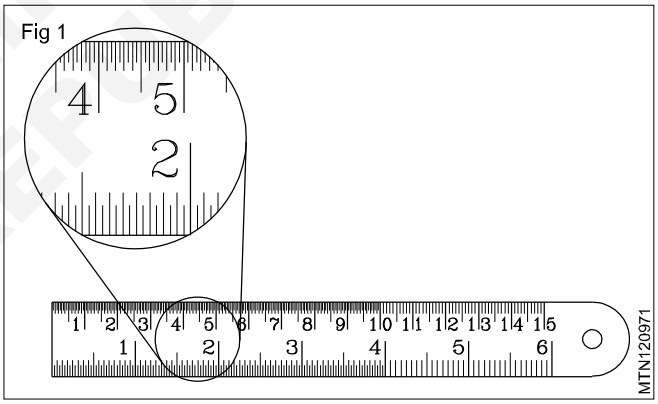
The reading accuracy of the steel rule is 0.5 mm.

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.

Fig 1



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.

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)

- check flatness of surfaces (Fig 3)
- mark lines at 90^0 to the edges of workpieces (Fig 4)
- set workpieces at right angles on work, holding devices. (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.

Fig 1

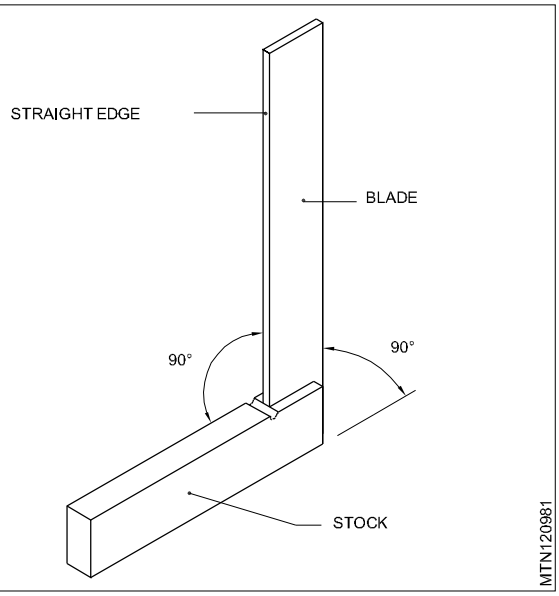


Fig 2

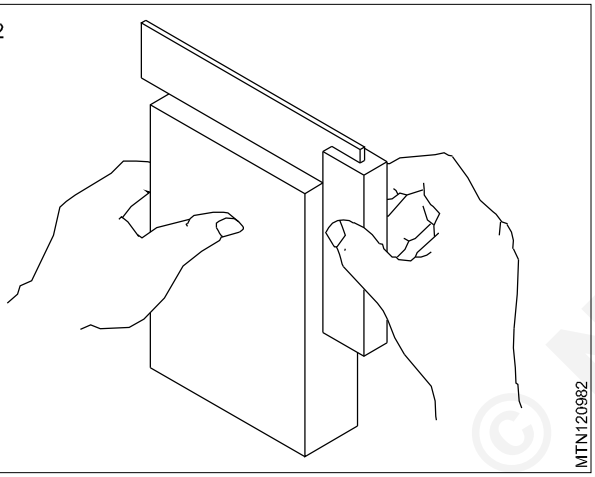


Fig 3

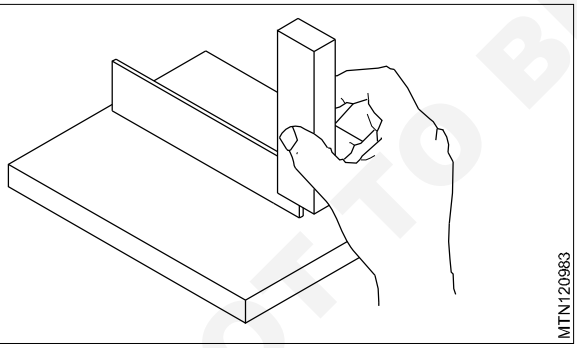


Fig 4

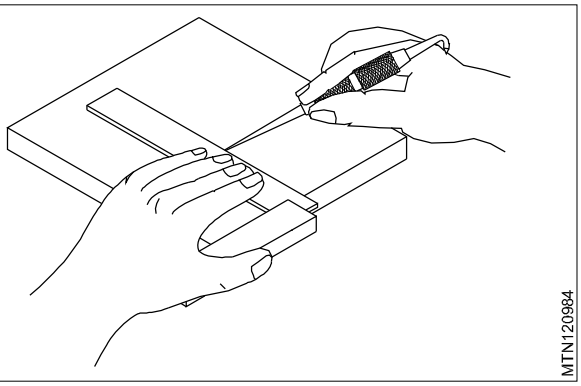


Fig 5

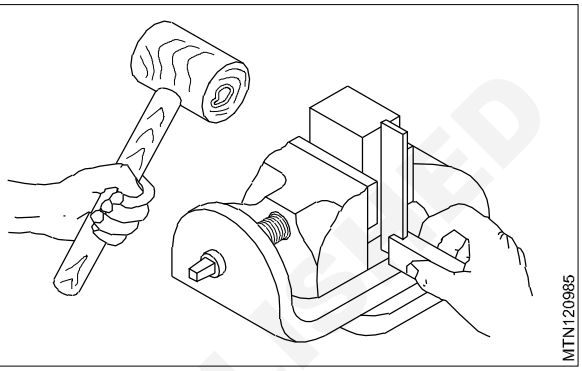
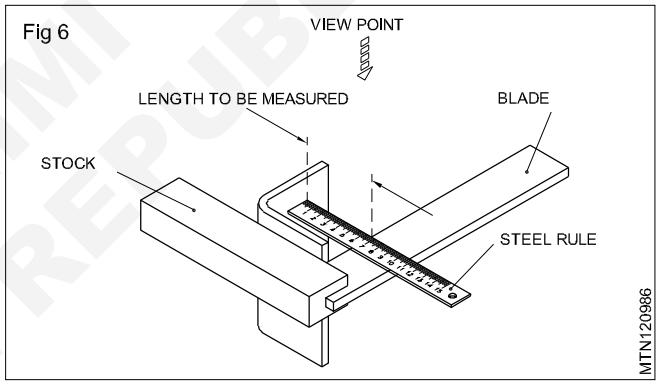


Fig 6



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.

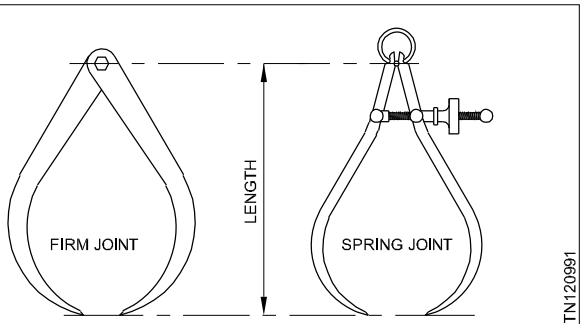
Calipers are of different types depending on the type of joint and the shape of leg.

Types of joint: The commonly used calipers are;

- Firm joint calipers
- Spring joint calipers

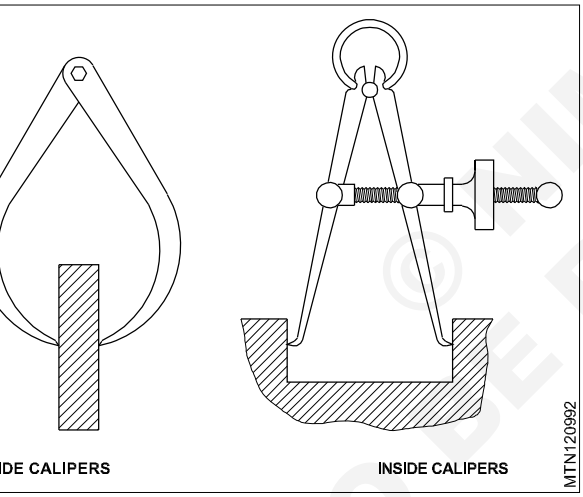
Firm Joint calipers (Fig 1): In the case of firm joint calipers, both legs are pivoted at one end. To take measurements of a workpiece. It is opened roughly to the required size. Fine setting is done by tapping the caliper lightly on a wooden surface.

Fig 1



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.

Fig 2



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

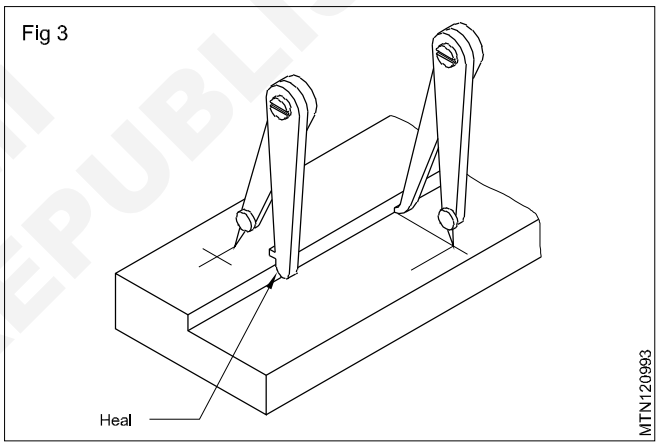
Outside and inside calipers are differentiated by the shape of the legs.

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 are used for marking lines on inside and outside edges.

Fig 3



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 be considered in respect of divider points.**

Dividers are used for scribing circles, arcs and transferring and stepping of distances. (Fig 1a & 1b)

Dividers are available with firm joints and spring joints. The measurements are set on the dividers with a steel rule (Fig 2a &2b).

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 3a).

For the correct location and seating of the divider legs, prick punch marks of 30° are used (Fig 3b).

Fig 1

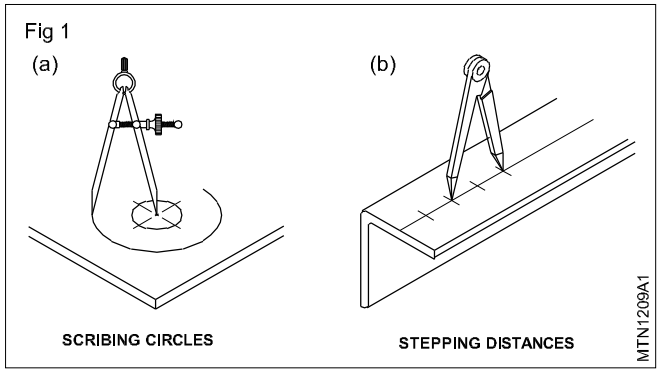
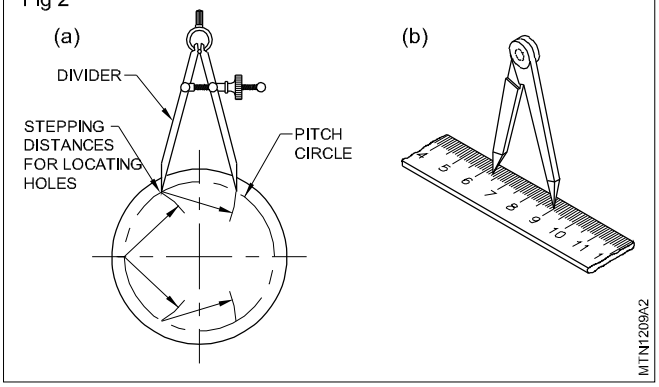


Fig 2



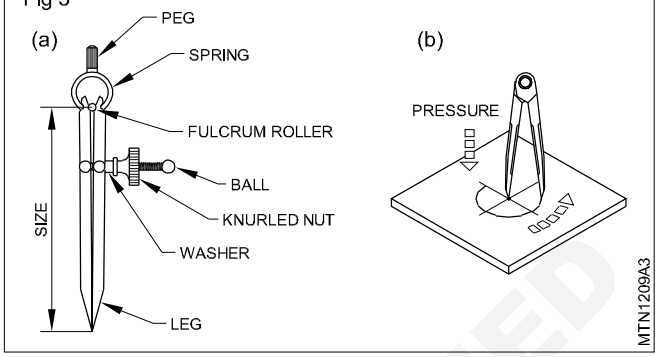
Both the legs of the divider should always be of equal length.

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.

Fig 3



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.**

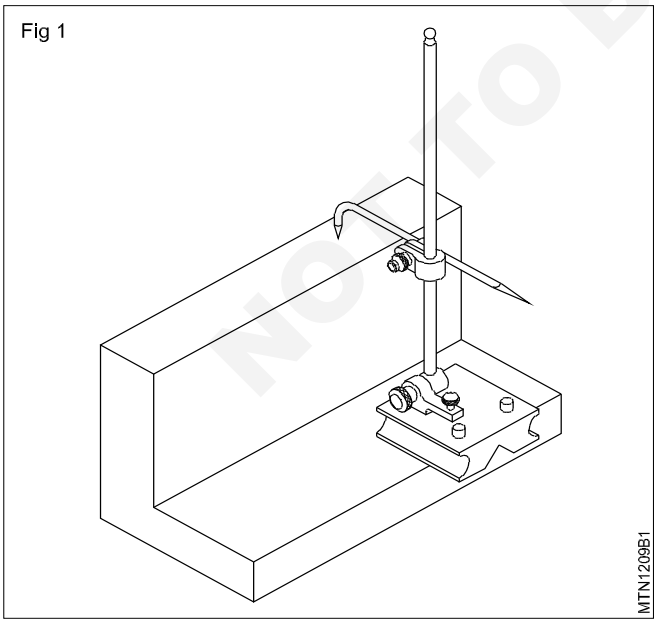
The surface gauge is one of the most common marking tools used for.

scribing lines parallel to a datum surface

Types of surface gauges

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

Fig 1

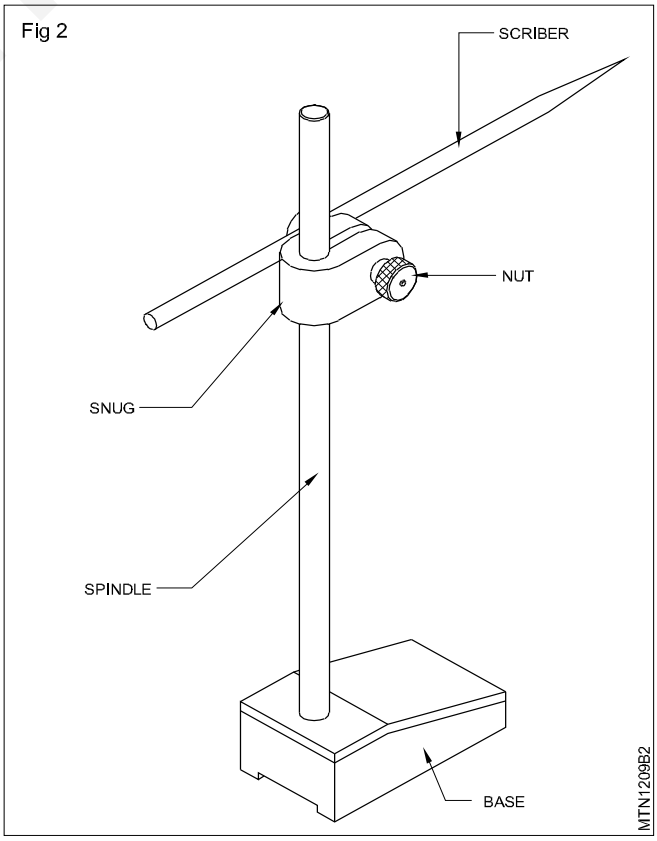


Surface gauge-fixed type (Fig 2)

- 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 2



Universal surface gauge (Fig 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

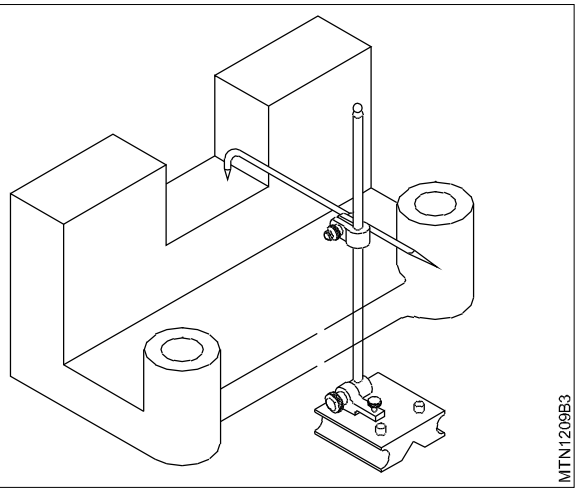


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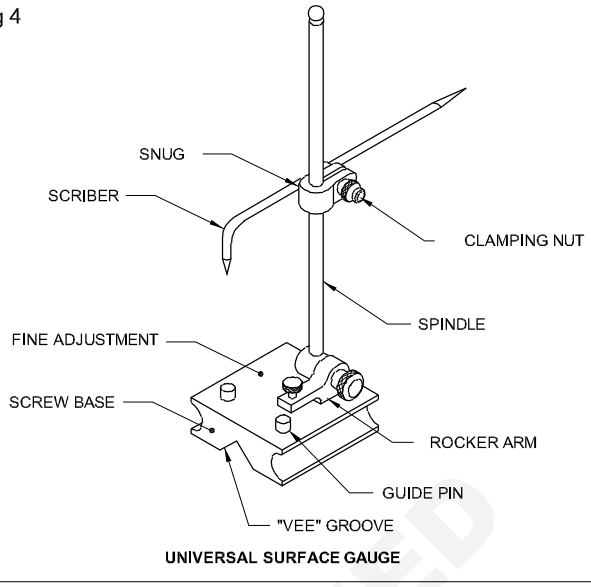
Fig 4



UNIVERSAL SURFACE GAUGE

MTN1209B4

Scriber

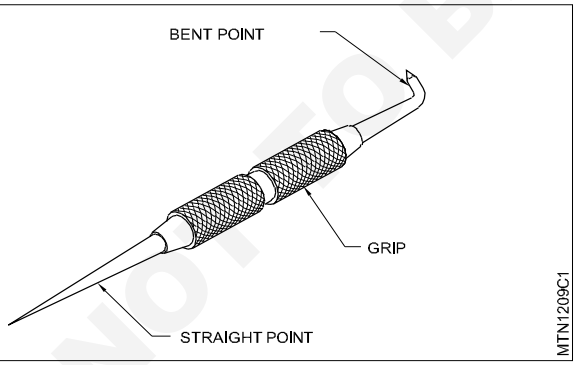
Objectives: At the end of this lesson you shall be able to
- **state the features of scribers**
- **state the uses of scribers.**

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



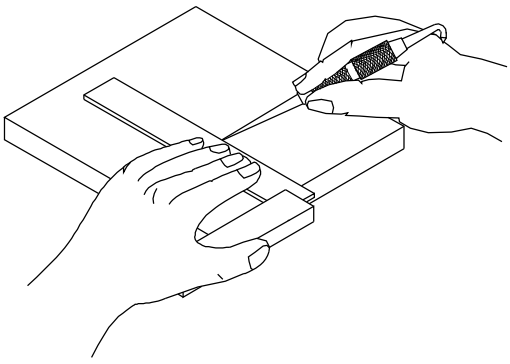
MTN1209C1

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.

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)

Fig 2



MTN1209C2

Hand tools

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

Fig 1

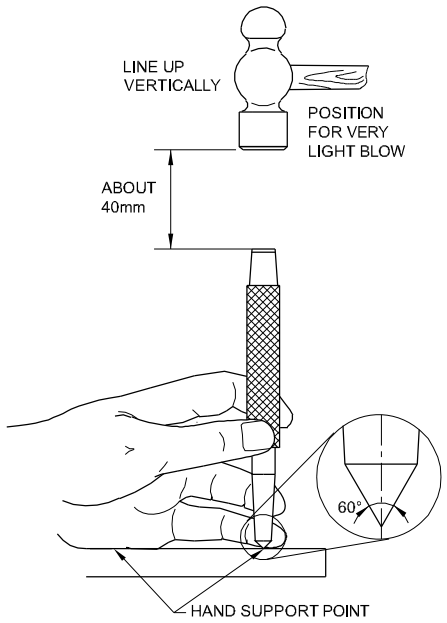
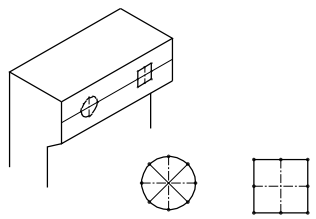


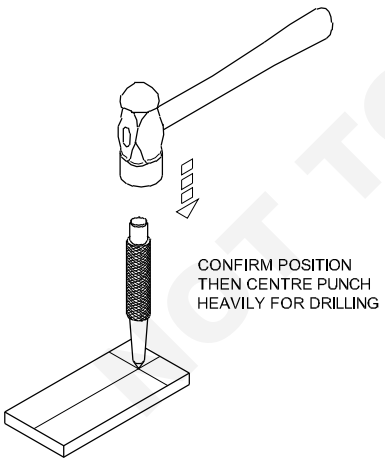
Fig 2



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).

Fig 3

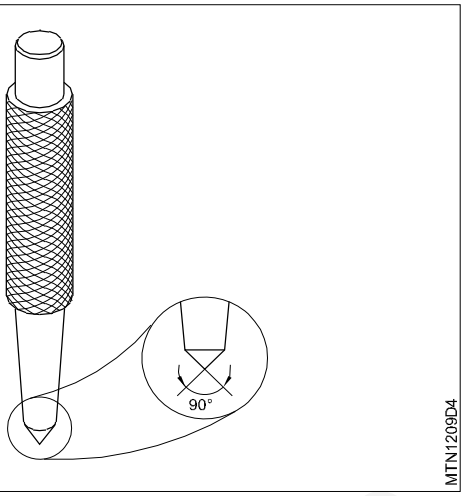


A 100 mm prick punch with a 7 mm diameter body could have a 2.5 mm diameter point ground to an angle of 60° or 30°

Centre punches

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

Fig 4

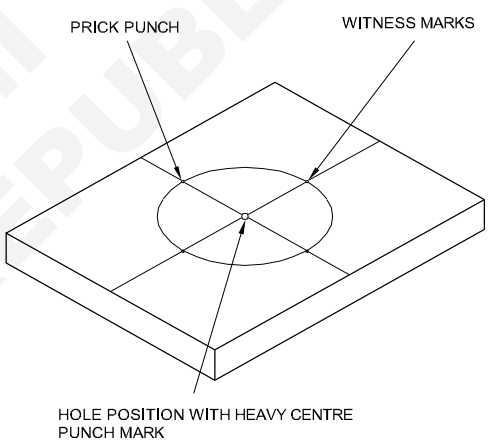


A 100 mm centre punch could have a 10 mm diameter body and a 6 mm diameter point ground to an angle of 90°.

Centre punches are used;

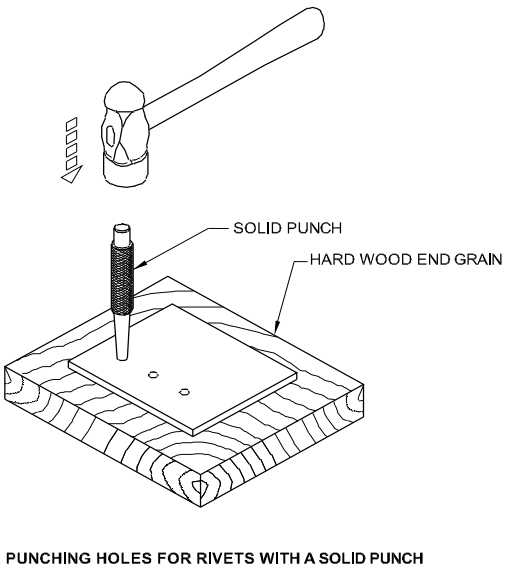
- to make deeper witness marks on scribed lines and to locate a centre position and make it easier for the drill to start correctly (Fig 5).

Fig 5



Solid punch (Fig 6)

Fig 6



PUNCHING HOLES FOR RIVETS WITH A SOLID PUNCH

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

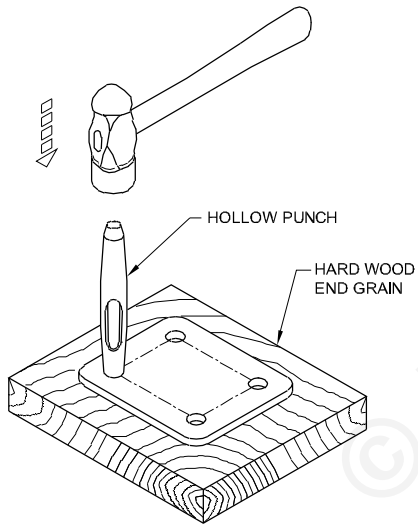
Letter and number punches

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

Fig 7



USING A HOLLOW PUNCH

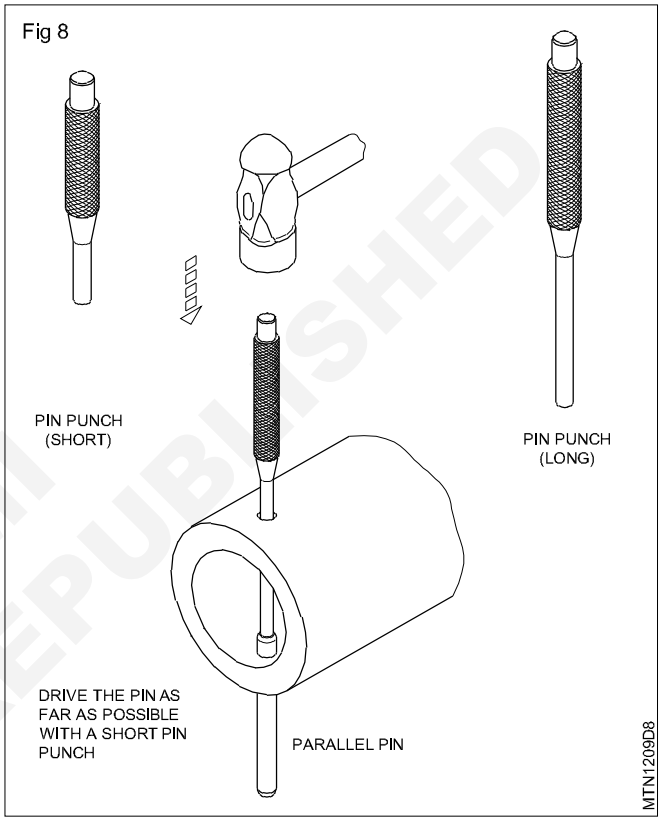
While using solid or hollow punches, the materials is rigidly supported with a block of wood (with the end of grain up) or lead. This will also avoid any damage to the tip of the punch while punching.

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.

Fig 8



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.

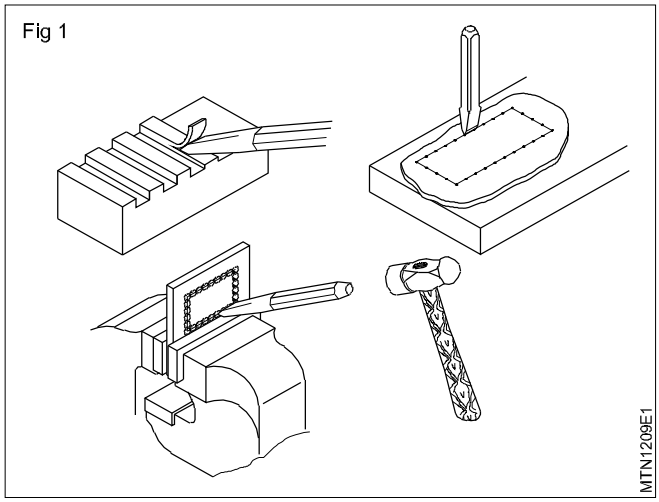
Parts of a chisel (Fig 2)

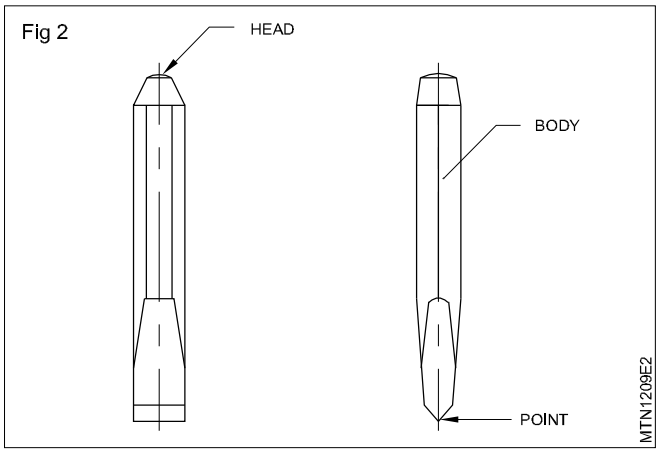
A chisel has the following parts.

- 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 tempered.

Fig 1





Common types of chisels

There are four common types of chisels;

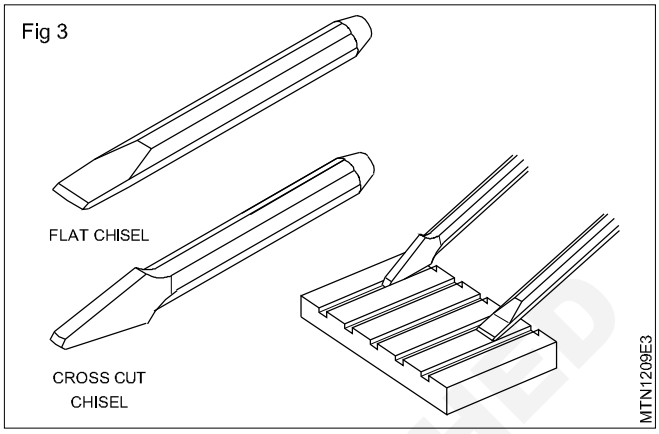
- Flat chisel (1)
- Cross-cut chisel (2)
- Hall round nose chisel
- Diamond point chisel

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.

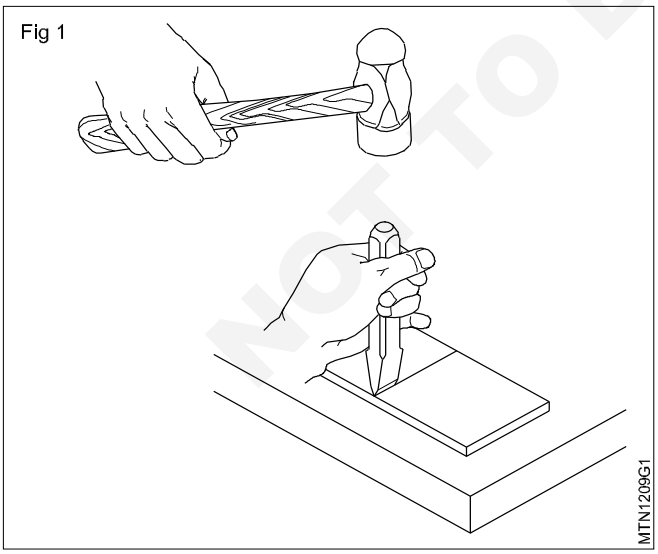


Hammers

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



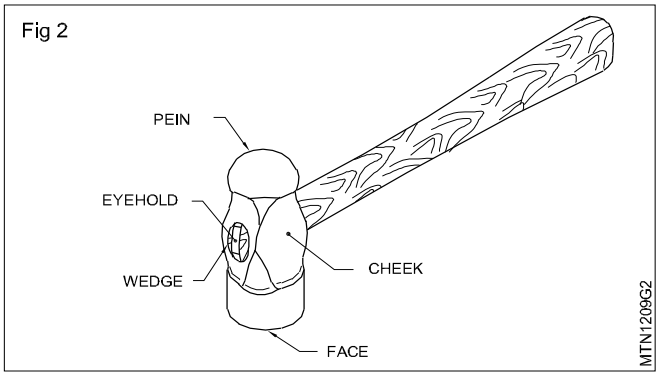
Major parts of a hammer (Fig 2)

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.

The parts of a hammer head are the

- Face (1)
- Pein (2)
- Cheek (3)
- Eyehole (4)
- Wedge (5)

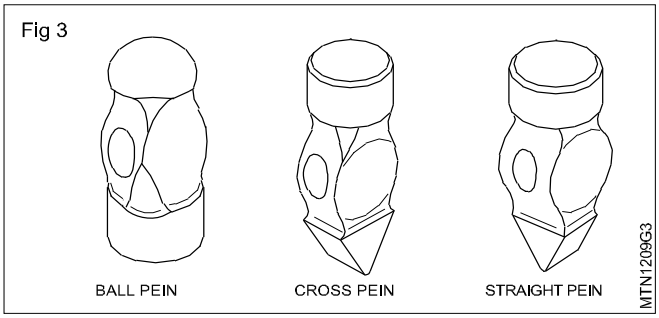


The face is the striking portion. Slight convexity is given to it avoid digging of the edge.

The peen 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)

- Ball peen
- Cross peen
- Straight peen

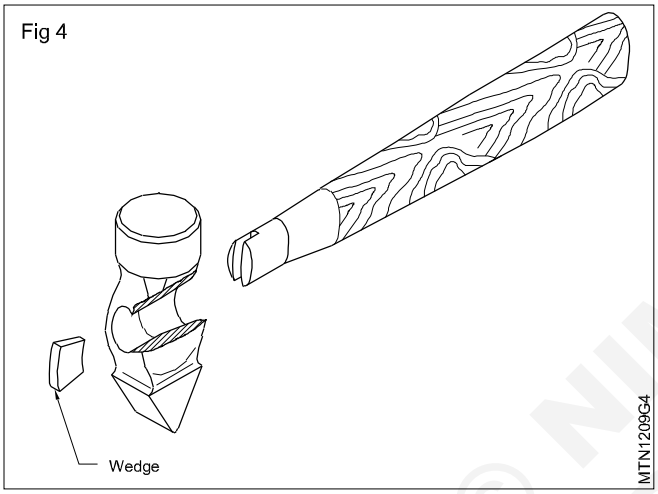
The face and the peen are hardened.

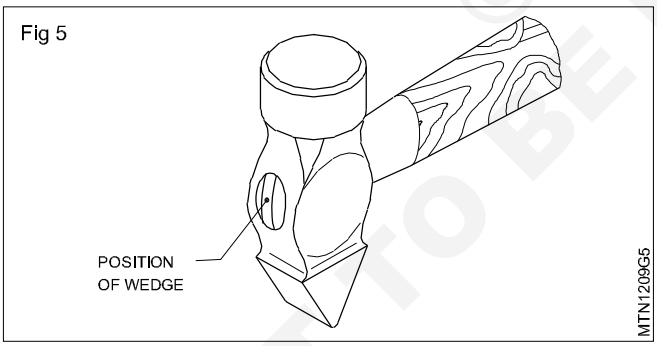


The cheek is the middle portion of the hammer-head. The weight of the hammer is stamped here.

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 peen. Their weight varies from 125 gms to 1.5 kg.

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

Before using a hammer

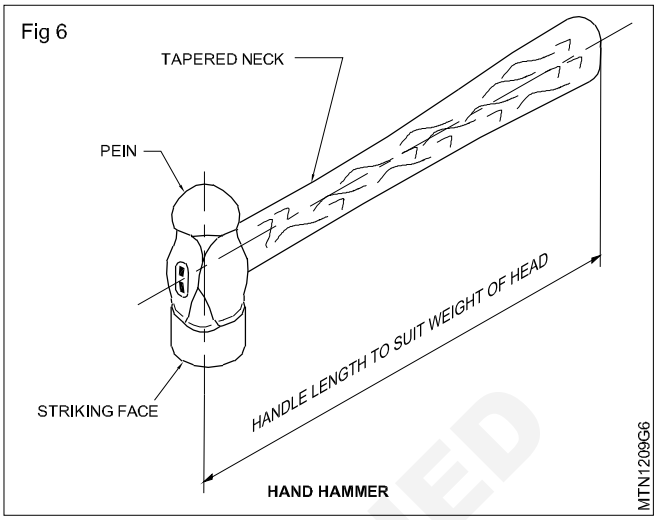
Make sure the handle is properly fitted

Select a hammer with the correct weight suitable for the job.

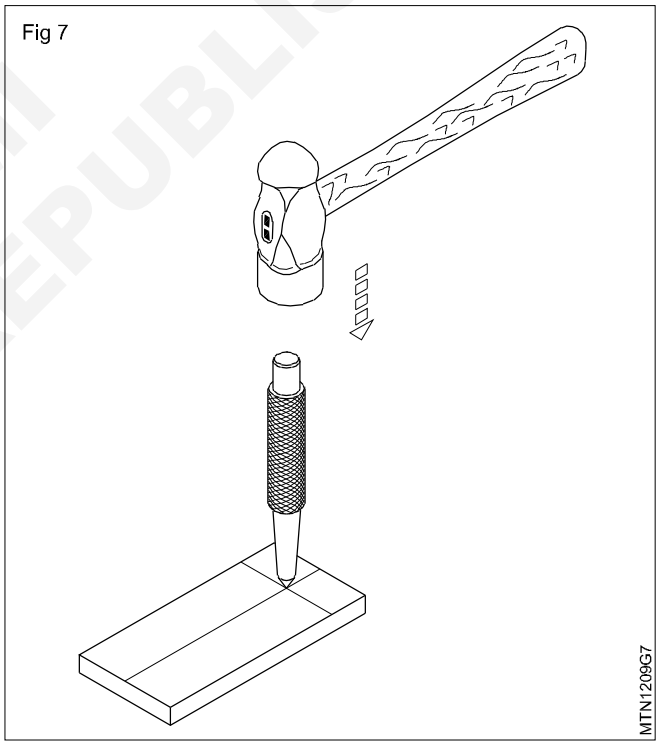
Check the head and handle for any cracks

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 peen hammer (Fig 8)

A ball peen 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 peen hammer (Fig 10)

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

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

Fig 8

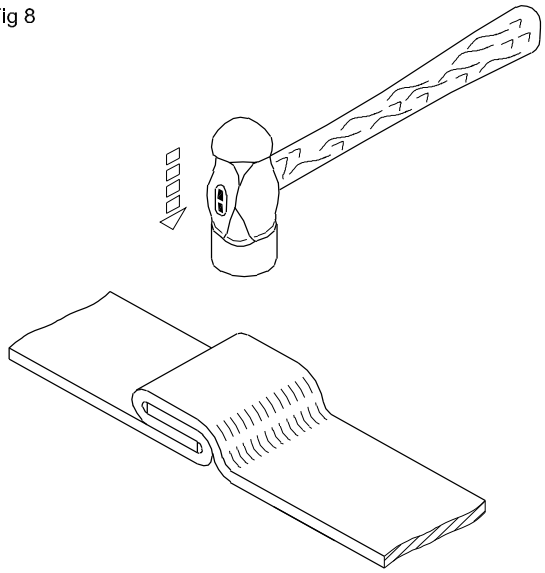


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Fig 9

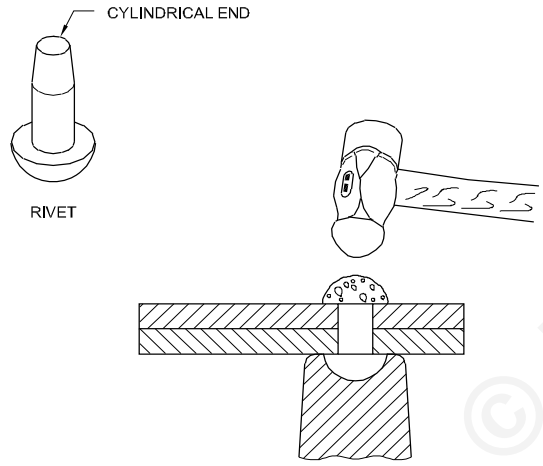

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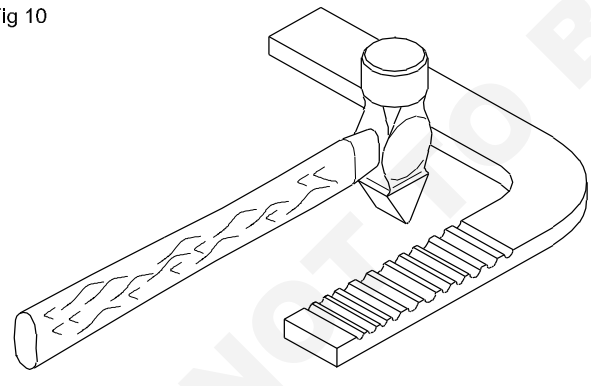
Fig 10



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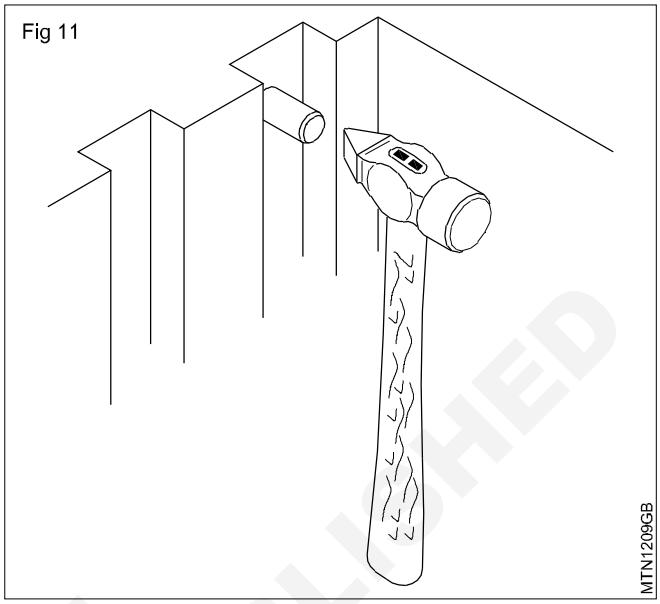
Straight pein hammer

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

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

Fig 11



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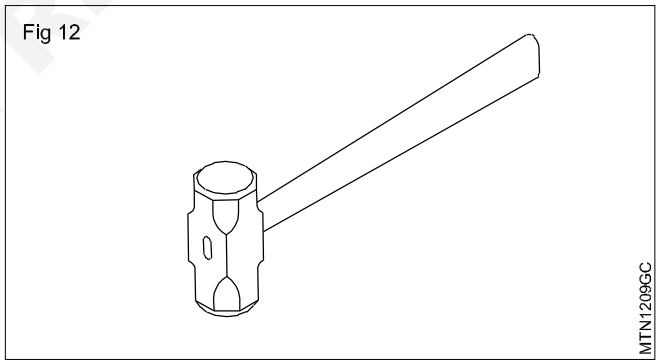
A lump hammer or club hammer is a small sledge hammer (Fig 12) whose relatively light weight and short handle allow single-handed use. It is useful for light demolition work, driving masonry nails, and for use with a steel chisel when cutting stone or metal. In this last application, its weight drives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

Fig 12



MTN1209GC

Wooden mallet

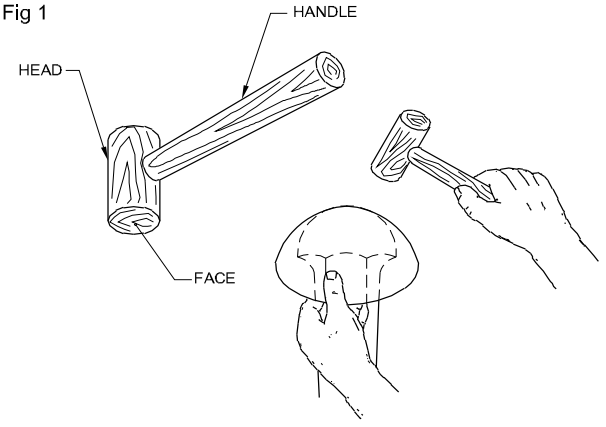
Objectives: At the end of this lesson you shall be able to
- **name the different types of mallets**
- **state the uses of each type of mallets.**

Mallets: Mallets are soft hammers and are made of raw hide, hard rubber copper, brace, 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

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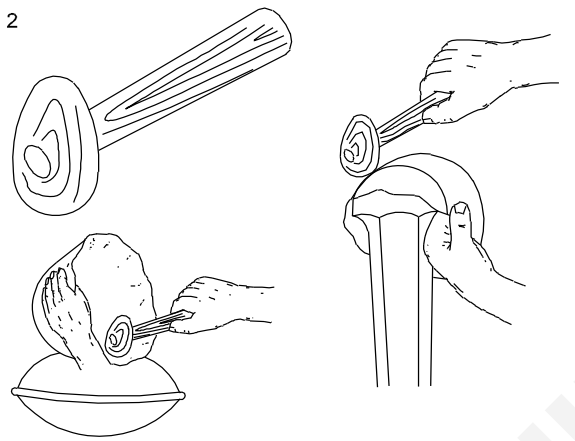
Fig 2

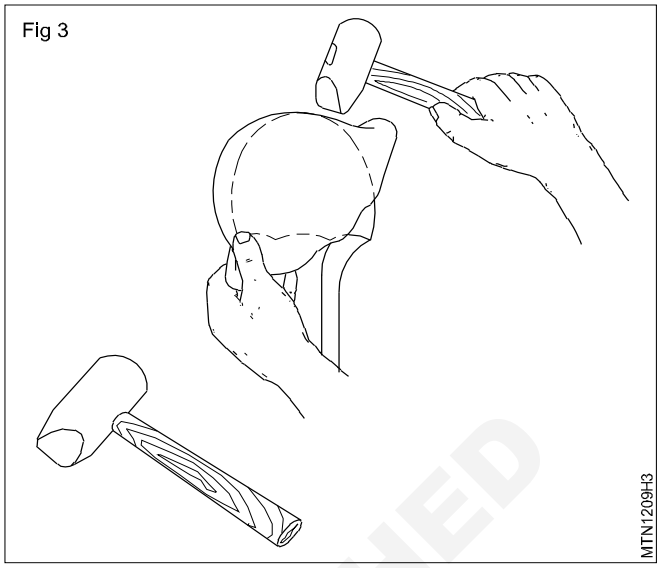


SHAPING THE HEMISPHERICAL BOWL BY RAISING
BOSSING MALLET

MTN1209G2

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

Fig 3



MTN1209H3

Screw drivers

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

- **classify the hand-held screwdrivers and 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 Screwdrivers: Standard screwdrivers are classified as:

- Heavy duty screw drivers
- 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.

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 circuiting live parts.

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 1

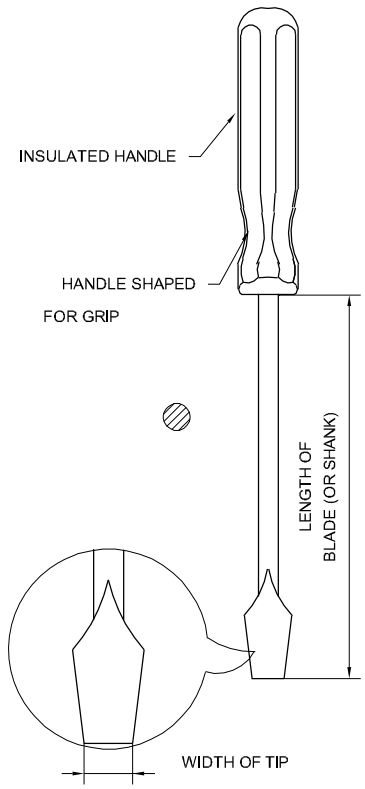


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Fig 2

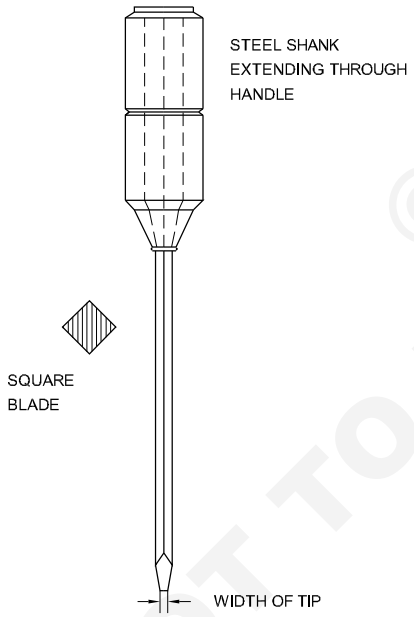

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Fig 3

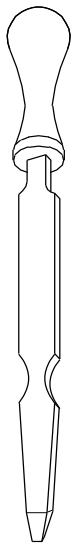

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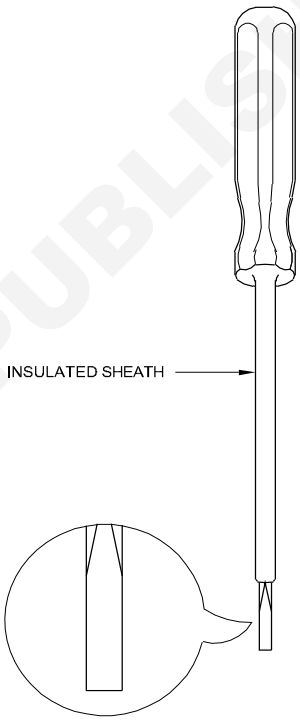
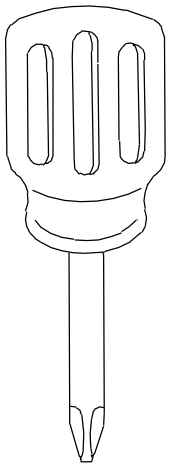
Fig 4



LIGHT DUTY SCREW DRIVER

MTN1209I4

Fig 5



STUMPY SCREW DRIVER

MTN1209I5

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.

Ratchet screwdriver (Fig 7): The following are the features of ratchet screwdrivers.

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

Fig 6

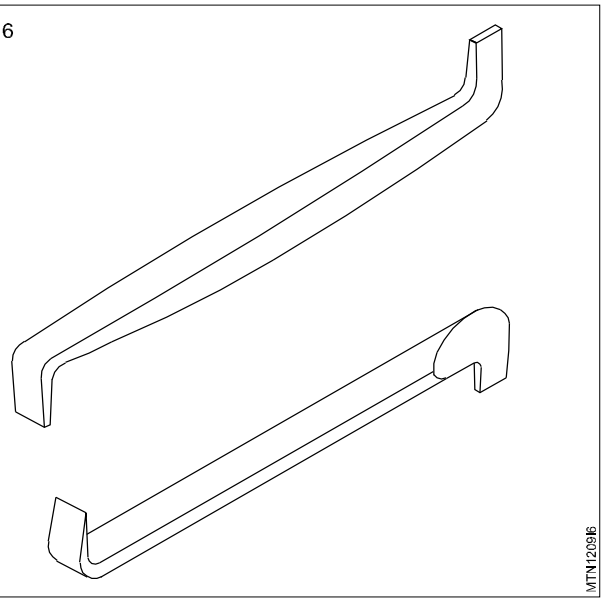


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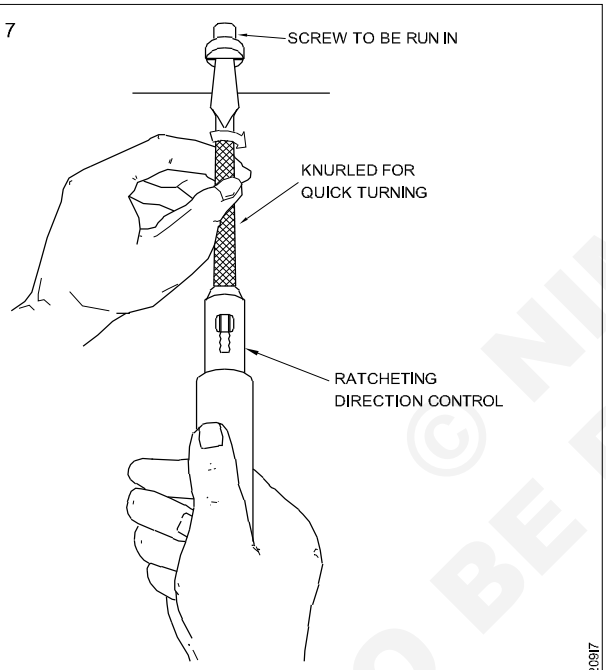
Fig 7



RATCHET SCREWDRIVER

MTN120917

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.

Phillips (cross-recess) screwdrivers (Fig 8)

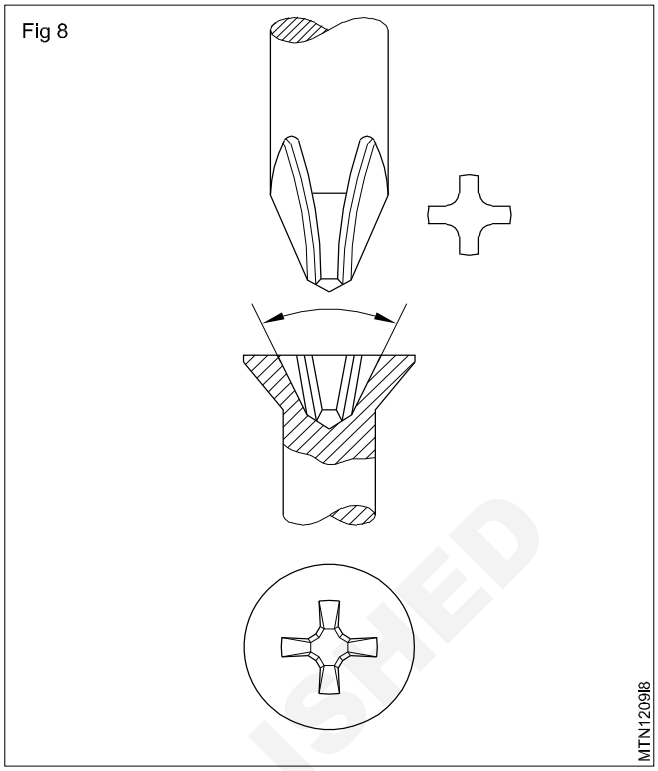
Phillips screwdrivers have cruciform or cross-shaped tips that are unlikely to slip from the cruciform slots in Phillips recessed head screws.

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

The extreme end is ground to 110°.

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.

Fig 8



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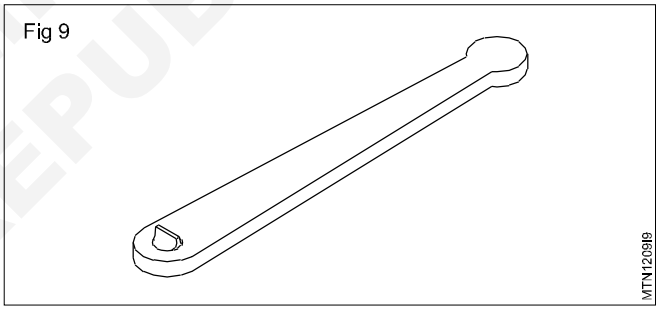
For quicker application ratchet offset screwdrivers are also available with renewable tips. (Fig 9)

Fig 9



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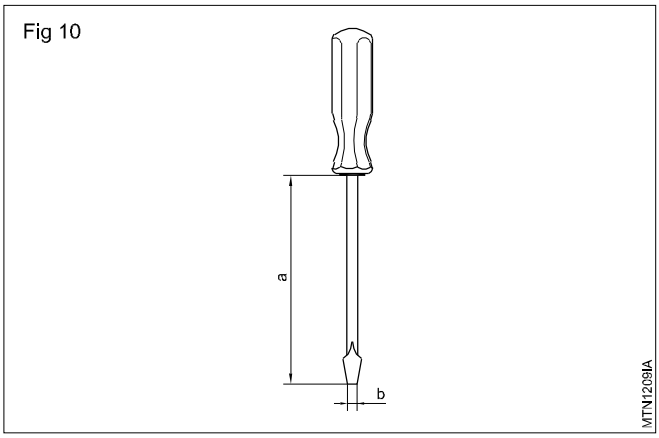
Specification: Screwdrivers are specified (Fig 10) according to the;

- 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

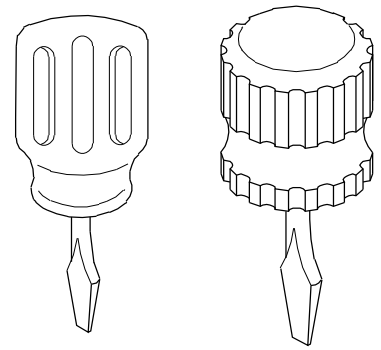


MTN12091A

Screwdrivers for special uses

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

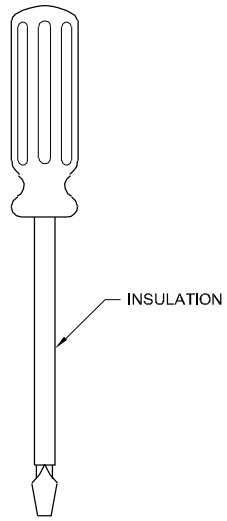
Fig 11



MTN1209IB

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

Fig 12



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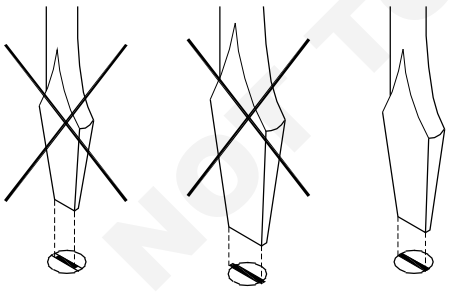
Precautions

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

Fig 13



MTN1209ID

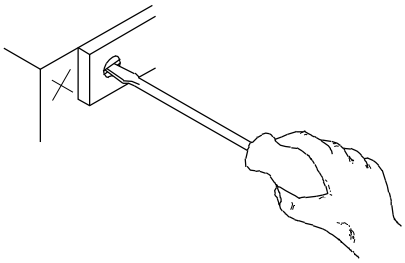
Make sure your hand and the handle are dry.

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

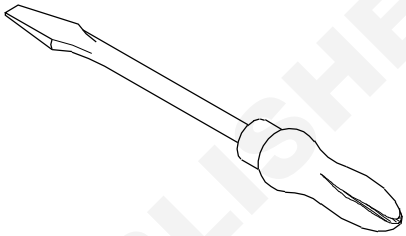


MTN1209IE

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.

Fig 15



MTN1209IF

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

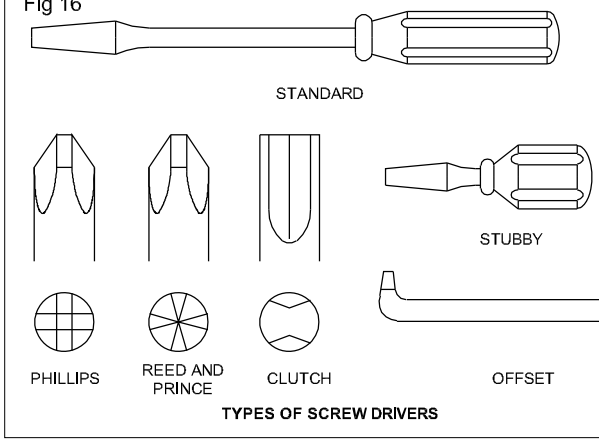
- Length of the blade
- Width of the tip

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 & philips types.

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

Fig 16



TYPES OF SCREW DRIVERS

MVN1206IG

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

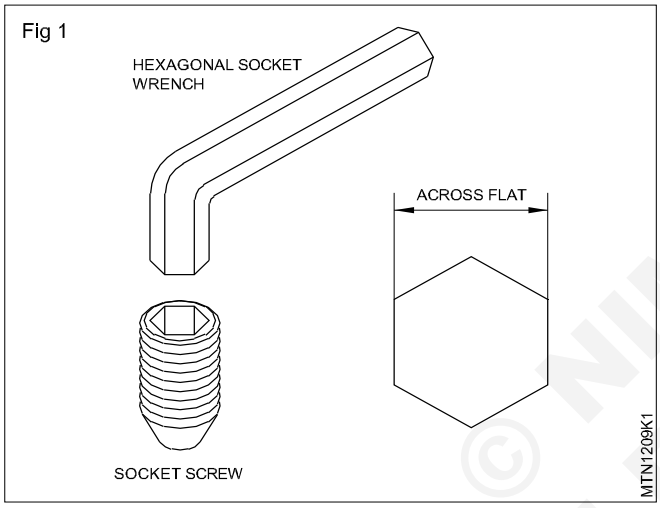
Objectives: At the end of this lesson you shall be able to
- **state the features and uses of hexagon socket screw keys**
- **specify hexagon socket screw keys**.

Hexagon socket screw keys/Allen keys are made from hexagonal section bars of chrome 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)

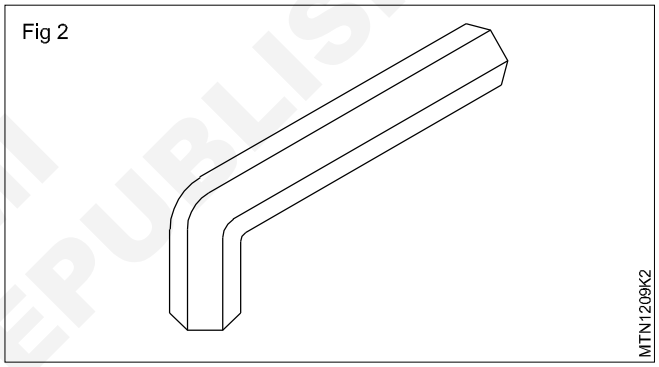
2,3,4,5,6,7,8 and 10mm

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.

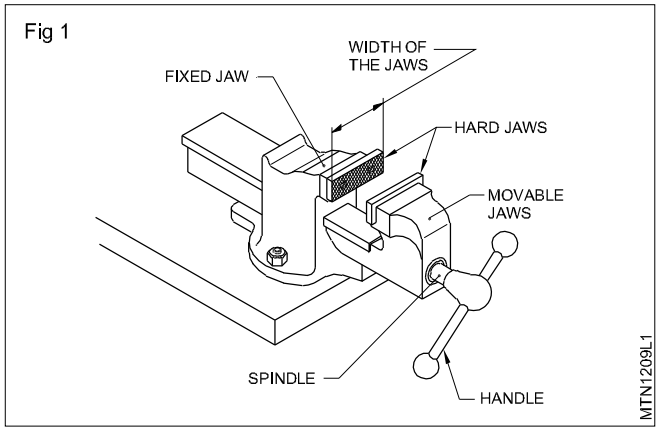
The size of the vice is stated by the width of the jaws.

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 sheet metal etc.

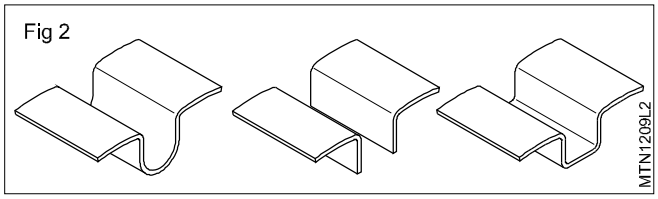
Fixed jaw, movable jaw, hard jaws, spindle, handle, box-nut and spring are the parts of vice.

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.



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

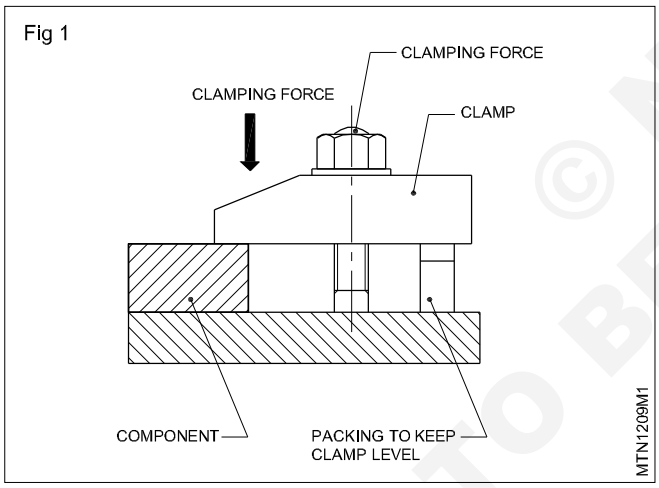
Should be able to manipulate for easy loading.

Should provide the required clamping force.

Should be capable of locking with minimum movement.

Should accommodate a range of sizes of jobs.

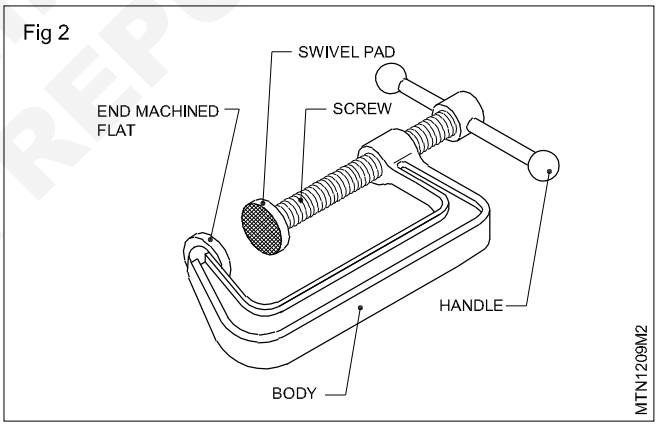
(Fig 1) shows a typical clamping device, employing a screw and nut to provide the clamping force.



'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)

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.



Spanners and their uses

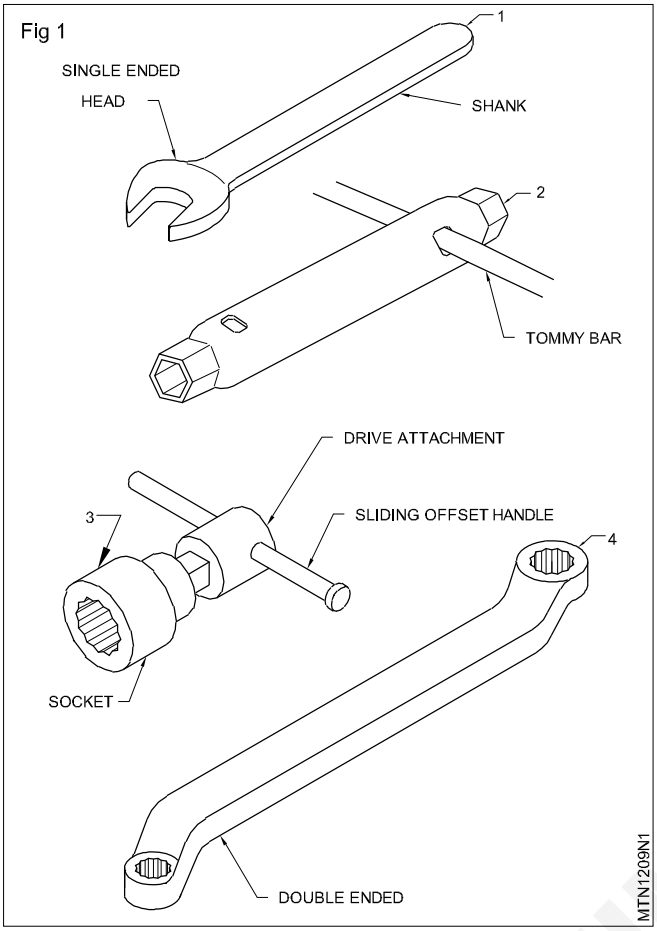
Objectives: At the end of this lesson you shall be able to
- **state the necessity of spanners**
- **identify the different types of spanners**
- **specify the spanners**
- **list out the parts of adjustable spanners**
- **state the features of 'C' spanners and their uses.**

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 spanners 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).

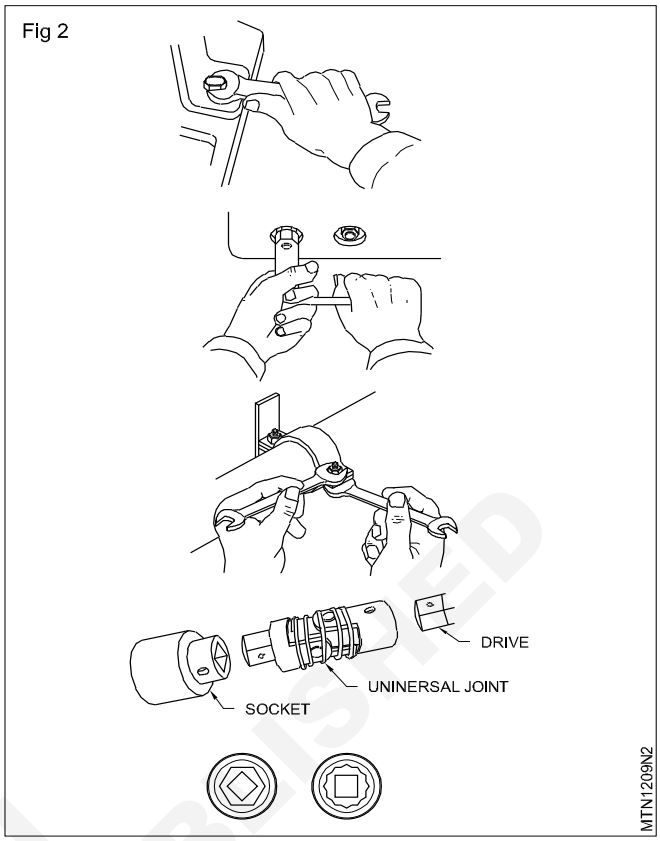
Use two spanners as shown in the figure to stop the head of the bolt rotating as the nut is operated (Fig 2).

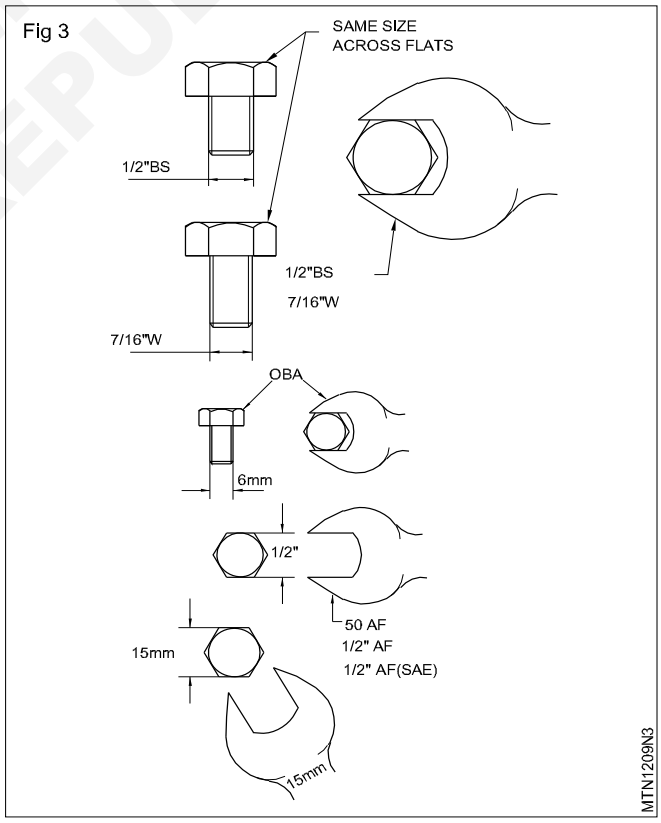
Socket spanners may be turned by accessories which have square driving ends (Fig 2).

Size and identification of spanners

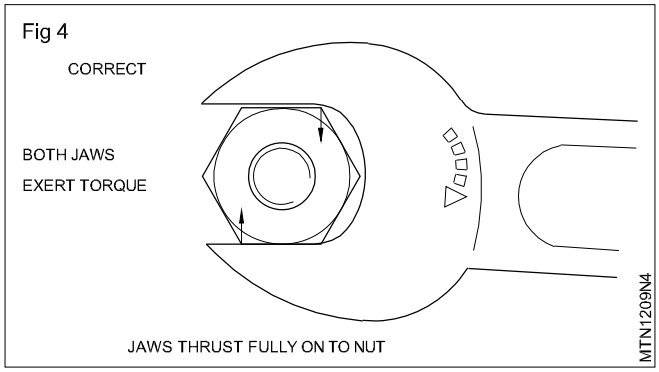
The size of a spanner is determined by the nut or bolt it fits. The distance across the flats of a nut or bolt varies both with the size and the thread system (Fig 4).

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.

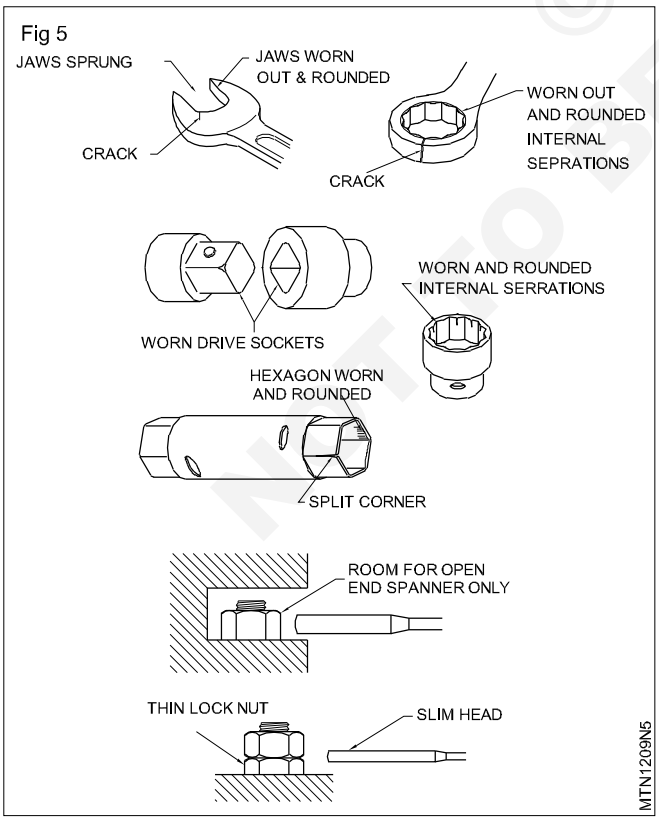
Place the spanner so that its jaws be carefully on the flats of the nut.

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 (Fig 5).



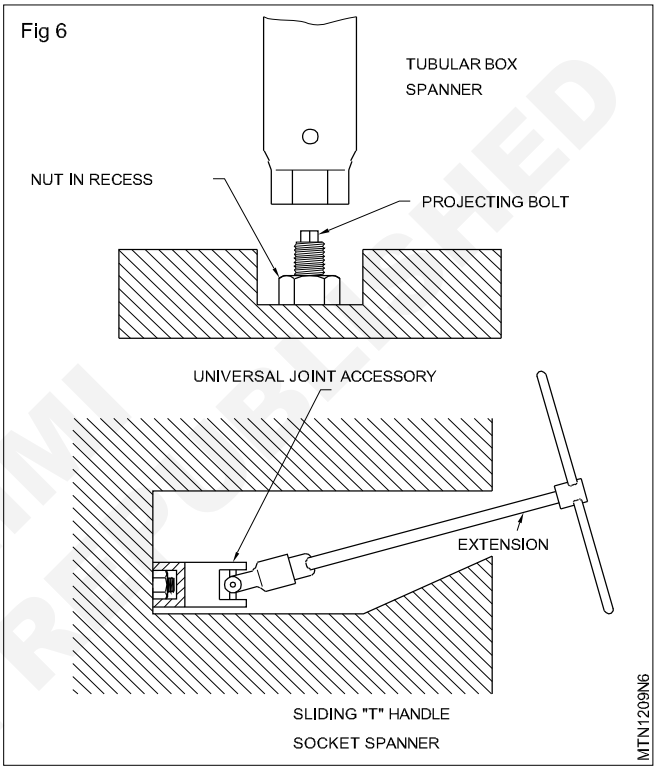
Length of spanners (Fig 6)

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 (Fig 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 250mm spanner can be adjusted from zero to 28.5mm. Adjustable spanners may range in length from 100mm to 760mm. the type illustrated has its jaws set an angle of 22½° 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.

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.

Fig 7

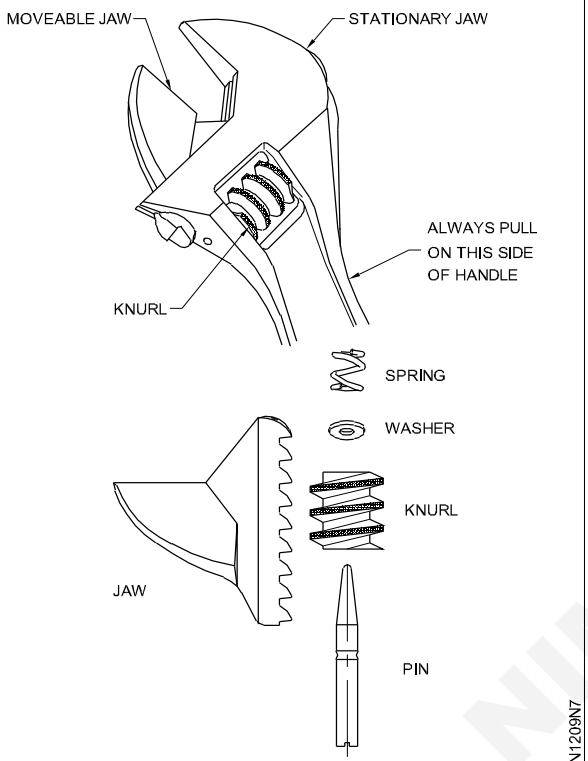
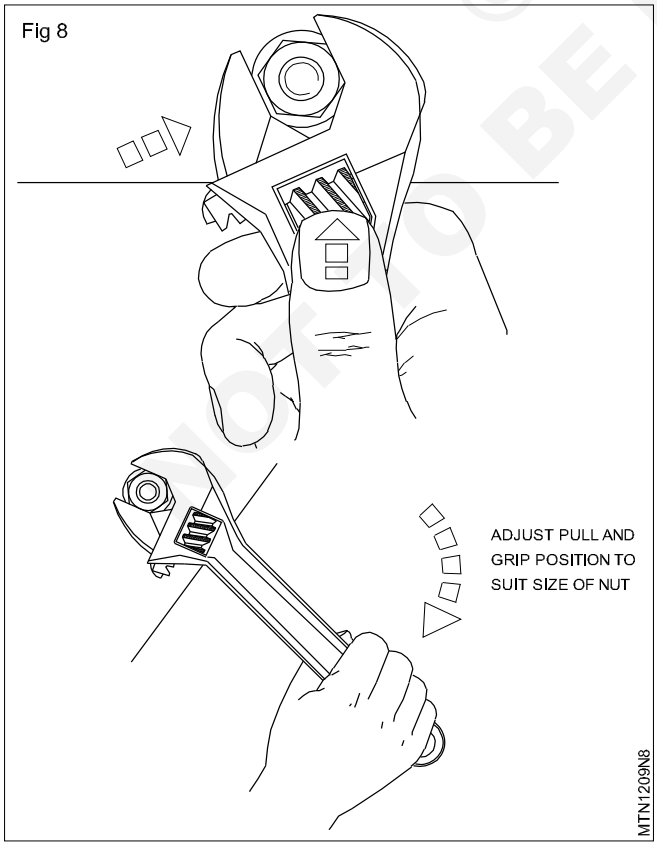


Fig 8



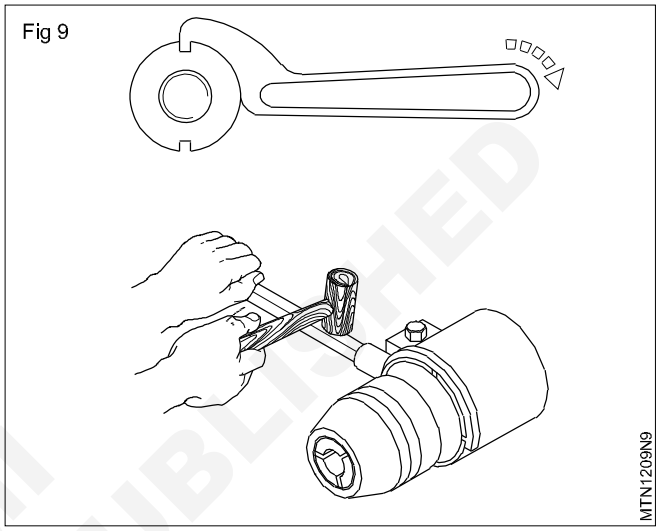
'C' spanners (Hook spanners) (Fig 9)

It has a lug that fits in a notch, cut in the outer edge of a round nut. The 'C' section is placed around 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.

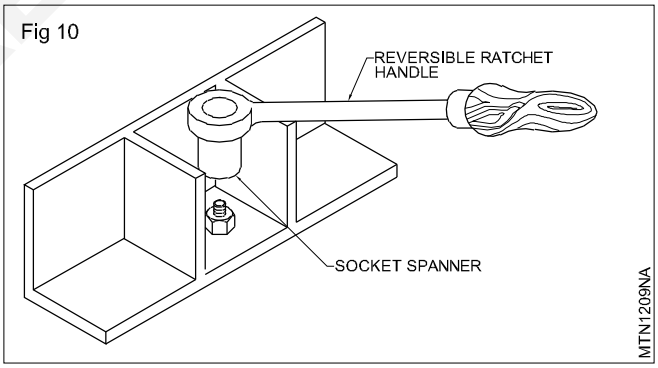
C' Spanners are also used for zero - setting of micrometer.

Fig 9



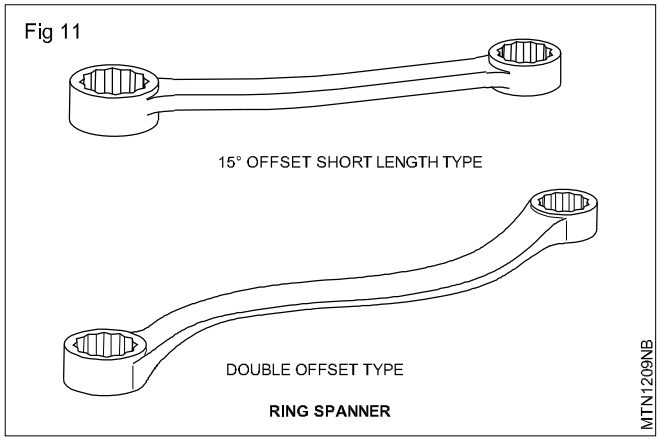
With socket spanners (Fig 10): Use the reversible ratchet handle for doing fast work, where turning space is restricted.

Fig 10



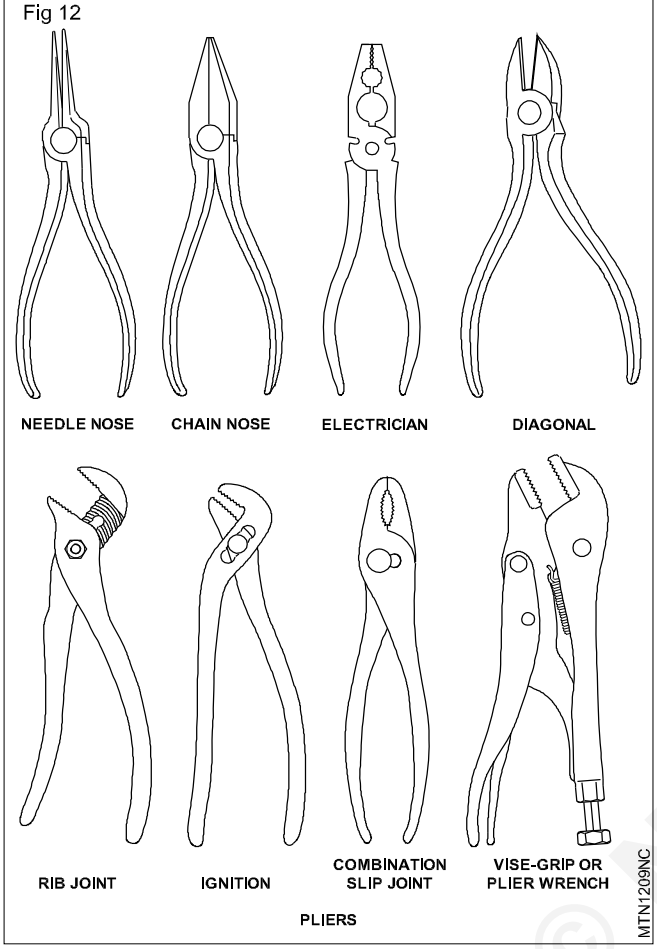
Ring or box spanner (Fig 11): For critical tightening and loosening of nuts. For multi contact on bolts and nuts.

Fig 11



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

Fig 12



Safety

1 Avoid cutting hardened objects.

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

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

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 fasteners 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

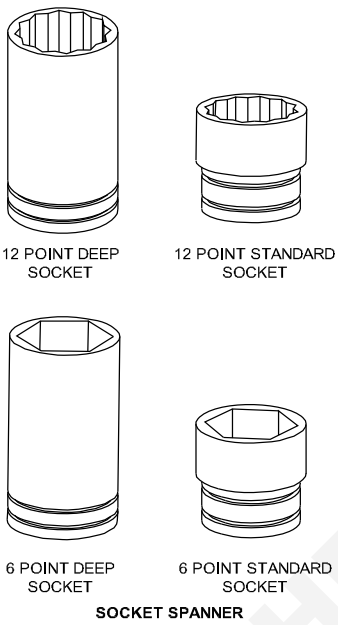


Fig 15

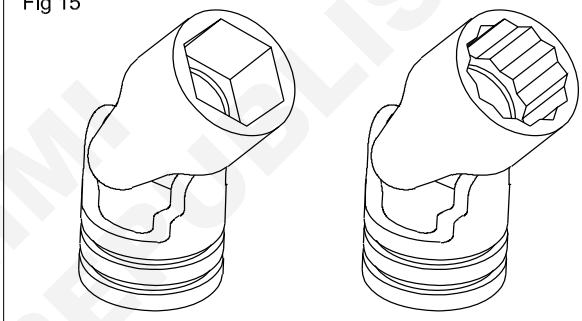


Fig 16

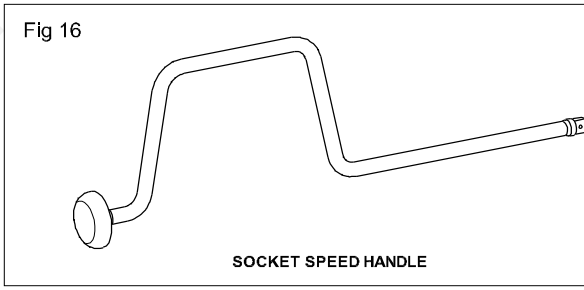
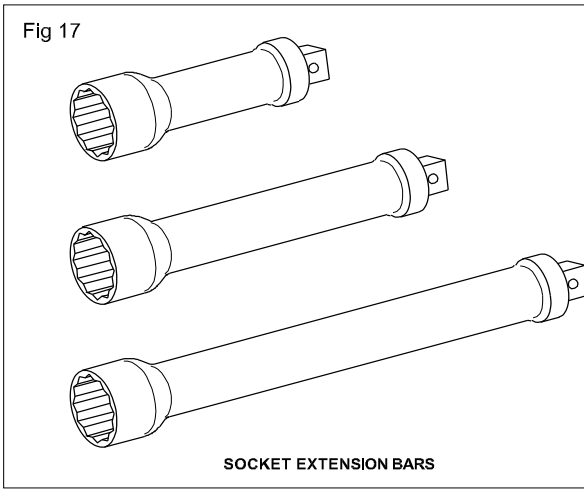


Fig 17



Pliers

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

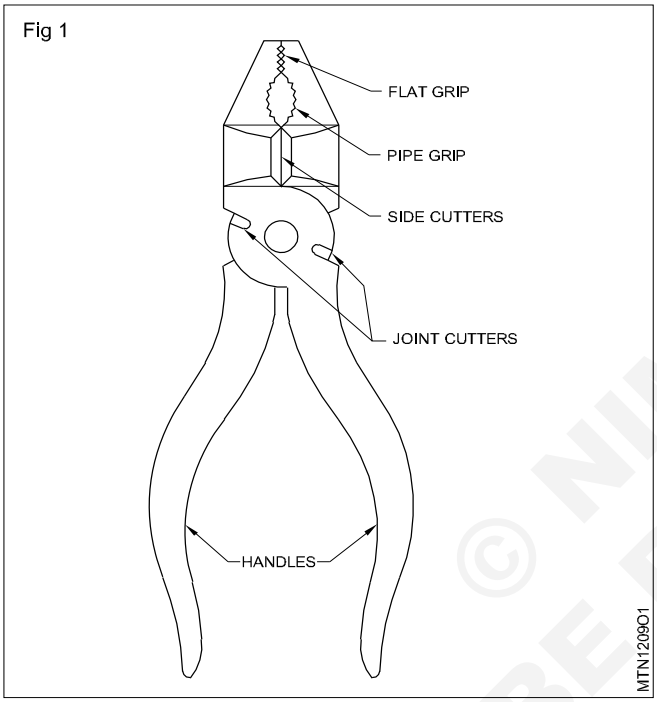
Features

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
- Joint cutters
- Handles

Fig 1

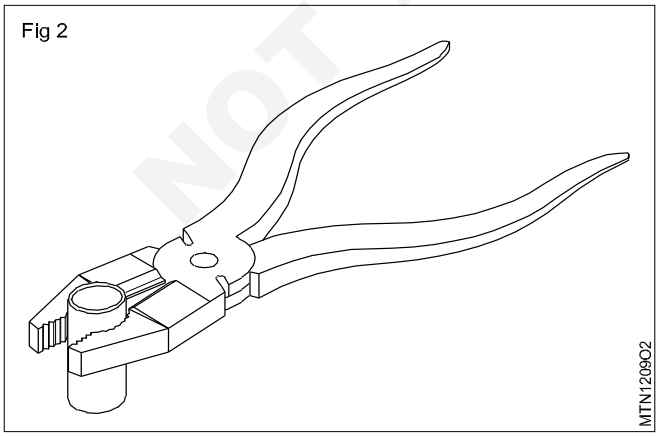


Features

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)

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

Fig 3

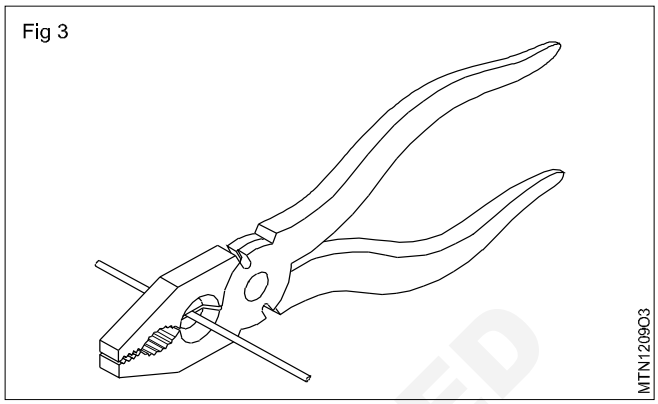
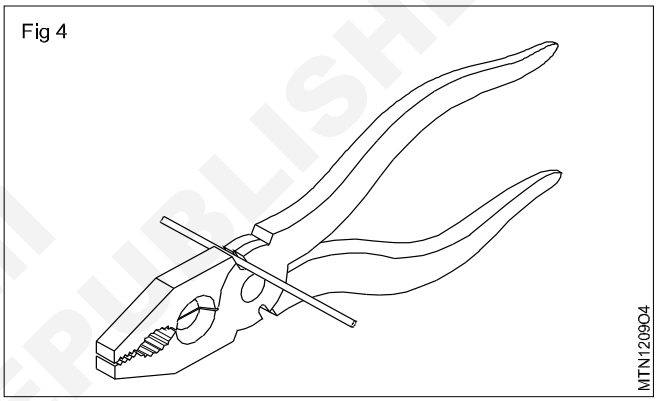


Fig 4



Handles are used for applying pressure by hand.

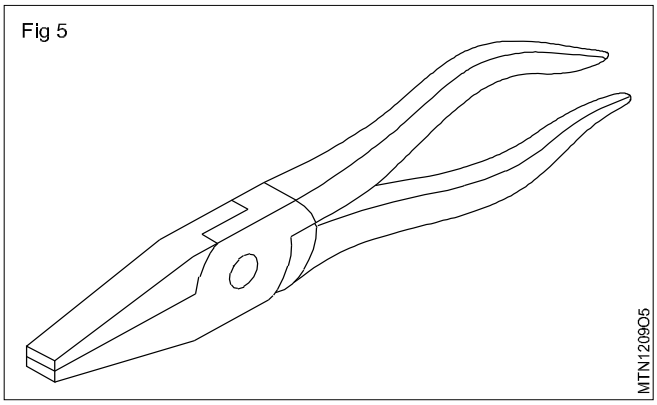
Pliers are available in sizes from 150 mm to 230 mm. (Size = Overall length)

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)

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 6

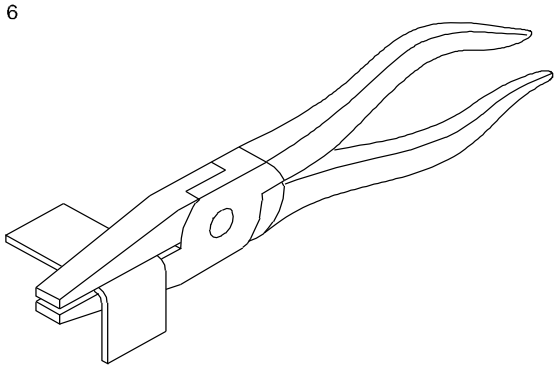


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Fig 7

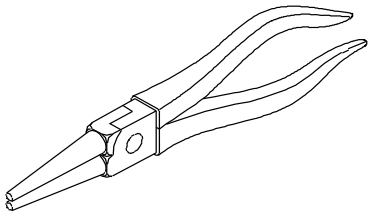

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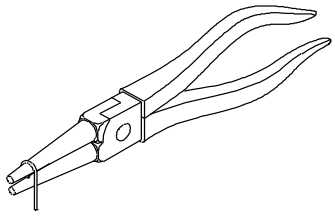
Fig 8



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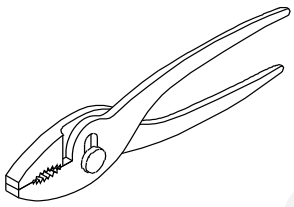
Slip-joint pliers: These pliers are available in various ranges of positions with different shapes of pivot pins so that they have various ranges of jaw opening. Mainly used for gripping. (Fig 9)

Fig 9



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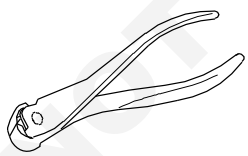
End cutting pliers: These pliers have the same uses as the side cutting pliers. (Fig 10)

Fig 10



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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)

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)

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

Fig 11

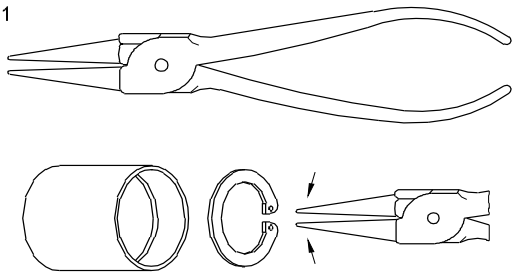

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Fig 12

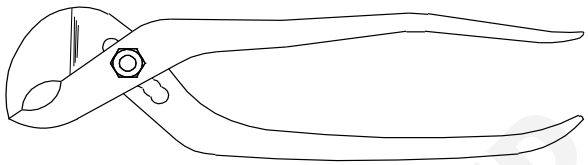

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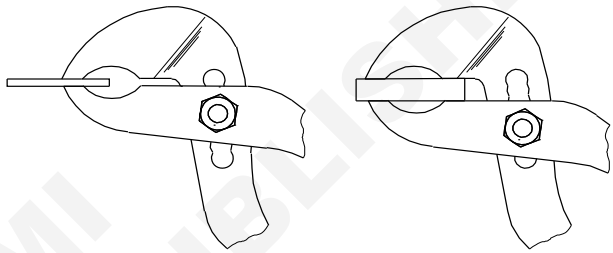
Fig 13



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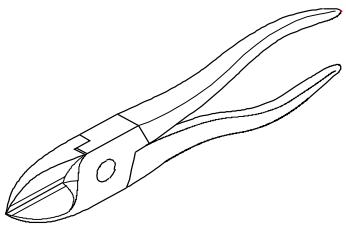
Side cutting pliers: It is made with jaws set at an angle. They are used for shearing off wires in confined spaces and cutting off wires close to the surface level. (Fig 14)

Fig 14



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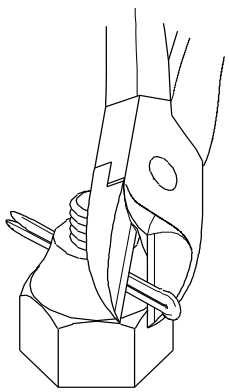
They are also used for spreading the cotter pin. (Fig 15)

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.

Fig 15



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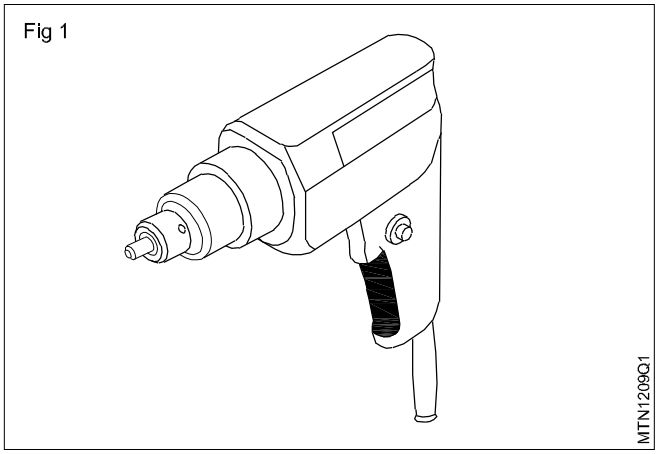
Air impact wrench, air ratchet

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.

Fig 1



MTN1209Q1

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.

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)

Air Ratchet (Fig 3)

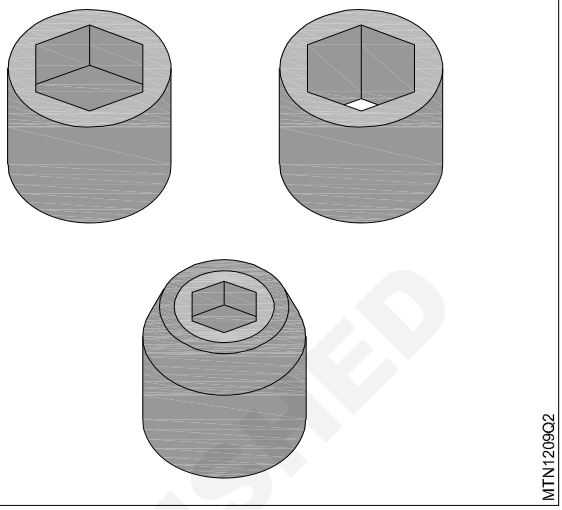
An Air Ratchet is a quite identical to General ratchet wrench.

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.

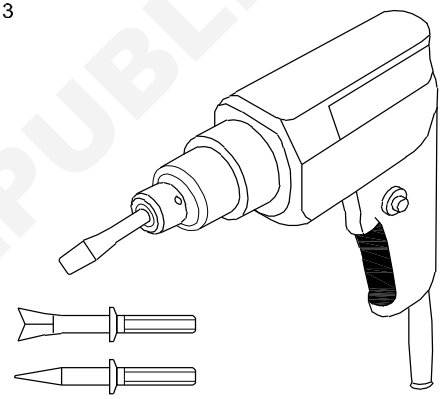
The direction of socket drive can be changed to clockwise (or) anti clockwise as per the user requirement.

Fig 2



MTN1209Q2

Fig 3



MTN1209Q3

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.

> **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.

Wrenches

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

Types of wrenches

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

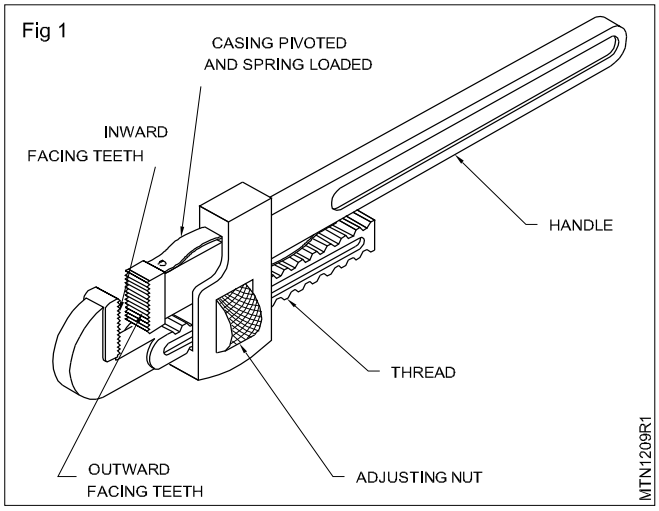
Stillson pipe wrenches (Fig 1 & 2): These are used for gripping and turning pipes of a wide range of diameters.

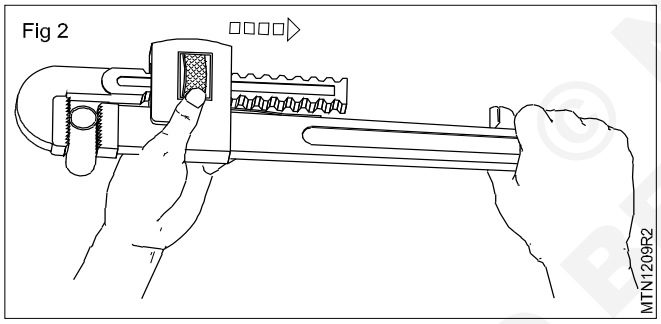
The parts and their names are shown in the figure.

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.





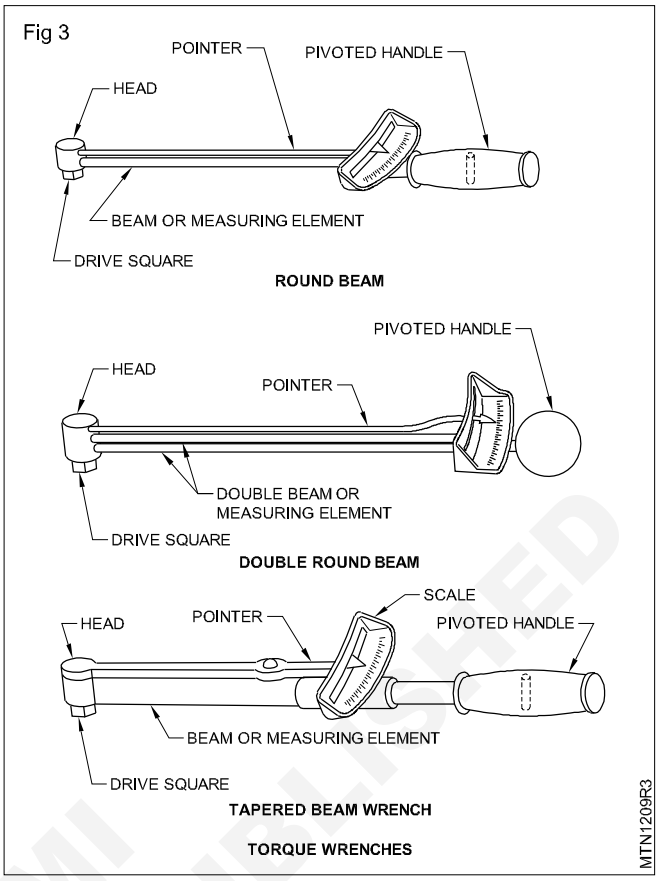
Torque wrench (Fig 3)

A torque wrench is necessary to tighten bolts, nuts etc. To the exact torque as specified by the manufacturers. Excessive tightening may lead to breakage of the fast tener/parts and loose tightening will lead to leakage/ breakage during operation. Torque wrenches are available in special shapes and sizes. Selecting the torque wrench of the appropriate size and range is very important. Torque wrenches are available in pound feed (lb-ft), pound inch (lb-in), kilogram metre (Kg-m) kilogram - centimetre (Kg-cm) and Newton metre (N-m). Newton metre is the preferred metric unit, although others are still used by the manufactures.

To convert pound feet to kilogram-metres by 0.138 and to convert to Newton-metres multiply the pound feed by 1.35.

Dial type

It has a scale and the torque can be read directly.



Brake over (Micrometer)

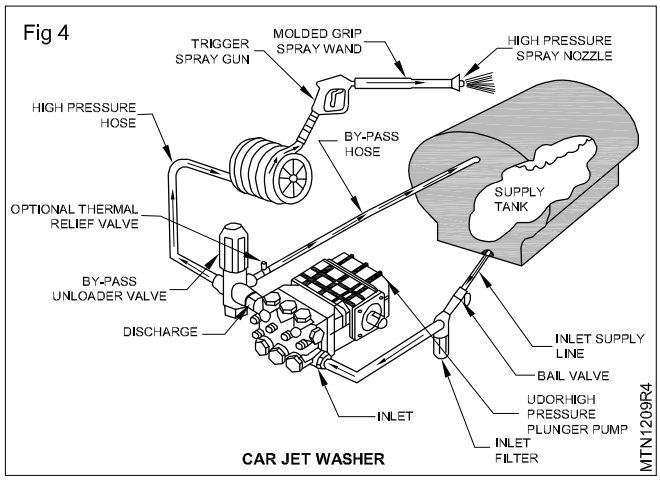
It contains a micrometer scale (1) on the handle and a ratchet head (2). In this the torque can be set on the micrometer scale (Ref.job sequence). (Both pound-feet and metric scales are marked on the graduated barrel). The wrench makes a metallic 'click' that is heard and felt on the handle when fasteners are tightened at the correct.

Torsion bar torque wrench

Its gauge is a simple pointer (3) that moves across a graduated scale (4) which shows the amount of torque being applied.

Digital read out torque wrenches are also available.

Car jet washer (Fig 4)



- Car jet washer is used to clean the interior and exterior of motor vehicle different type of car washer are available in the market
- It is also used for pressure wash the auto mobile employments in workshop
- Car jet washer is used for cleaning the dirty floor and wall of floor mates
- It is also used is ear service station for commercial purpose.

Flaring, flare fittings and testing the joints

Objectives: At the end of this lesson you shall be able to
- **illustrate the necessity of flaring**
- **list the types and applications of flare fittings**
- **pressures the joint system and test for leaks.**

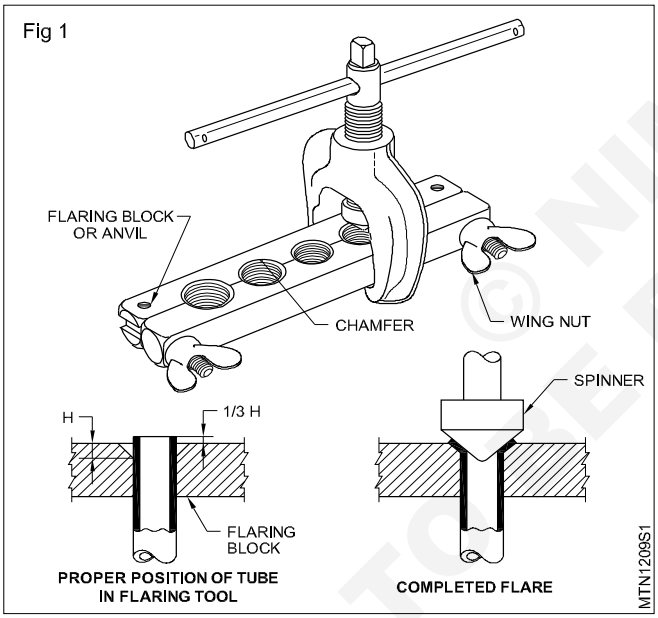
Flaring necessity: When connecting tubing to fittings, it is common practice to flare the end of the tube and to use fittings designed to grip the flare for a vapour tight seal. Special tools are used for making flares.

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)

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.

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.

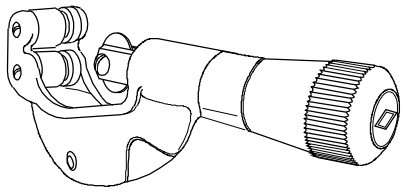
Leak can be detected with the use of soap solution. There are also other methods for leak detection.

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

A pipe cutter is more convenient and better than a saw when cutting pipes and metal tubing. (Fig 2)

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 right through.

Fig 2



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 based on the power utilized 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

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

Hydraulic pullers are designed to help you extend bearing life in your applications through proper installation, 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. cylinder, 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 marine engine liner from the cylinder block during engine Reconditioning Work.

Mechanical Puller Operation (Fig 1)

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) (Fig 2)

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

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 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 2A)

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 2B)

6 Turn the T-handle counter-clockwise to remove the puller from the component. (Fig 2C)

Fig 1

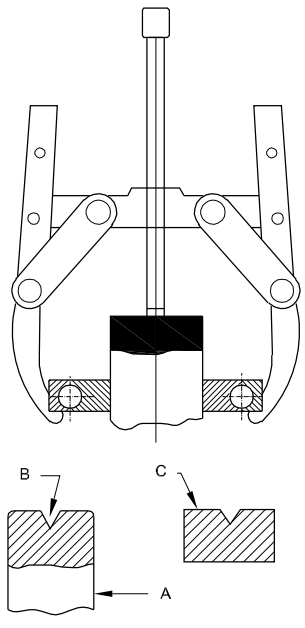
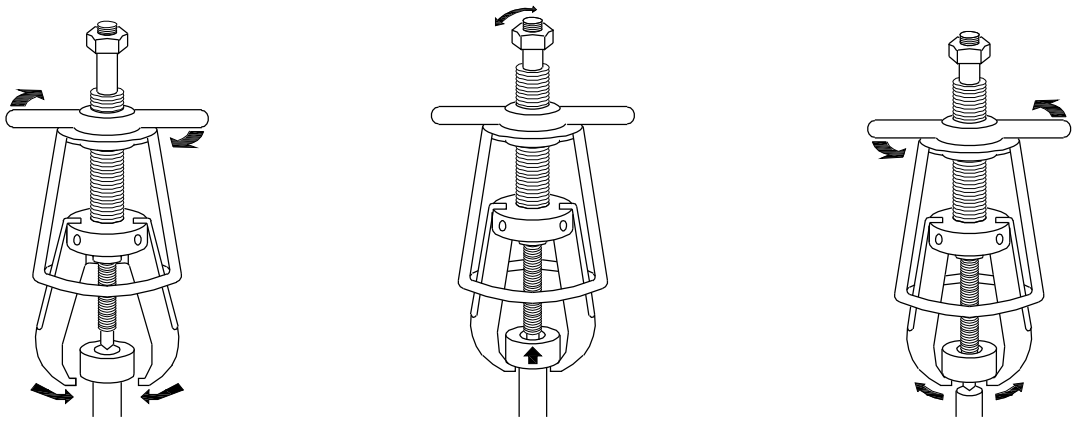


Fig 2



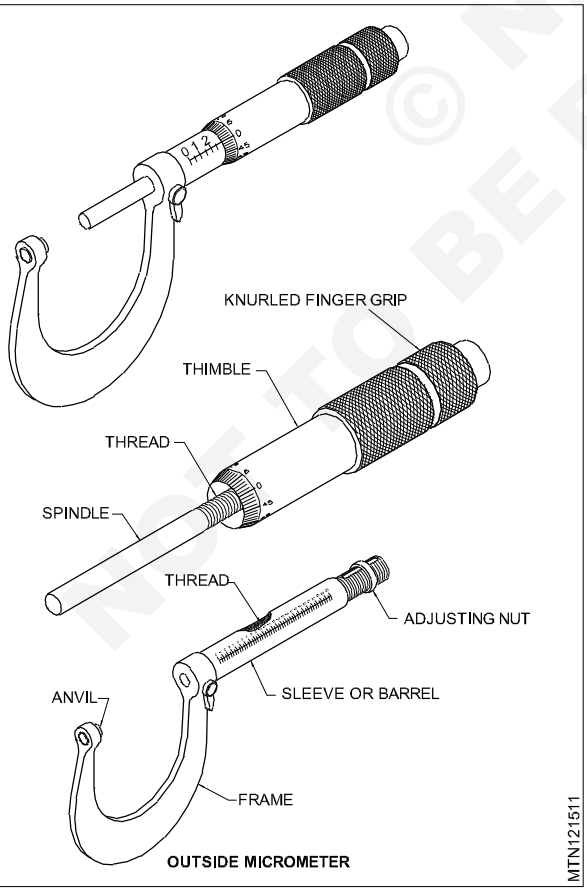
Outside micrometer

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

- **name the main 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.**

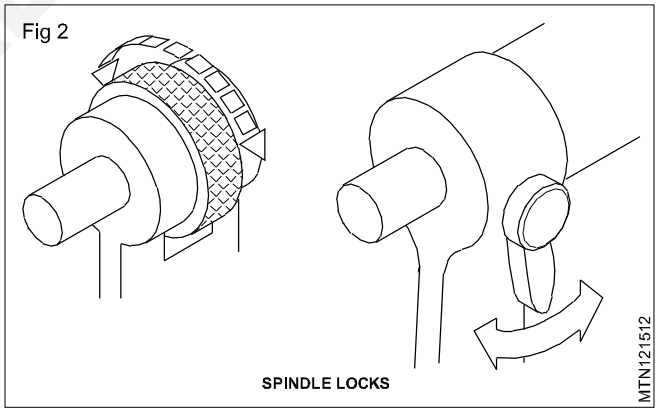
The purpose of a metric micrometer is to read an accuracy of 0.01 mm of an object. It is available in various sizes. However, the measuring range is limited to the length of the threaded spindle. (Fig 1)

Fig 1



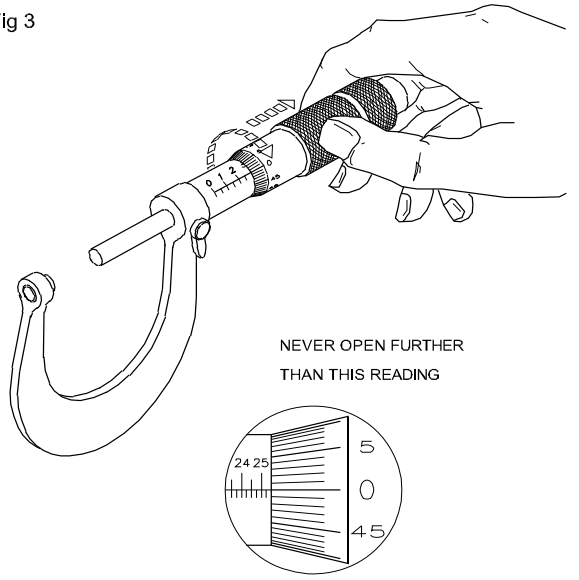
The main parts of a micrometer are the frame, anvil, spindle and the thread, sleeve or barrel and the thimble, there is a knurled collar or small lever on the frame to lock the spindle in the barrel. (Fig 2) In addition to this, a ratchet stop is provided to the spindle in order to prevent a possible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

Fig 2



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 anvil 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.

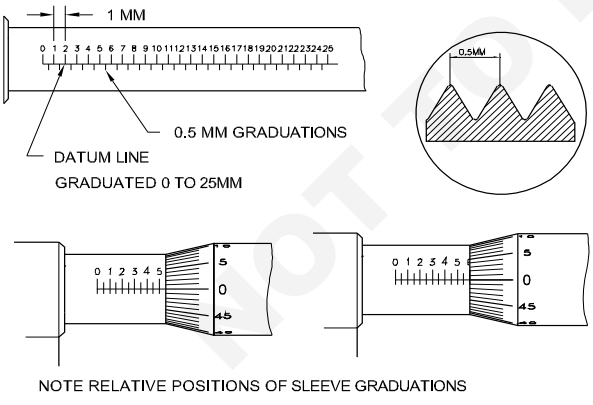
When the face of the anvil and the face of the spindle are in contact, the “O” graduations of the index line and “O” graduation of the thimble coincide with each other.

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

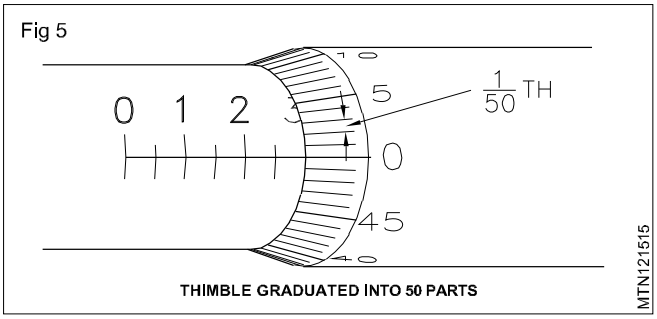
The main scale is graduated in ½mm. Every 5thmm is shown with the reading. The pitch of the screw thread is accurately maintained to ½mm (Fig 4).

Fig 4



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)

Fig 5



Determining the reading of a metric micrometer

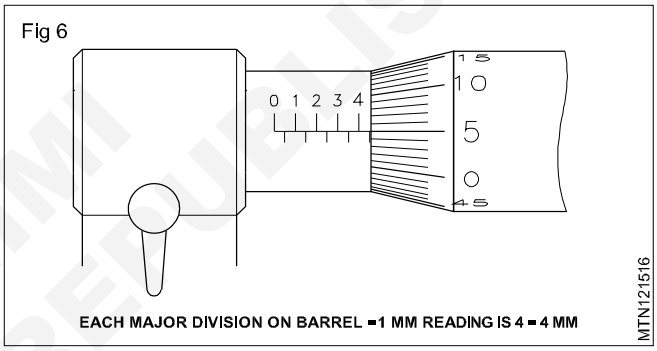
Before using the micrometer for measurement, it is necessary to ascertain that there is no error in the micrometer.

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

Fig 6

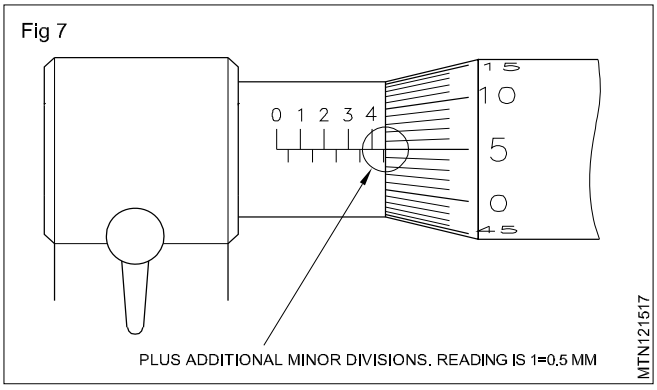


Add to this any half millimeters that are completely visible from the bevel edge of the thimble.

The figure reads ½ = 0.5 mm (Fig 7)

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

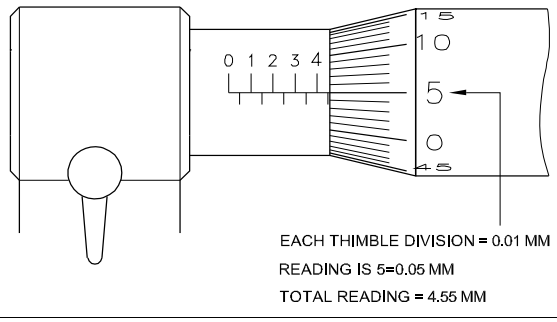
b 0.50 mm

c 0.05 mm

Total reading 4.55 mm

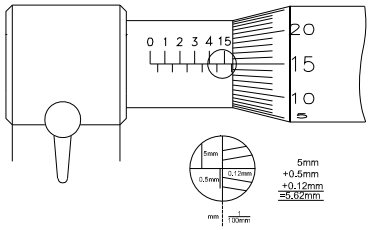
A 0-25 mm capacity outside micrometer can read a A 0-25 mm capacity outside micrometer can read a maximum

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

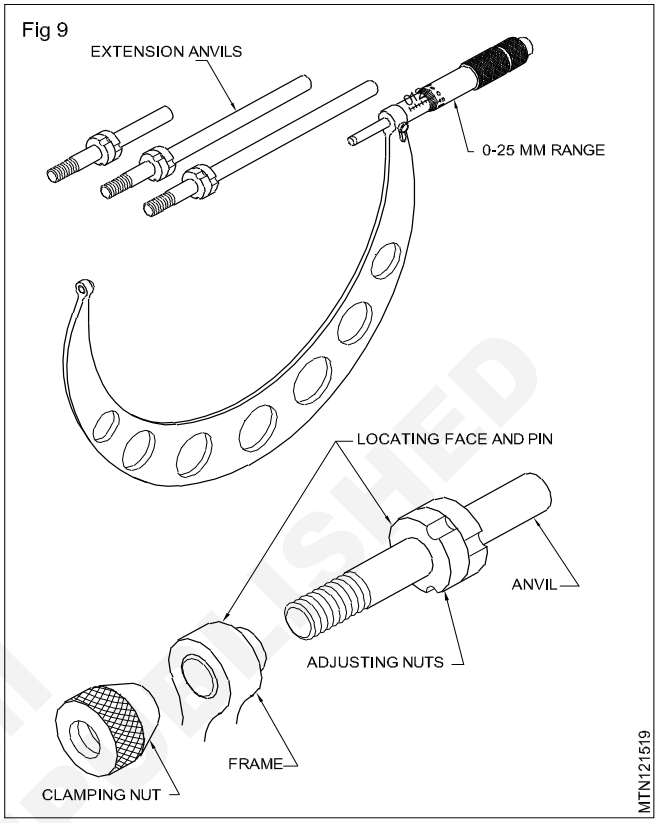


Outside micrometers have limited reading capacity as they are dependent upon the length of the spindle which itself is limited and fixed.

A 0-25mm capacity outside micrometer can read a maximum dimension of 25mm. 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.

Large micrometers (Fig 9)

Fig 9



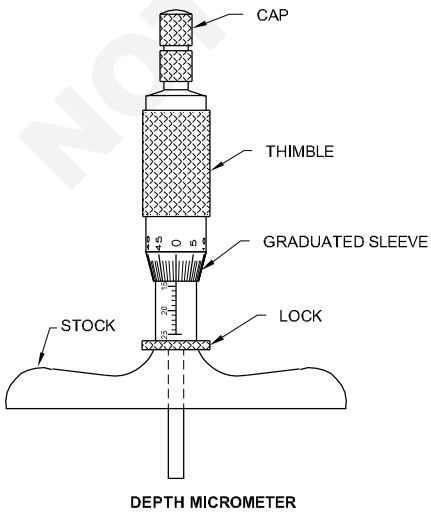
Depth micrometer

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.

Fig 1



DEPTH MICROMETER

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.

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)

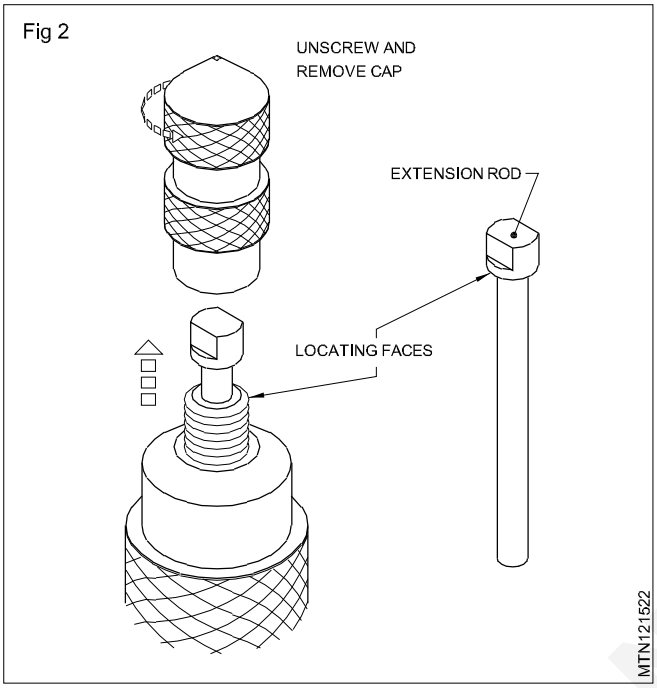
The measuring faces of the stock and the rods are hardened, tempered and ground. The measuring face of the stock is machined perfectly flat.

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 25mm. This is divided into 25 equal parts graduated. Each 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 0.5mm. (Fig 2)

Fig 2



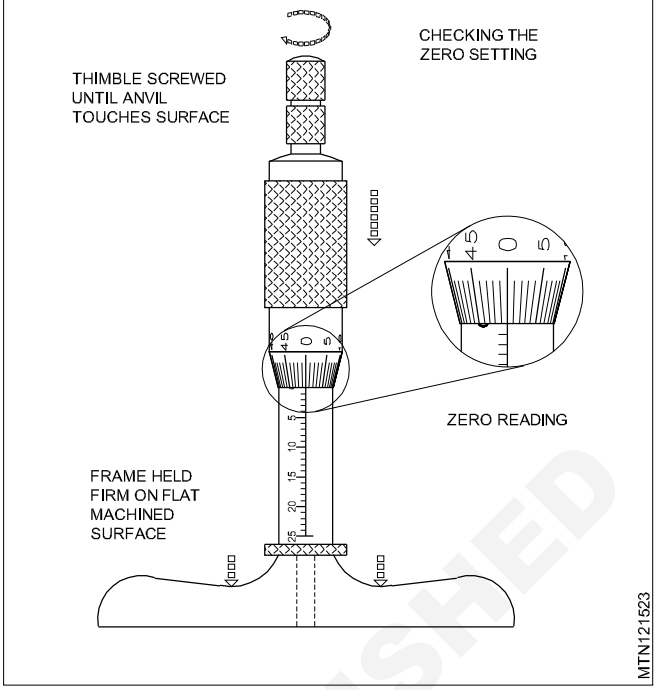
The graduations numbered are in the reverse direction to that marked on an outside micrometer.

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 3)

Fig 3



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.

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.

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.

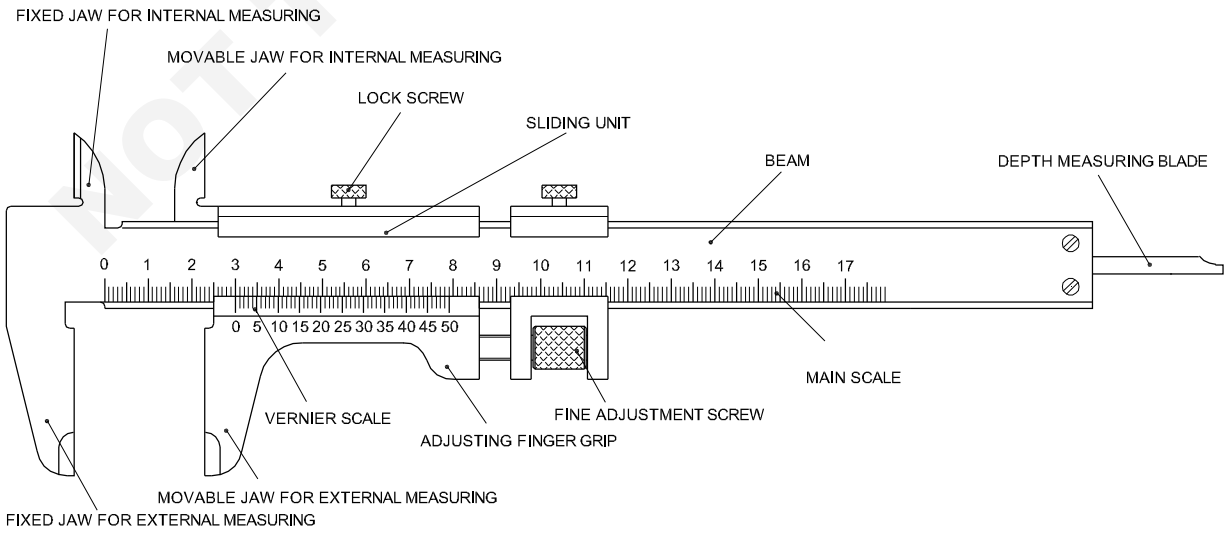
Cannot be used to measure components having deviations less than +/-0.02 mm.

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.

Fig 1

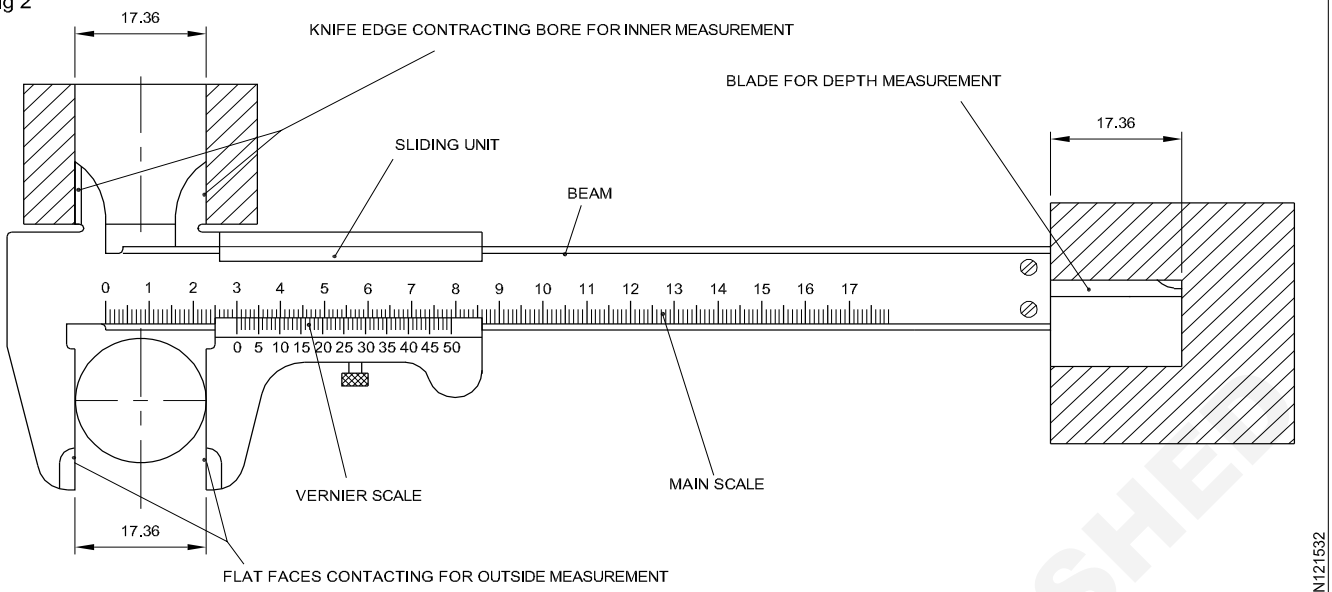


Note which of the vernier scale division coincides with any one line on the main scale.

Multiply this number with the least count.

Add the multiplied value to the main scale reading.

Fig 2



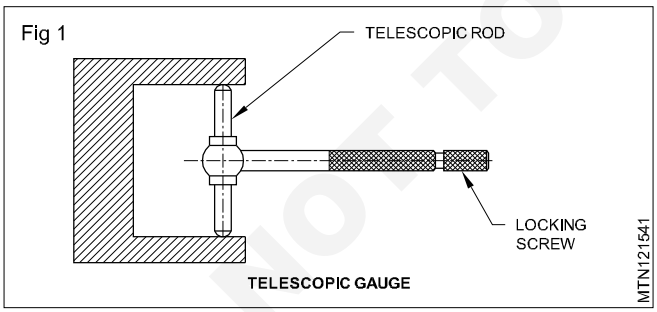
Telescopic gauge

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

- **name the parts of telescopic gauge**
- **measuring technique how to telescopic 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.

Fig 1



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.

Dial bore gauge

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

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

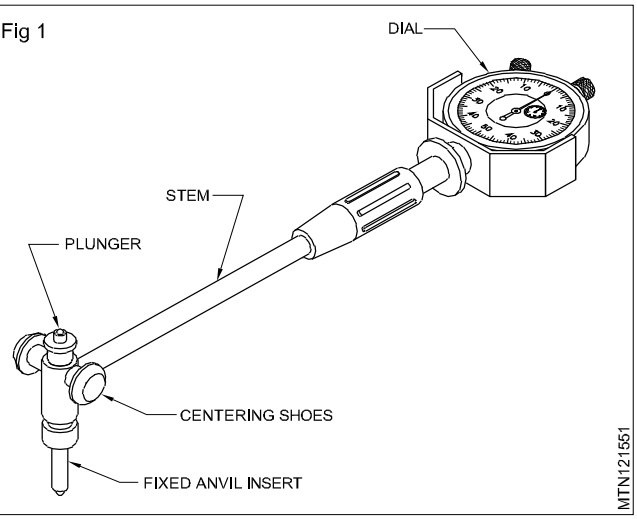
This is a precision measuring instrument used for measuring the internal dimensions. The dial bore gauge is normally available as a two-point, self-cantering type.

Dial bore gauge (Fig 1)

Stem: This holds all the components together and

contains the mechanism for transmitting the plunger motion to the dial.

Fig 1

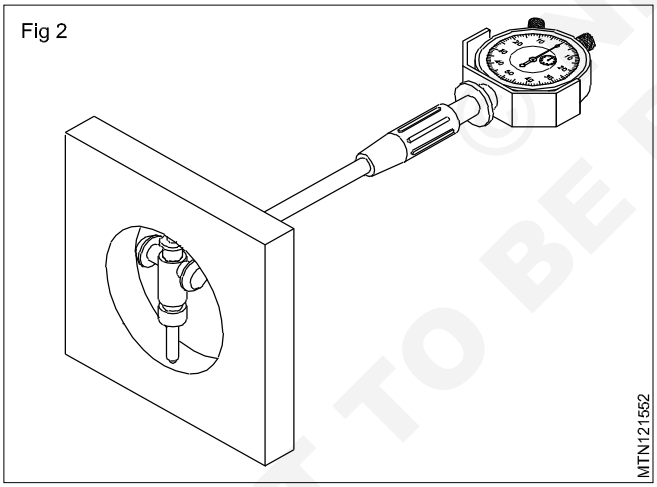


Fixed anvil/inserts: These anvils are interchangeable. The selection of the anvil is made depending on the diameter of the bore to be measured. For certain types of bore dial gauges, extension rings/washers are provided for extending the range of measurement.

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).

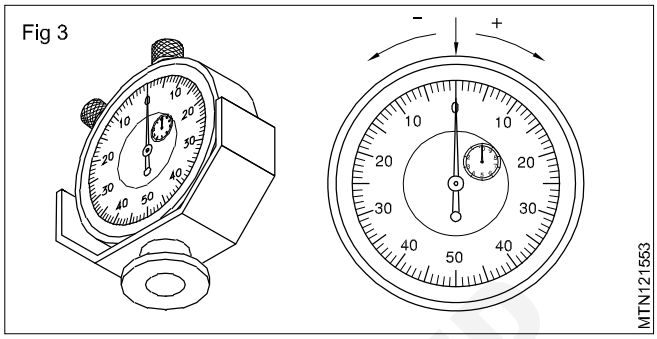
Fig 2



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.

Fig 3

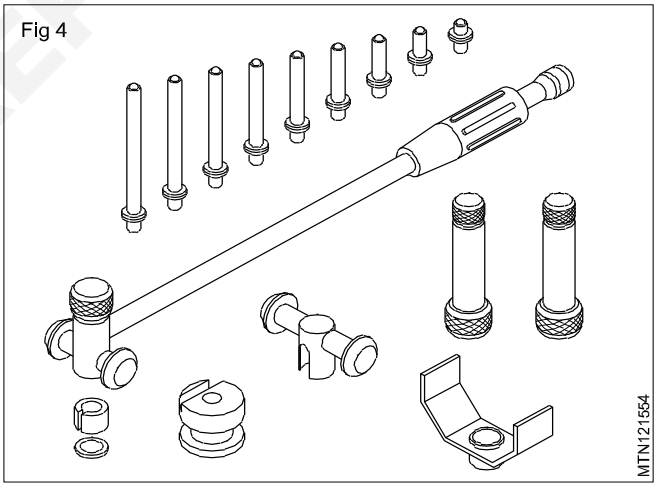


Bore dial gauges are available in various sizes with different measuring ranges. These are interchangeable measuring rods (external rods or combination washers) for measuring different sizes. (Fig 4)

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.

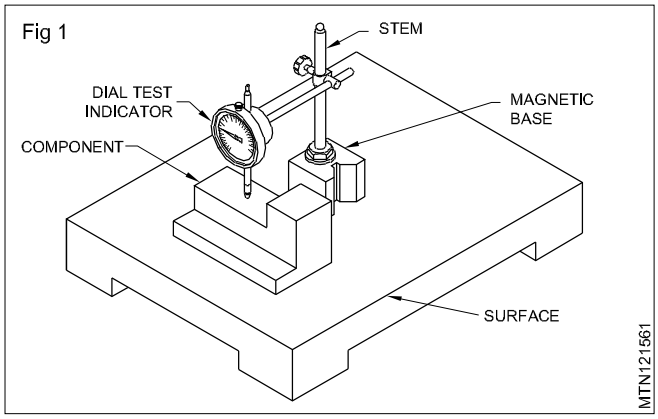
Fig 4



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.**

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)



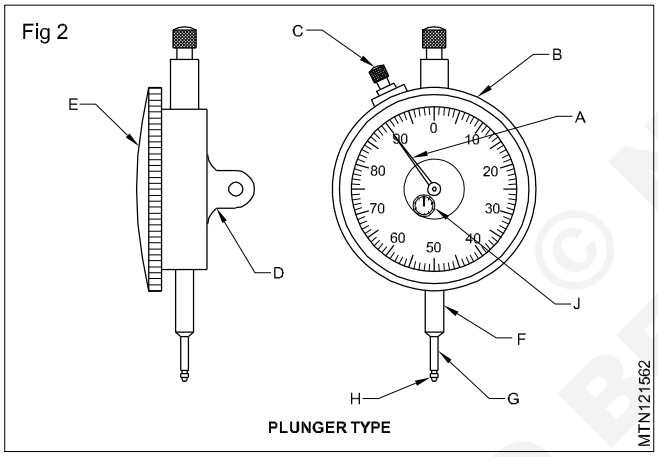
Principle of working: The magnification of the small movement of the plunger or stylus is converted into a rotary motion of the pointer on a circular scale.

Types: Two types of dial test indicators are in use. They are the

1 Plunger type (Fig 2)

2 Lever type (Fig 3)

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)

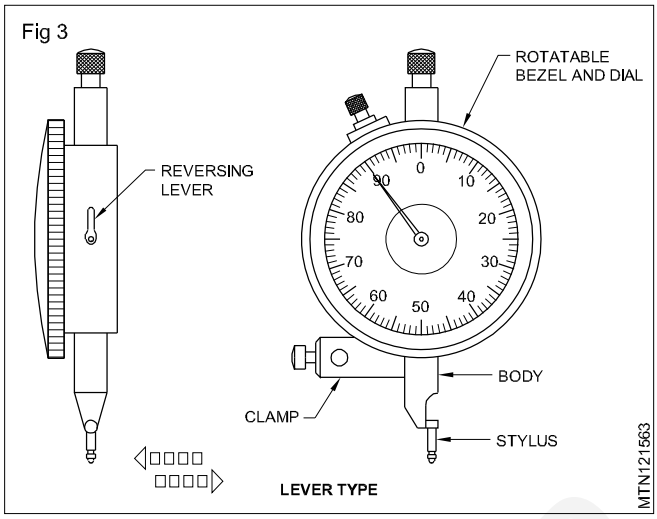
Plunger (G)

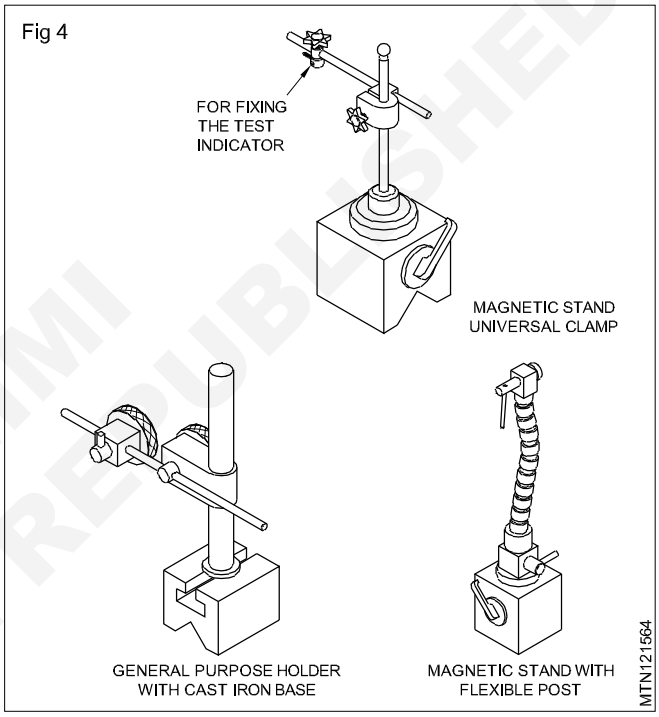
Anvil (H)

Revolution counter (J)

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

The lever type dial test indicator (Fig 3 to 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.





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.

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.

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

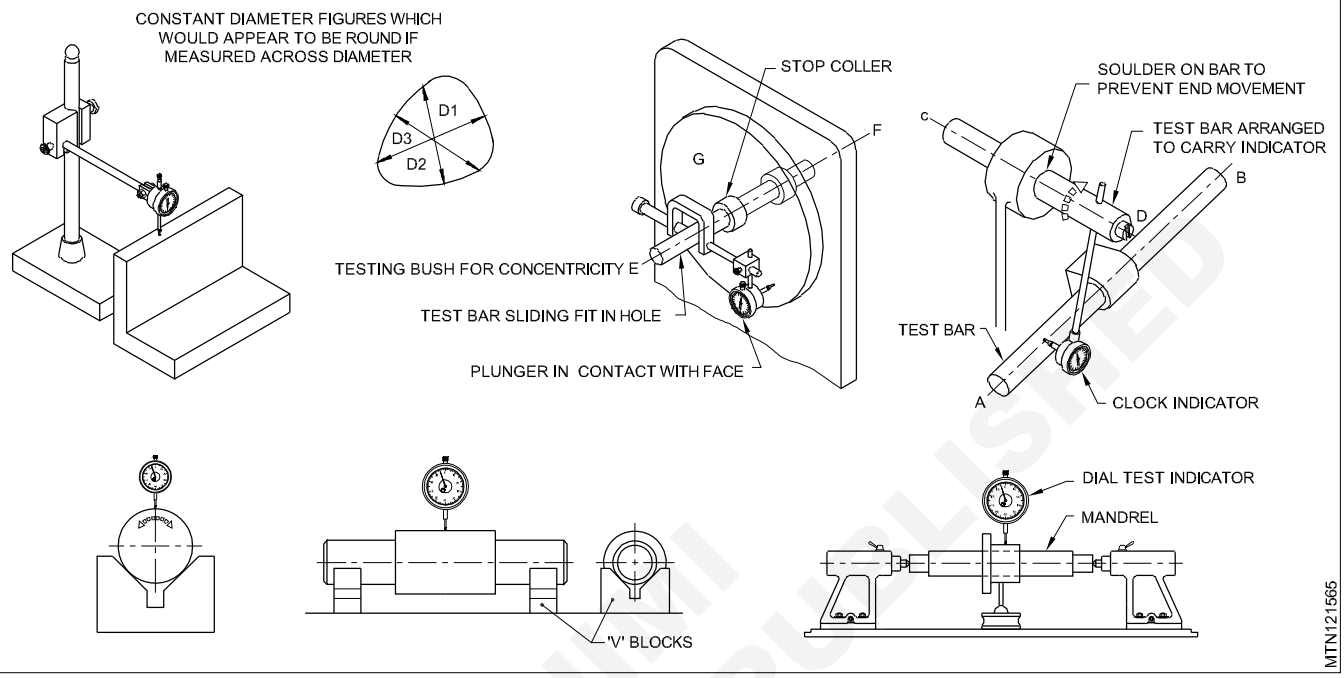
- To compare the dimensions of workpiece against a known standard, eg. Slip gauges.
- To check plane surfaces for parallelism and flatness.

- To check straightness of shafts and bars.
- To check concentricity of holes and shafts.

Indicator stands (Fig 4 & 5): 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 5



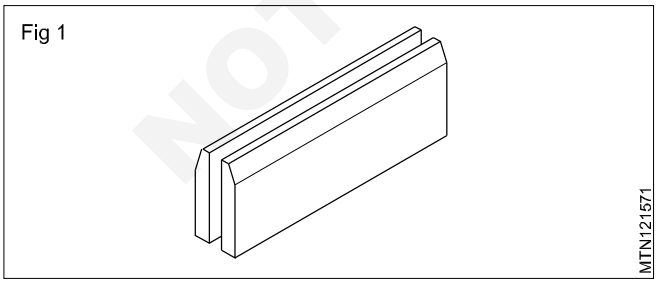
Straight edges

Objectives: At the end of this lesson you shall be able to
- **name the different types of straight edge**
- **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



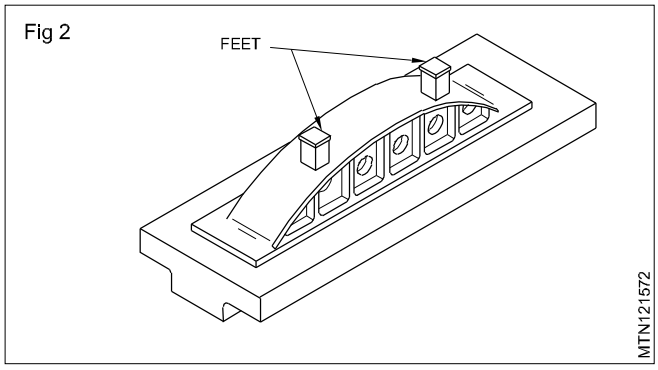
Cast iron straight edges (Fig 2): These are made from close- grained, grey, cast iron and can be considered as narrow surface plates. They are available up to 3 meters length and are used for testing machine tool sideways, cast iron straight edges have ribs, and bow-shaped tops to prevent distortion.

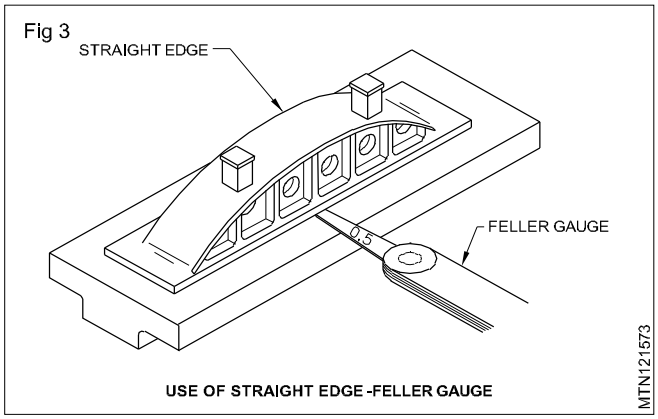
These straight edges are-shaped tops to prevent distortion. These straight edges are provided with feet to prevent distortion under their own weight.

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 2





USE OF STRAIGHT EDGE -FELLER GAUGE

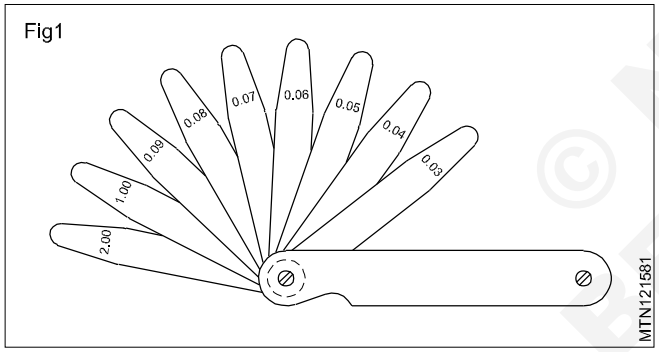
Feeler gauge and uses

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 feeler gauges**
- **state the method of setting a feeler gauge**
- **state the different uses of feeler gauges.**

Features

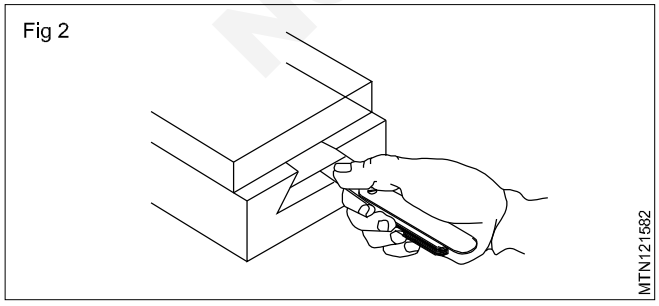
A feeler gauge consists of a number of hardened and tempered steel blades of various thicknesses mounted in a steel case.

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. (Fig 2)



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 to 1mm in steps of 0.01mm.) The length of blade is usually 100mm.

Example

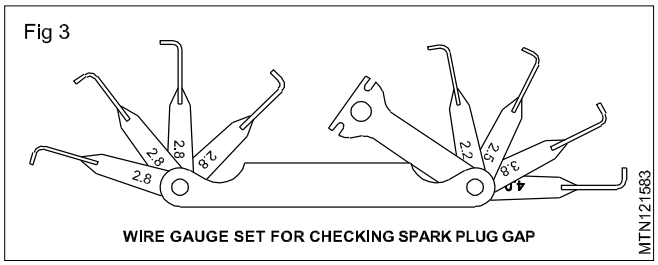
Set No.4 of Indian standard consists of 13 blades of different thicknesses.

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 of feeler gauge: 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)
- to check and measure the bearing clearance, and for many other purposes where a specified clearance must be maintained.

Wire gauge (Fig 3): The plug wire gauge is a thickness gauges using wires of varying diameter instead of thin flat strips of steel. It is used for checking spark plug gap.



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.

Screw pitch gauge

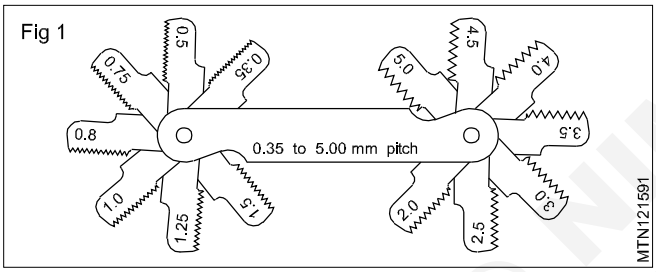
Objectives: At the end of the lesson you shall be able to
- **state the purpose of a screw pitch gauge**
- **state the features of a screw pitch gauge.**
- **state the importance of straight edge**
- **state the sizes of uses of feeler gauge.**

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.

Fig 1



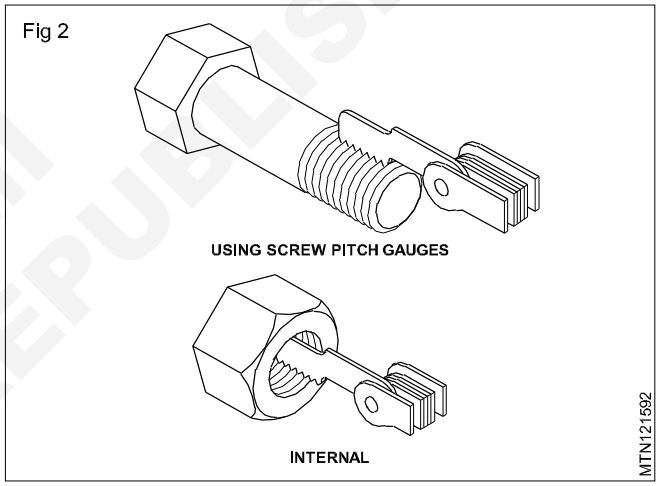
Some screw pitch gauge sets will have blades provided for checking British Standards threats (BSW, BSF etc.) at one end and the Metric Standard at the other end.

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.

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

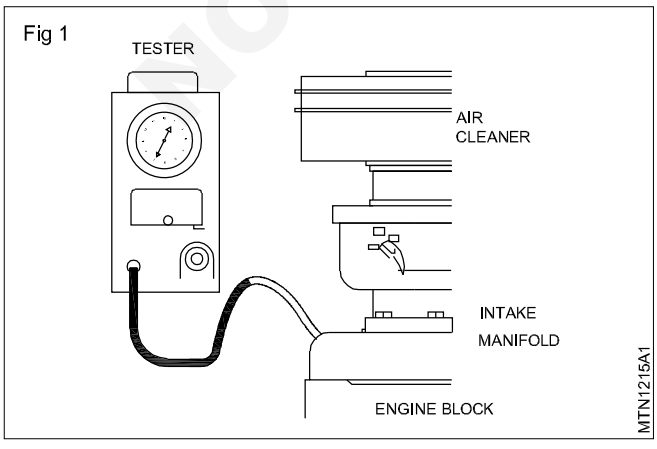


Vacuum gauge

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.

Fig 1



It is used to detect vacuum leaks at idle speed, sticking valves, worn rings, clogged exhaust, incorrect timing and positive crank case ventilation (PCV)

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 (Figs 1&2)

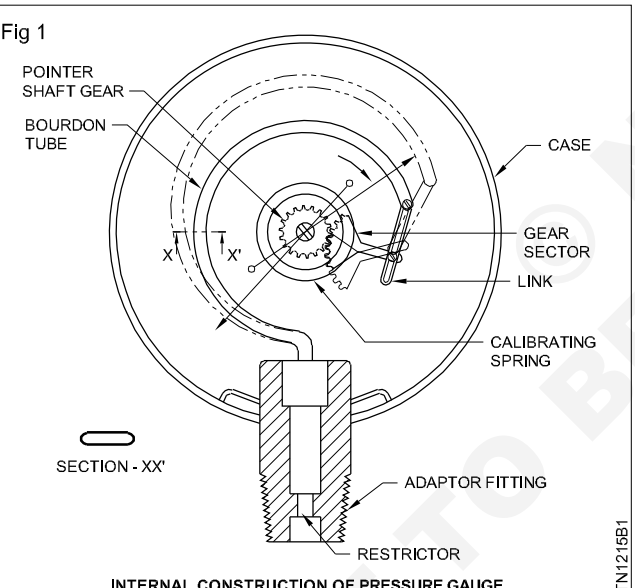
It is used to check the pressure of tyre unit. Bourdon tube pressure gauges made by stainless steel. A Pressure rise in bourdon tube makes it tend to straighten. This movement will pull on the link which will turn the gear sector counter clockwise. The pointer shaft with then turn clockwise to move needle on a graduated scale to indicate pressure.

Special features

- Excellent load-cycle stability and shock resistance.
- All stainless steel construction
- Positive pressure ranges 0-200 P.S.I (Fig 2)

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.

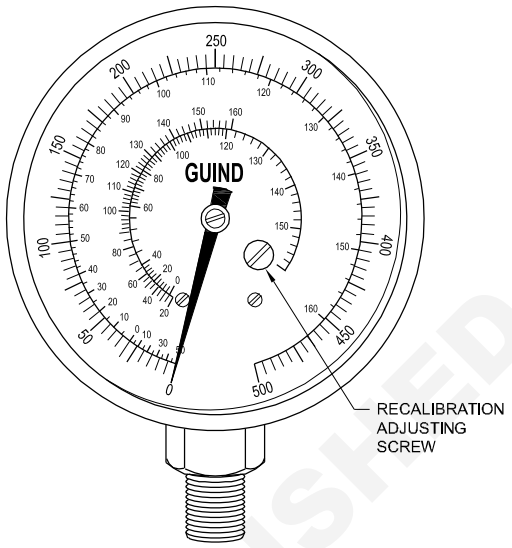
Fig 1



INTERNAL CONSTRUCTION OF PRESSURE GAUGE

MTN1215B1

Fig 2

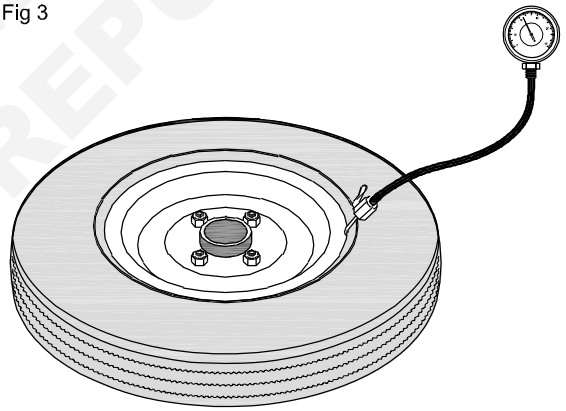


PRESSURE GAUGE

MTN1215B2

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



MTN1215B3

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)

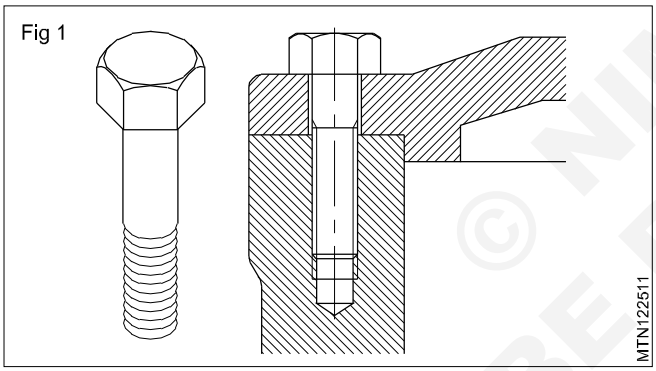
Types of machine screws (Heavy duty)

- 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)

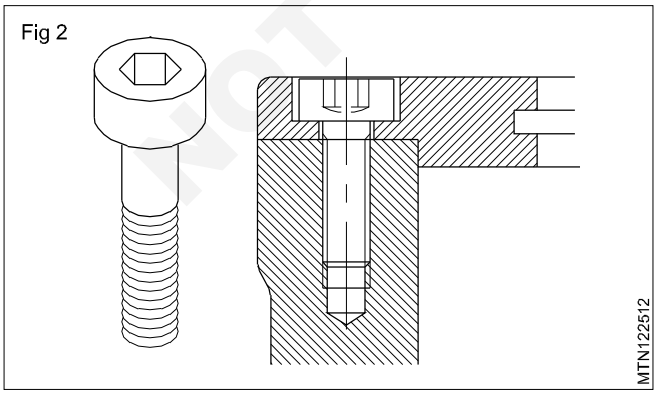
Fig 1



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.

Fig 2



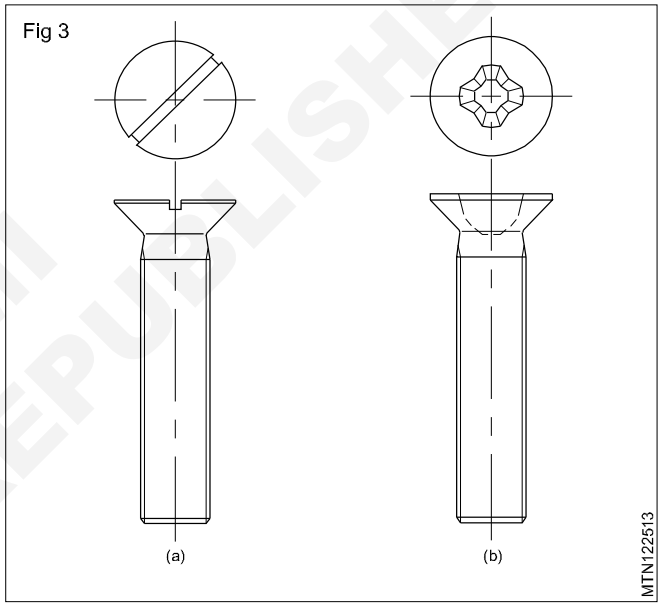
Hexagon head screws and hexagon socket head screws are made of steel. Hexagon head screws used in electrical work are made of brass.

Countersink head screws

There are four types of countersink head screws in common use. They are:

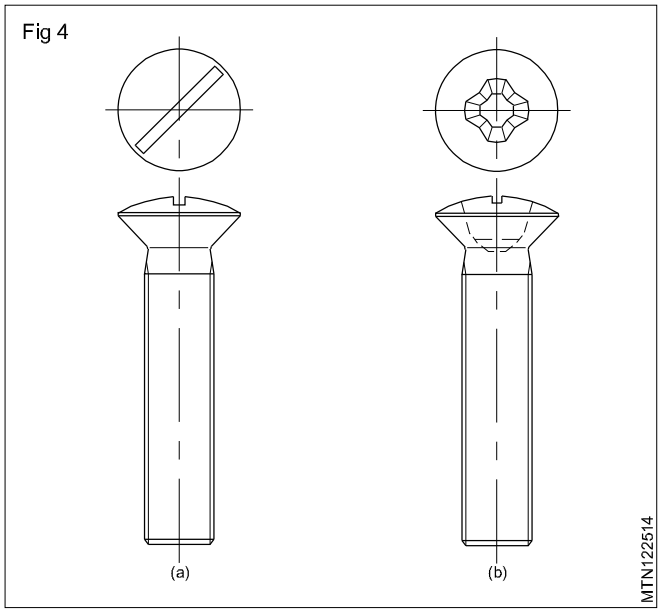
- slotted countersink head screws (Fig 3)
- cross-recessed countersink head screws (Fig 3)

Fig 3



- slotted raised countersink head screws (Fig 4)
- cross recessed, raised countersink head screws. (Fig 4)

Fig 4

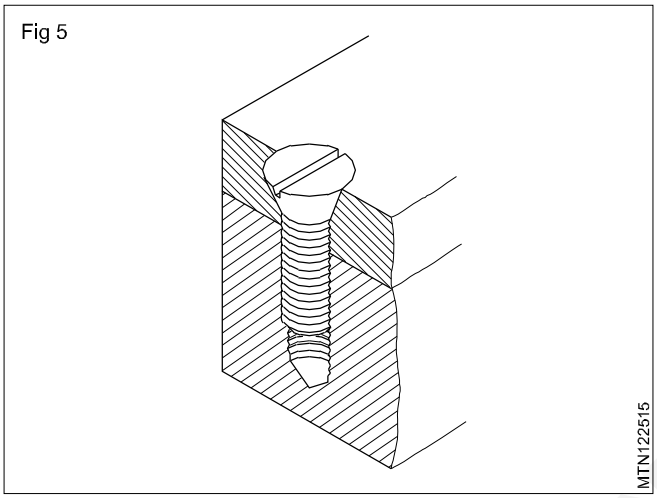


Countersink screws are capable of aligning the matching component correctly with the threaded hole. (Fig 5)

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.

- 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.

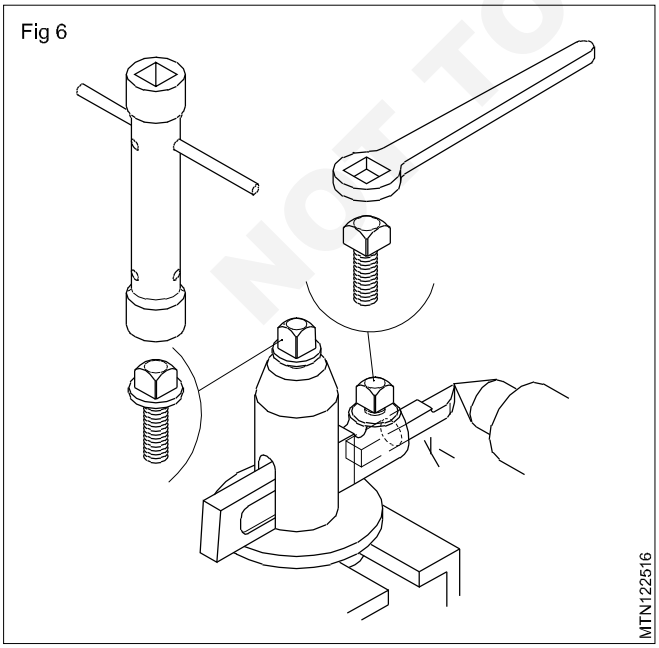
Fig 5



Square head screws (Fig 6)

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 6) 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.

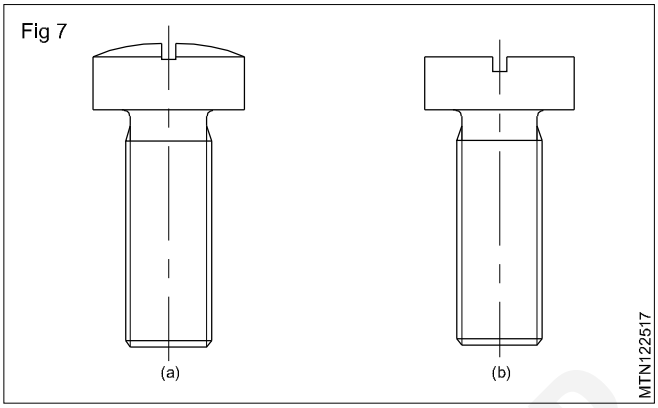
Fig 6



Other types of machine screws used in light assembly work are:

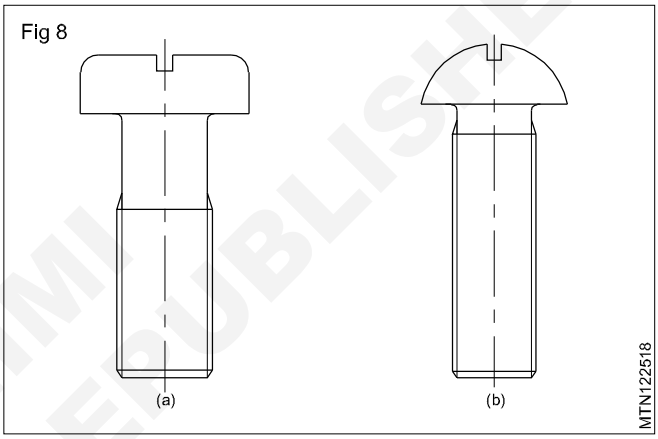
Pan head (Fig 7) ; Cheese head (Fig 7)

Fig 7



Raised cheese head (Fig 8) ; Round head (Fig 8)

Fig 8



These screws are also available with slotted head or as cross-recessed.

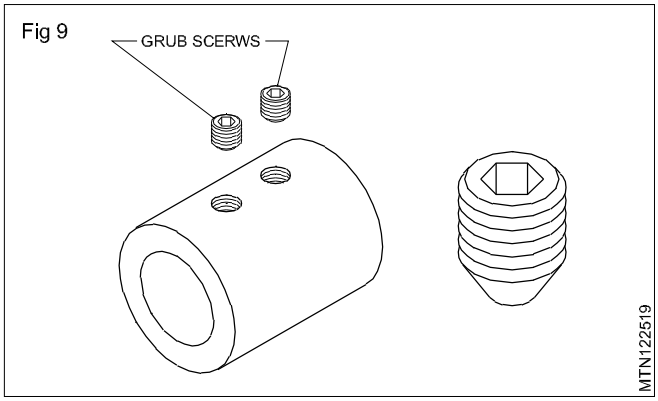
The screws used for light duty are normally available up to 10mm thread diameter.

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

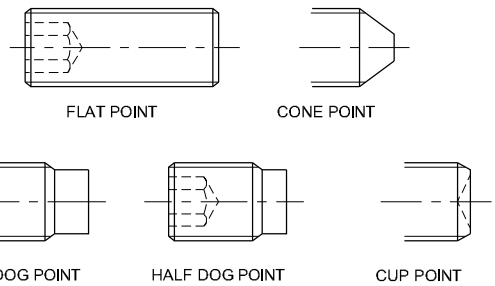
Hexagonal socket set screws (Fig 9)

Fig 9



These are headless socket screws available with different points for various functional requirements. (Fig 10)

Fig 10



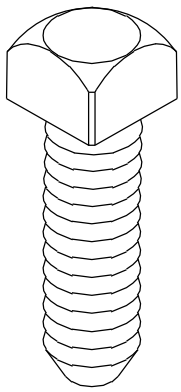
These points either allow to bite into the metal or tighten without damage to the work-surface. They are used to fasten pulleys, collars etc. to the shafts. They are used for higher strength applications where space is limited.

Square set screws (Fig 11)

These set screws have similar applications as hexagon socket set screws but have square heads projecting above the work-surface.

These are useful when the assembly needs frequent disassembly and setting.

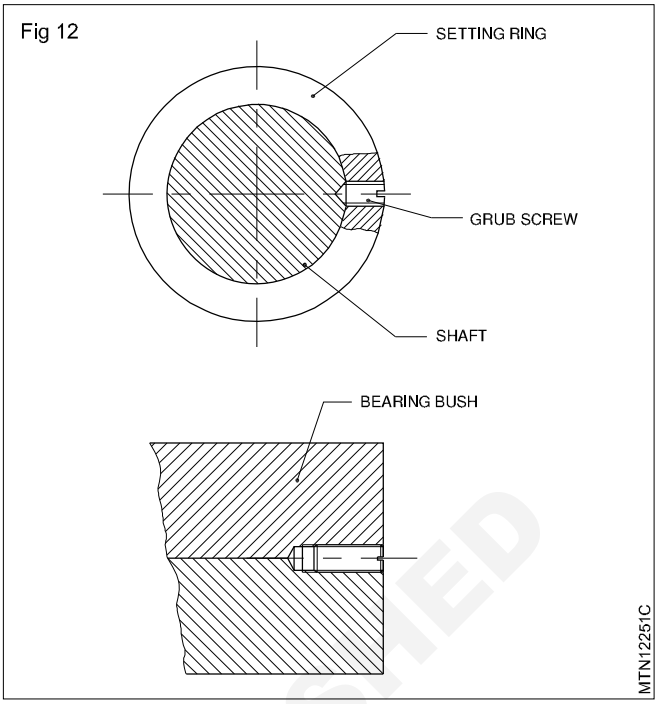
Fig 11



Grub screws

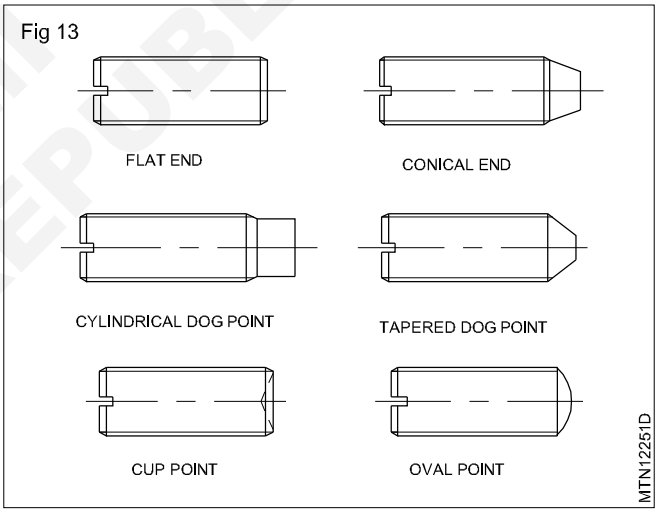
Grubs have similar application as hexagon socket set screws but are used for light holding. (Fig 12)

Fig 12



Grub screws are also available with different types of points (Fig 13)

Fig 13



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)

Type-C Slotted thumb screw partially threaded (Fig 3)

Type-D Slotted thumb screw fully threaded (Fig 4)

Type-E Flat thumb screws (Fig 5)

Fig 1

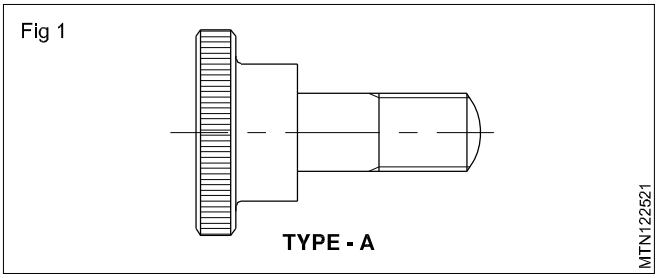
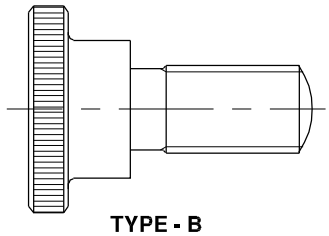


Fig 2



TYPE - B

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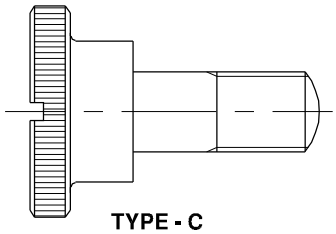
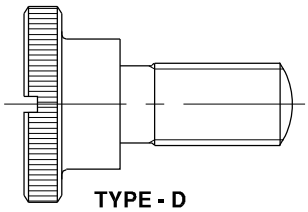
Fig 3



TYPE - C

MTN122523

Fig 4

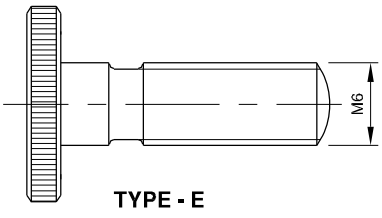


TYPE - D

MTN122524

The type of thumb screw selected depends on the actual requirement in the assembly.

Fig 5



TYPE - E

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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.

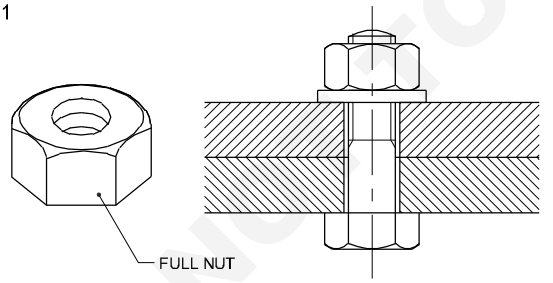
Types of nuts

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.

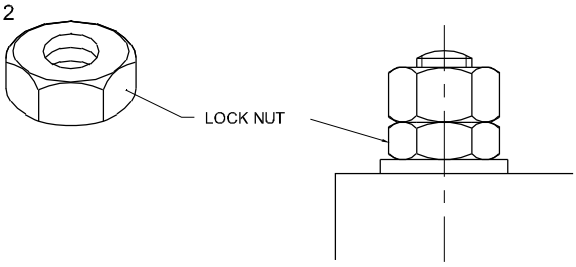
Hexagonal nuts (Fig 1 & 2)

Fig 1



MTN122531

Fig 2



MTN122532

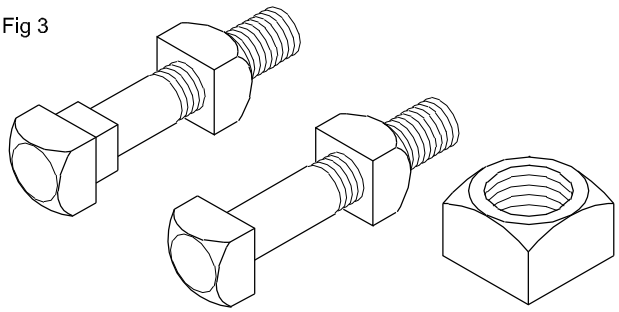
This is the most commonly used type of nut in structural and machine tool construction.

Hexagonal nuts are available in different thicknesses. Thin nuts are used as lock-nuts.

Square nut (Fig 3)

Square bolts are provided with square nuts. In bolts for coaches mostly square nuts are used.

Fig 3



MTN122533

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.

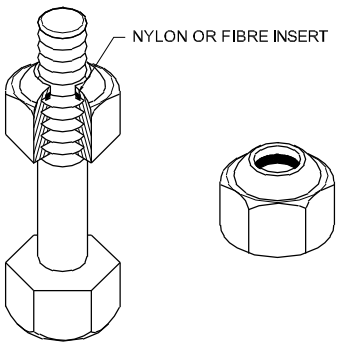
Self-locking nuts are not used with studs.

T-nuts

T-nuts are used along with studs on machine tools for fixing/holding devices or workpieces.

Slotted and castle nuts (Fig 4)

Fig 4

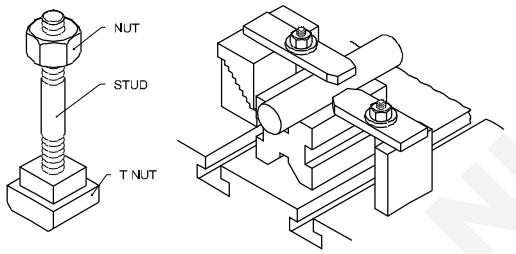


MTN122534

Round nuts (Fig 5)

Round nuts of different types are available for special applications.

Fig 5



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Slotted round nut (Fig 6 to 10)

Slotted round nut for hook wrench.

Round nut with set pin holes on sides

Round nut with holes in the face.

Fig 6

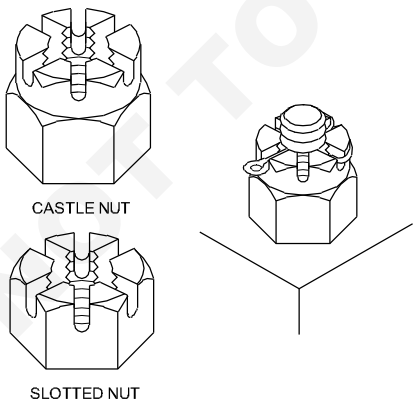

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Fig 7

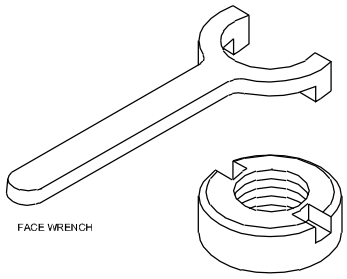

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Fig 8

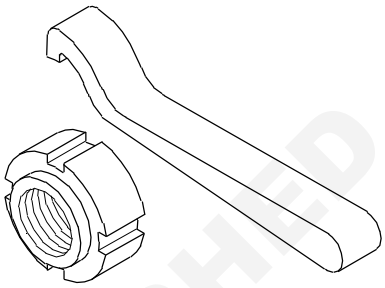

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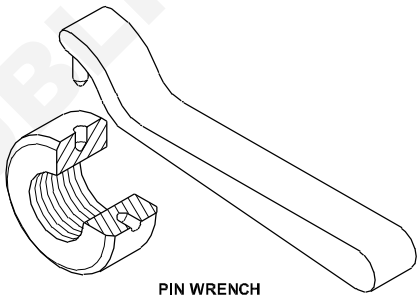
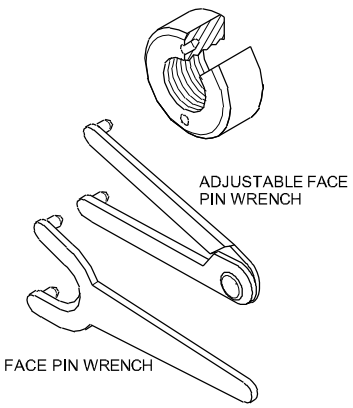
Fig 9



MTN122539

Fig 10



MTN12253A

Bolts, studs and nuts

Objectives : At the end of this lesson you shall be able to
- **state the bolts and nuts**
- **state the advantages of 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.**

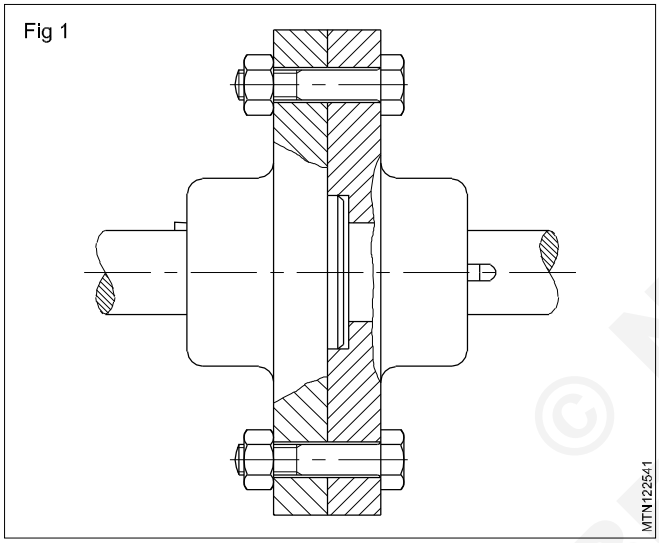
Bolts and nuts (Fig 1)

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

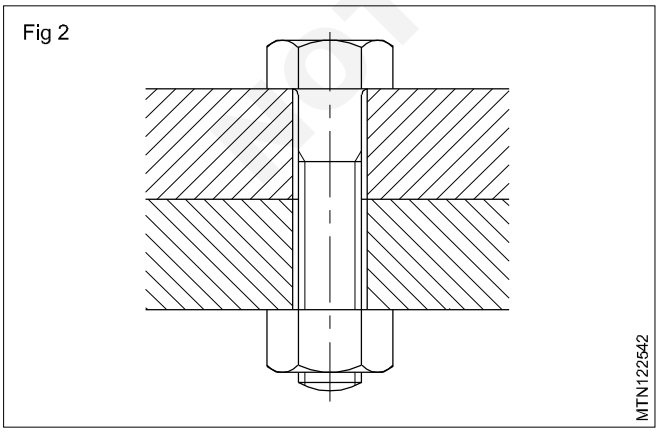


Bolts with clearance hole (Fig 2)

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

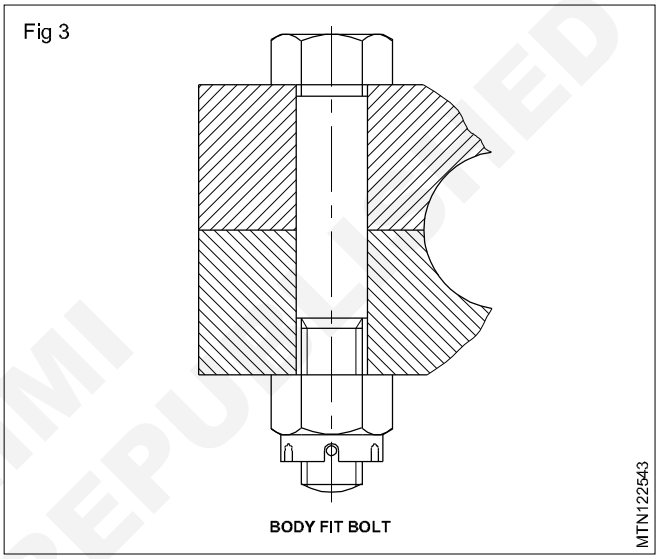


Body fit bolt (Fig 3)

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.

The bolt shank and the hole are accurately machined for achieving perfect mating.

Fig 3

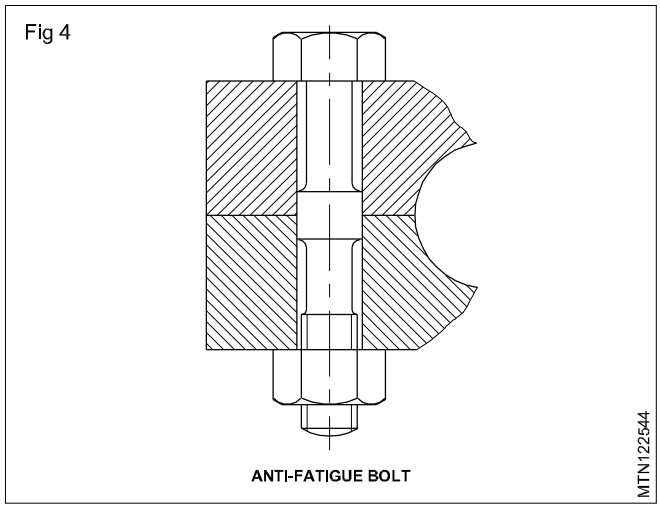


Anti-fatigue bolt (Fig 4)

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.

The shank diameter is in contact with the hole in a few places and other portions are relieved to give clearances.

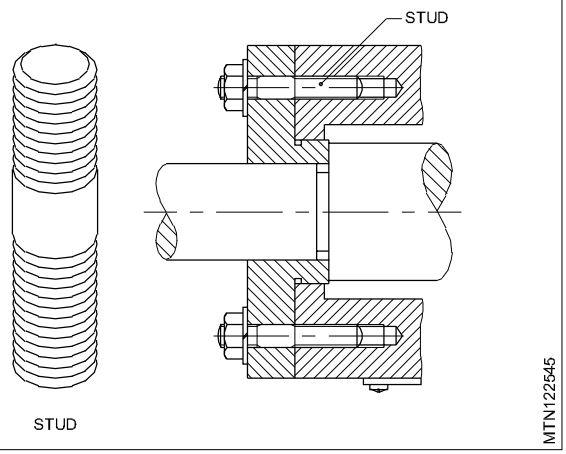
Fig 4



Studs (Fig 5)

Studs are used in assemblies which are to be separated frequently.

Fig 5



When excessively 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 the locking devices**
- **state the classification of lock nuts**
- **state 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.

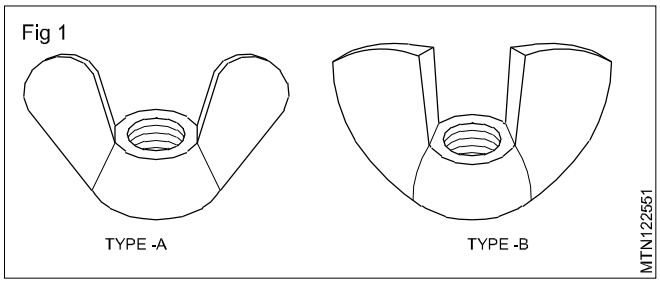
- Positive locking device
- Frictional locking device

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).

Fig 1



Thumb-nut (Fig 2): These are used in places where frequent adjustments are required and mere finger tightening enough. 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.

Fig 2

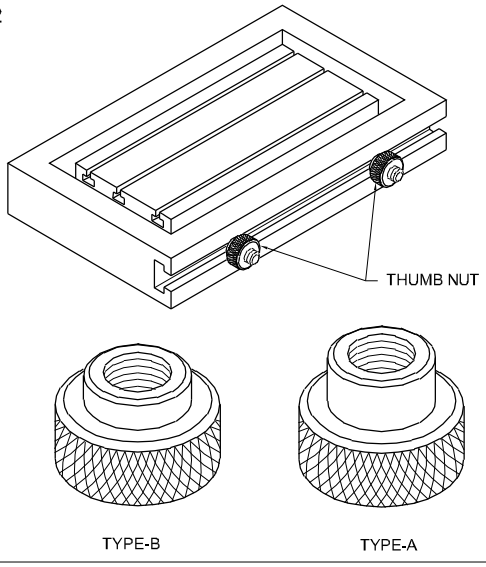


Fig 3

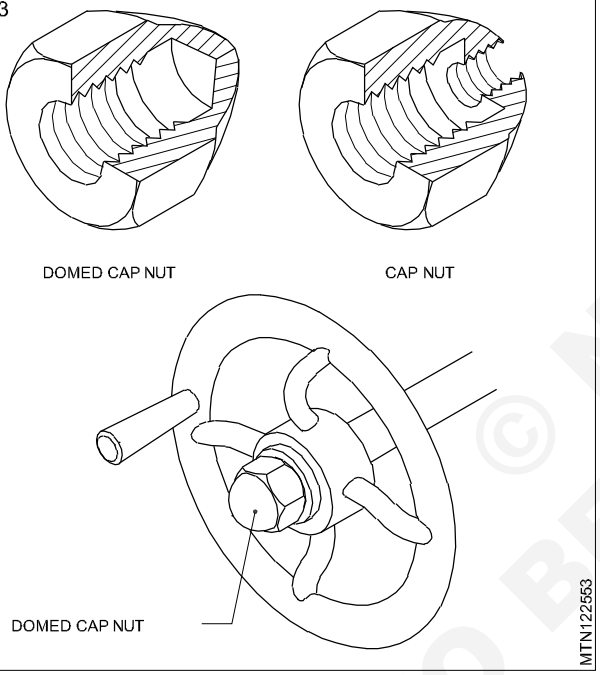
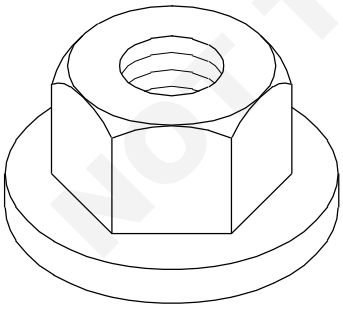


Fig 4

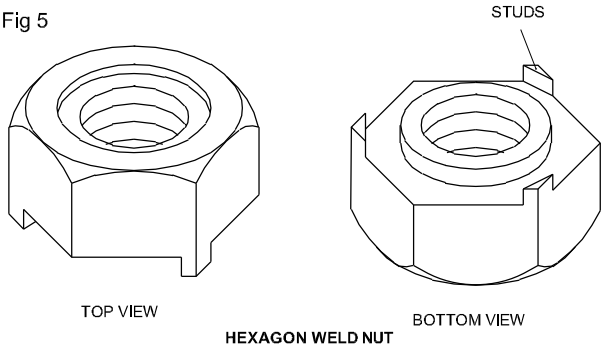


Hexagonal weld nuts (Fig 5)

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.

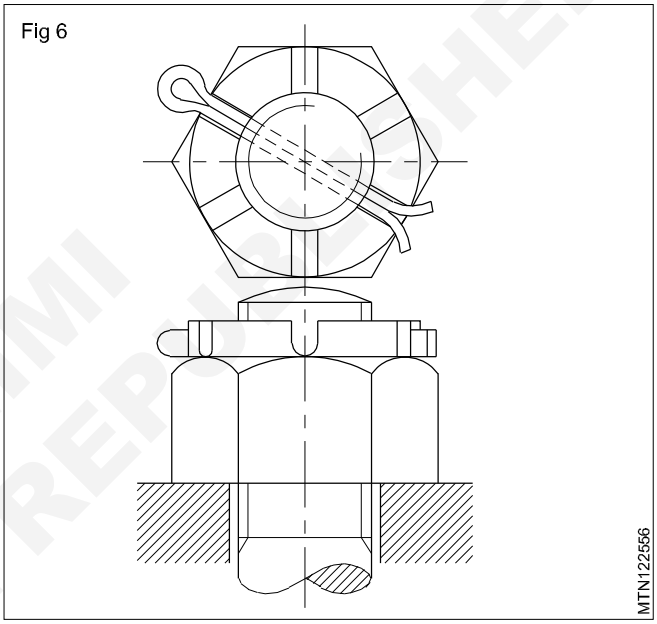
Fig 5



- A countersunk hole on one end to protect the thread during welding.

Out Castle nuts (Fig 6) are widely used in automobiles and locomotive engines to avoid sudden shock and vibration.

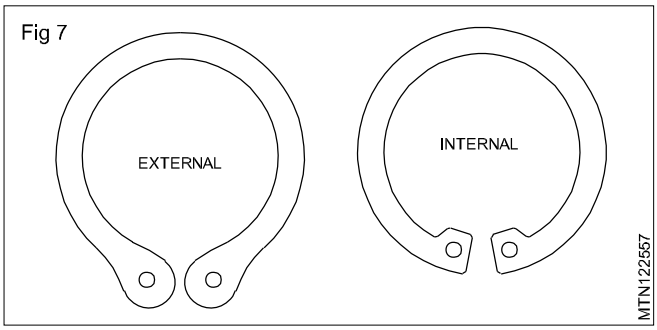
Fig 6



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

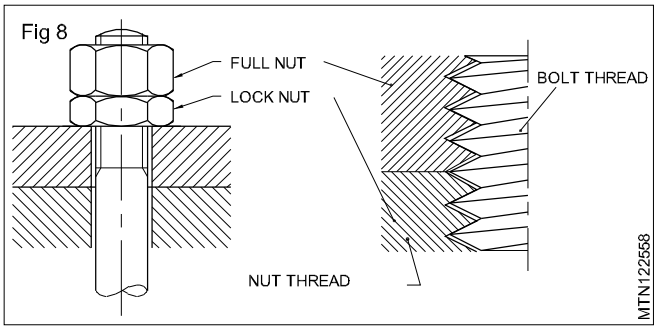


Chuck nut (Fig 8)

This nut is used along with one ordinary nut as shown in the figure.

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.

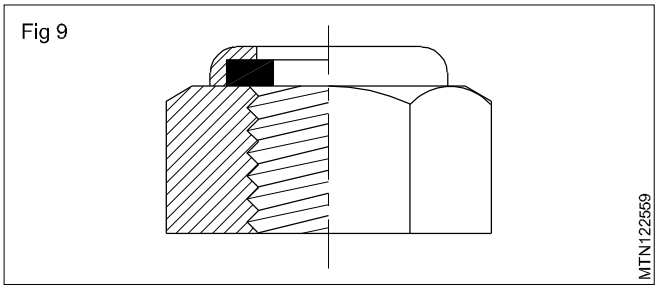
Fig 8



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



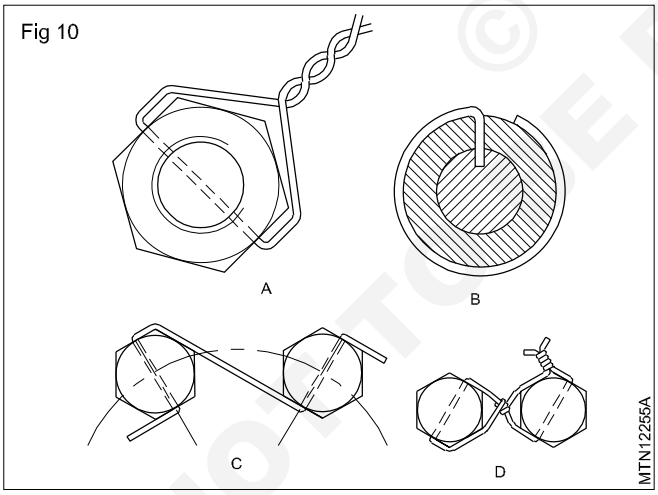
Wire lock (Fig 10)

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



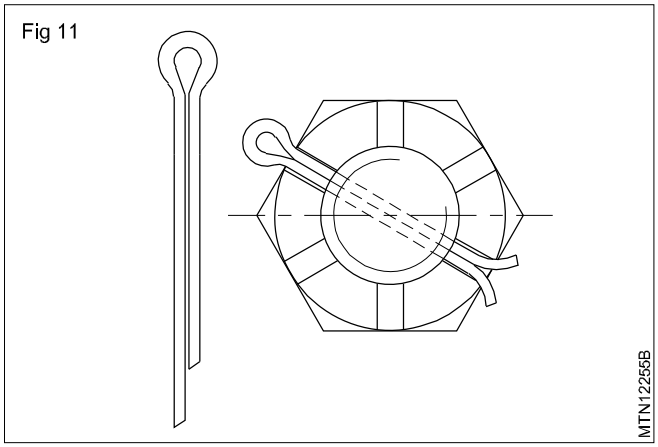
Split pin (Fig 11)

A split pin is made from a steel wire of semicircular cross section, 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.

Sawn nut (Wiles nut)

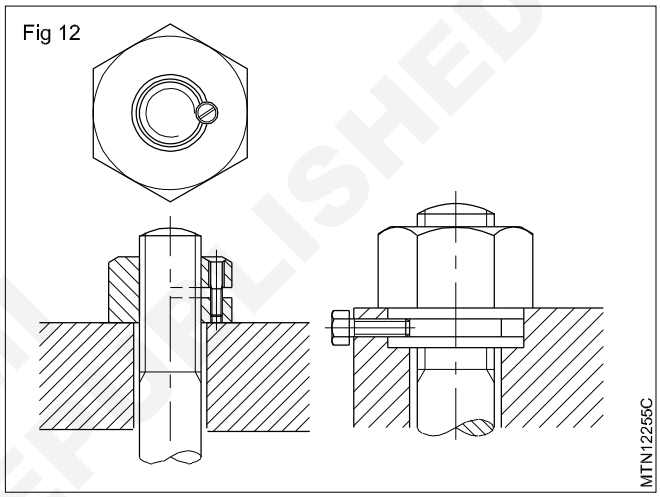
In this locking device, a slot is cut half way across the nut. A screw is fitted with a clearance hole on the top part and a matching thread on the lower part of the nut. Tightening of the nut provides positive locking for the nut.

Fig 11



Positive locking device (Fig 12): Frictional locking device

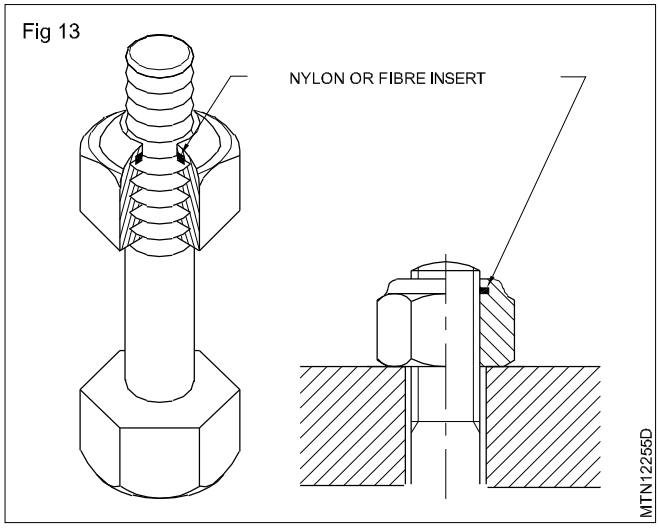
Fig 12



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.

Fig 13



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.

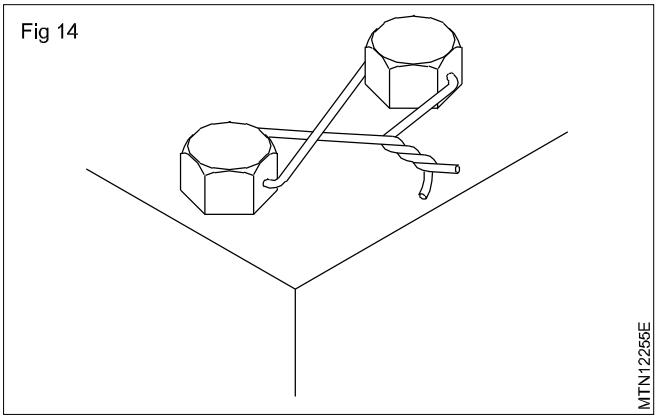
Frictional locking devices (Fig 14)

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.

Fig 14

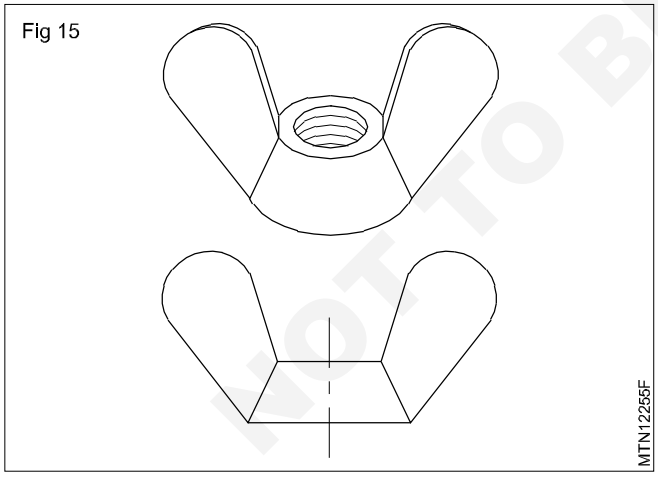


Commonly used locking devices

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.

Fig 15



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.

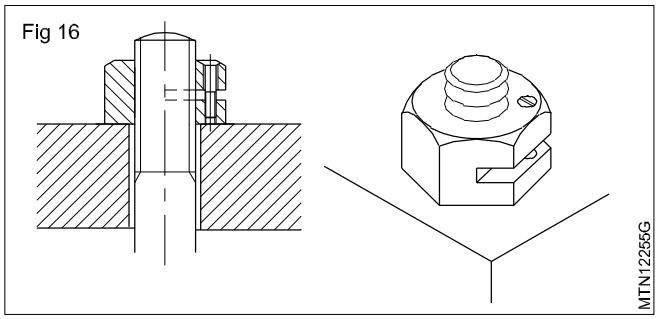
Locking ring

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.

Fig 16



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.

Fig 17

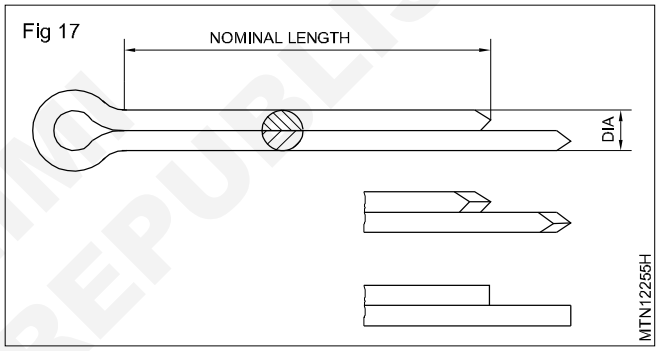
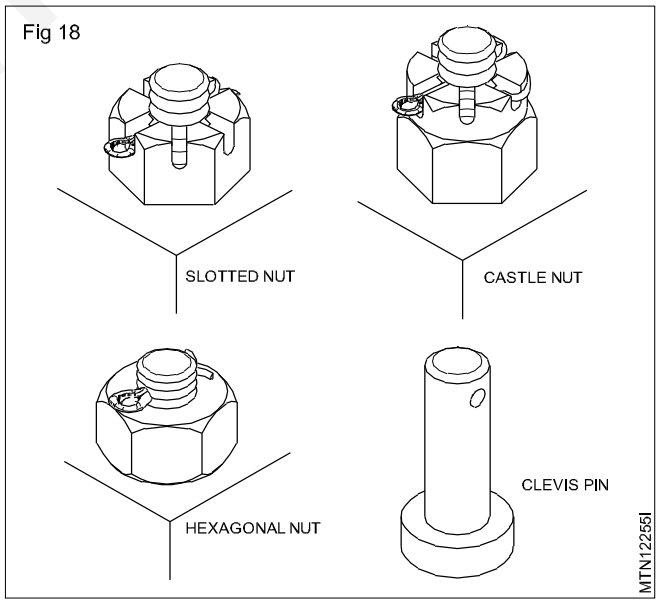


Fig 18

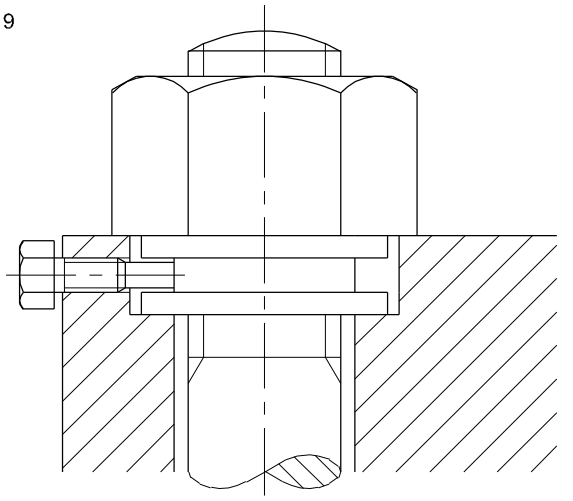


Split pins are used for locking slotted nuts, castle nuts, hexagonal nuts, clevis pins etc. and are used in different ways.

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.

Fig 19



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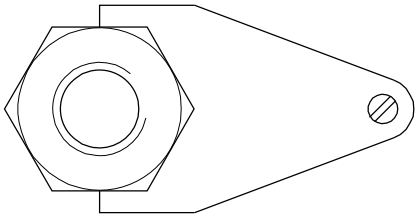
Locking plate (Fig 20)

For preventing the nut from loosening, locking plates are fixed on the outside of the hexagonal nut.

Fig 20



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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.

Fig 21

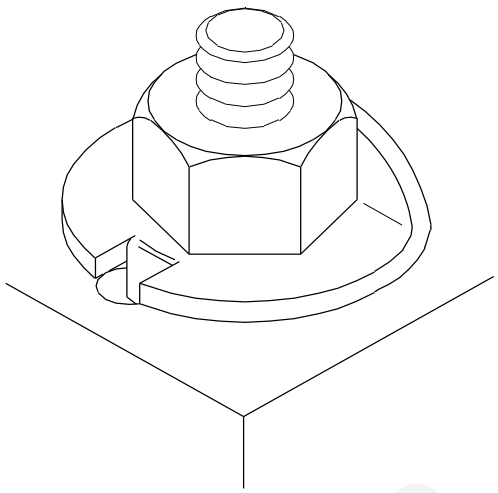

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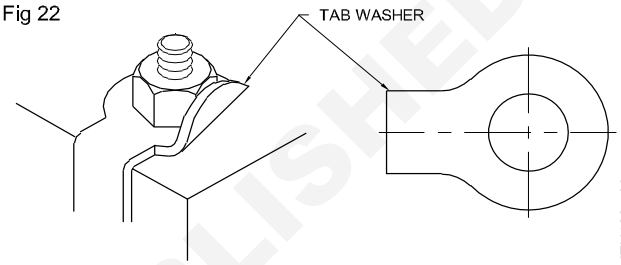
Fig 22



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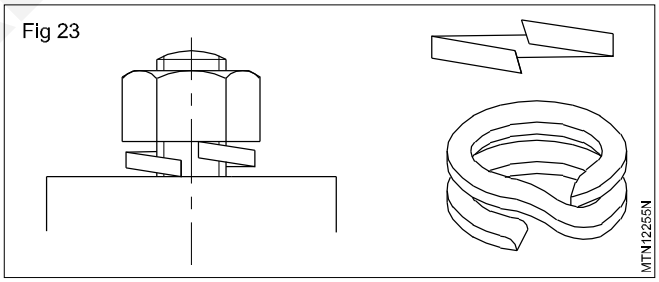
Spring washer (Fig 23)

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.

Fig 23



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Keys and Splines

Objectives : At the end of this lesson you shall be able to
- **state the different types of keys**
- **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

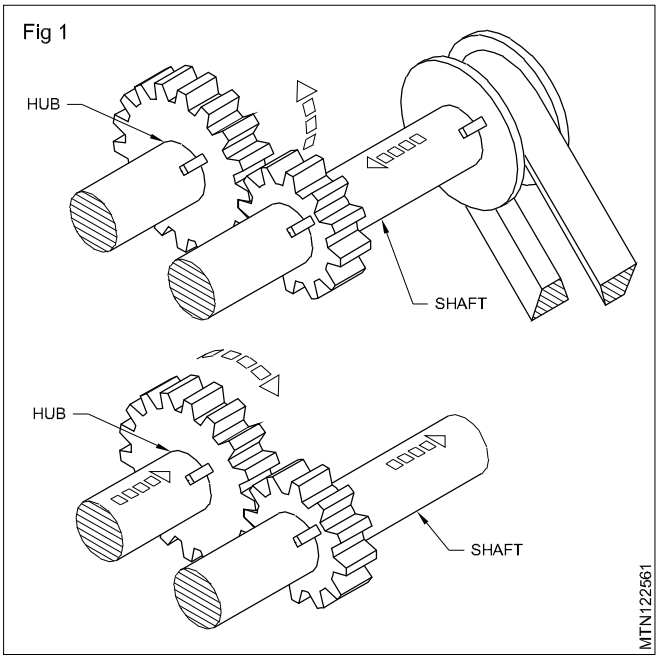
One face of this key has a curvature to match with that of the shaft surface. It has a taper of 1 in 100 and is driven in through the keyway. (Fig 2)

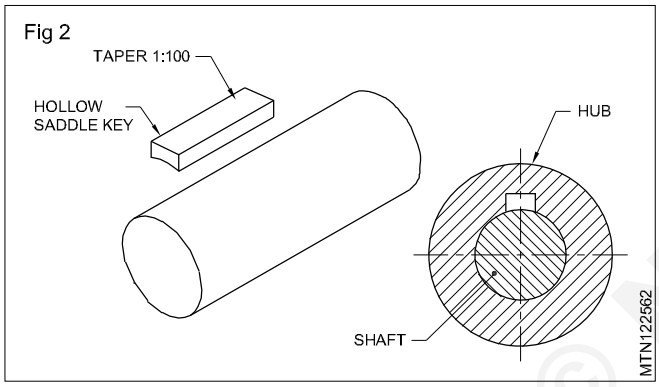
The hub is held on the shaft due to friction. This key is useful only for light duty transmission.

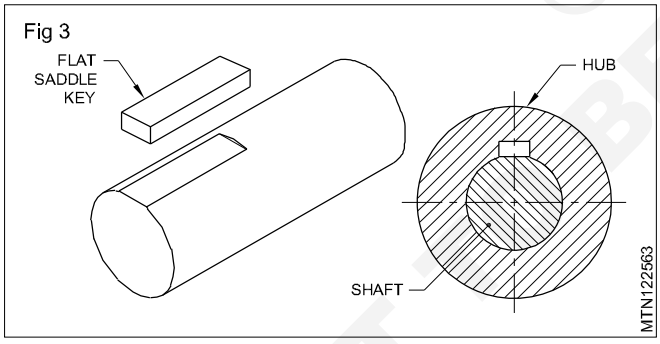
Flat saddle key

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)

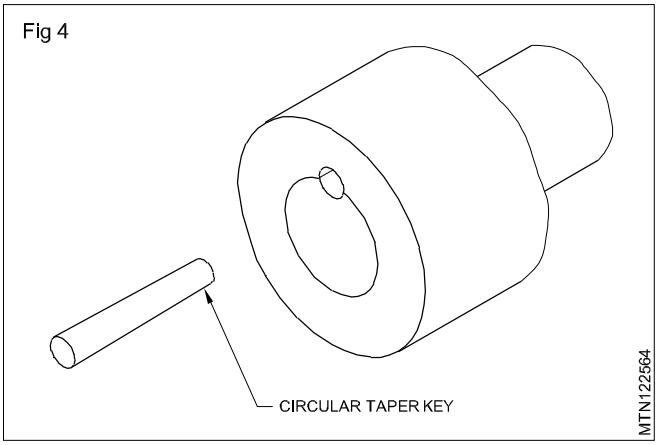
In this case both the shaft and the hub have semicircular keyways cut on them. (Fig 4) The taper key is driven in while assembling. This key is suitable only for light transmission.

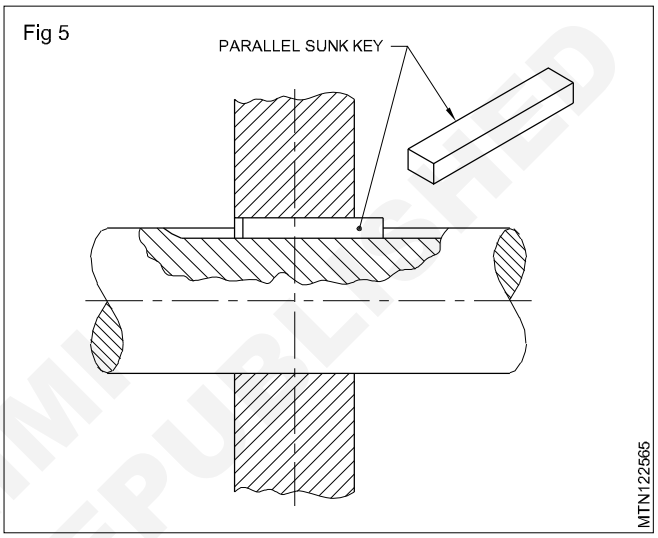
Sunk key (Fig 5 & Fig 6)

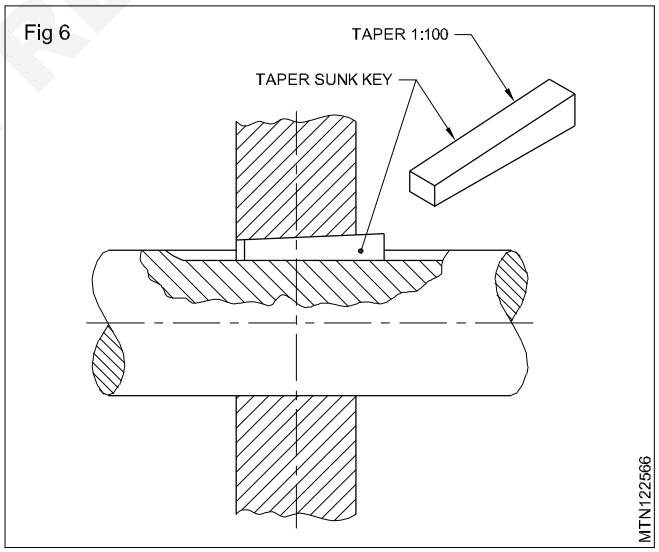
This key has a rectangular cross-section and its fits into the keyway cut on both the shaft and the hub. Sunk keys are either parallel or tapered. (Figs 5 and 6)

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. (Fig 7a and 7b)







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.

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) This key is particularly useful on tapered fittings of shafts.

Splined shaft & serrated shaft

Splined 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 10b)

In certain assemblies, serrated shafts are also used for transmission. (Figs 11a and 11b)

Fig 7

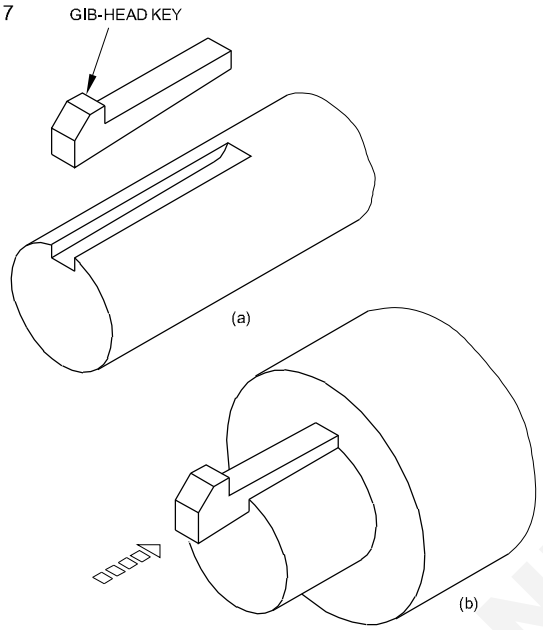


Fig 8

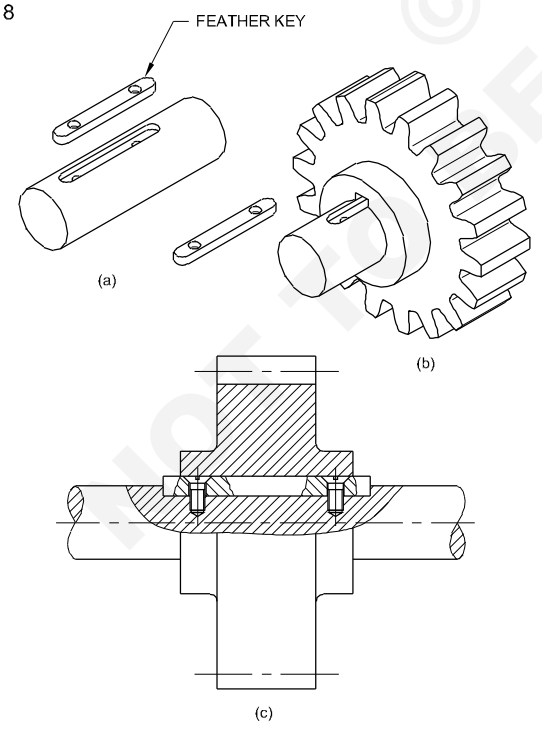


Fig 9

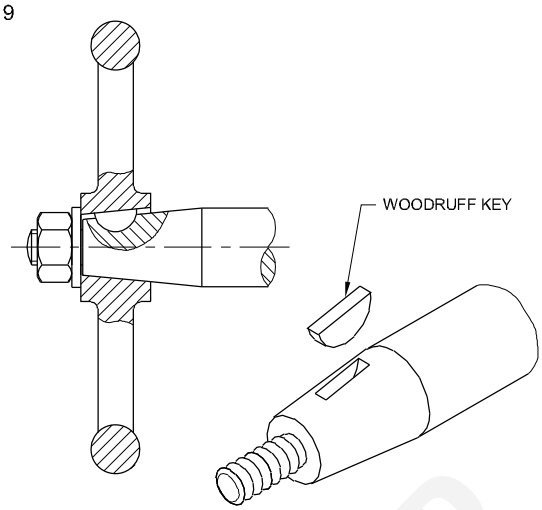


Fig 10

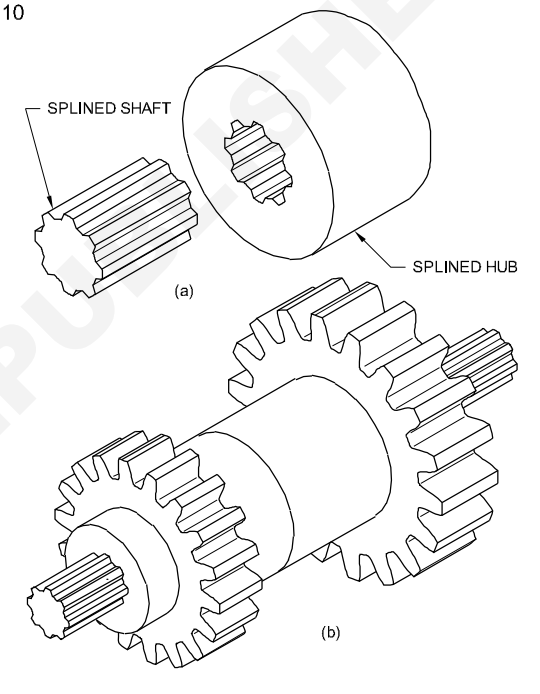
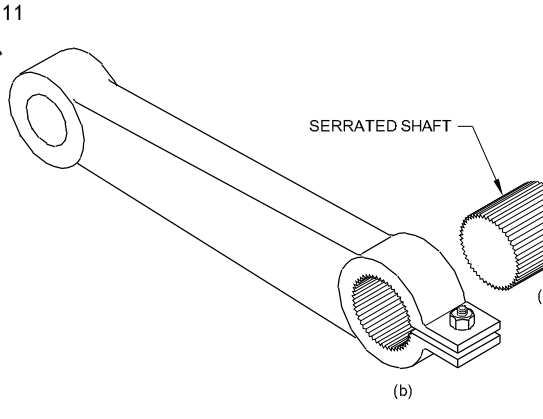


Fig 11

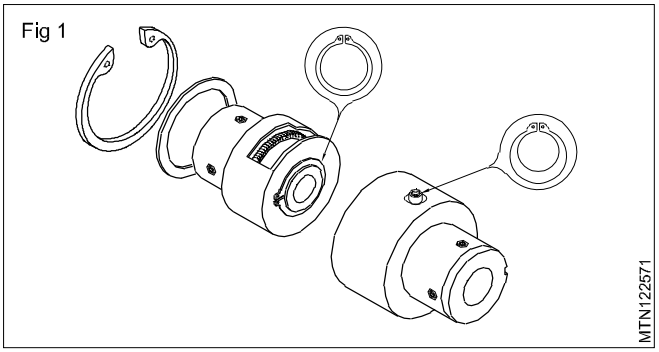


Circlips

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.

Fig 1

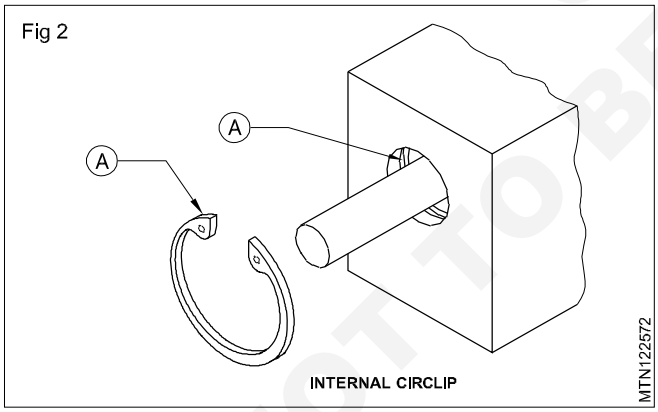


The rings are generally made of materials having good spring properties so that the fastener may be deformed elastically to a considerable degree and still spring back to its original shape. This permits the circlips to spring back into a groove or other recess in a part or they may be seated on a part in a deformed conditions so that they grip the part by functional means. Circlips are manufactured from spring steel with high tensile and yield strength.

Types: There are two types.

Internal circlips (Fig 2)

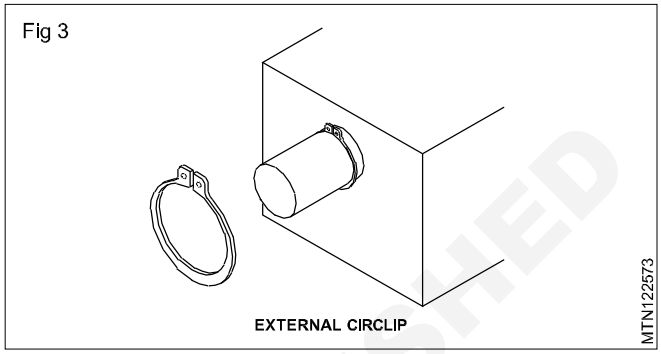
Fig 2



This type of rings are assembled in holes, bores or housing.

External circlip (Fig 3)

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.

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.**

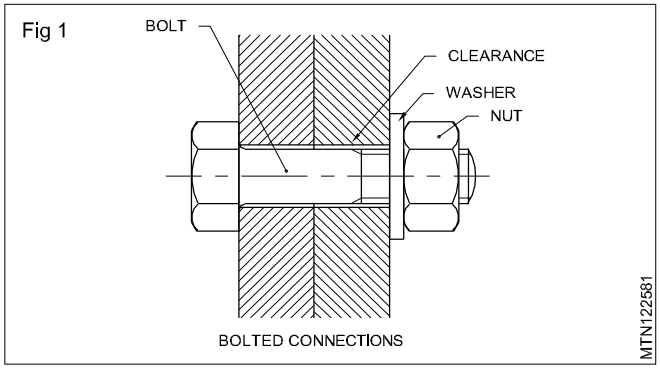
Purpose

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 over a larger area.



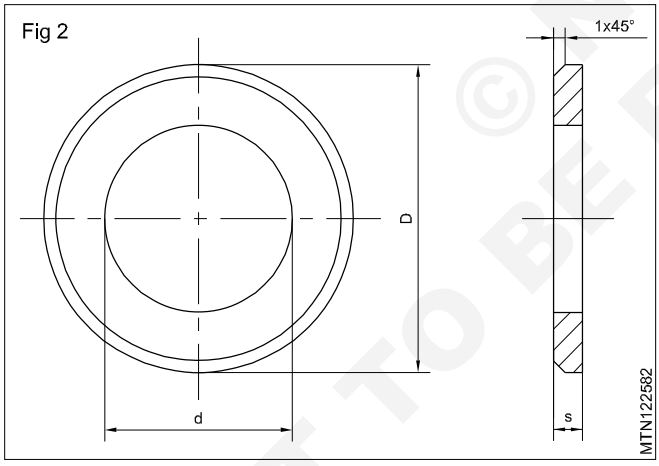
Types of washers: There are different types of washers available. They are;

- 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.



Machined washers (Fig 3)

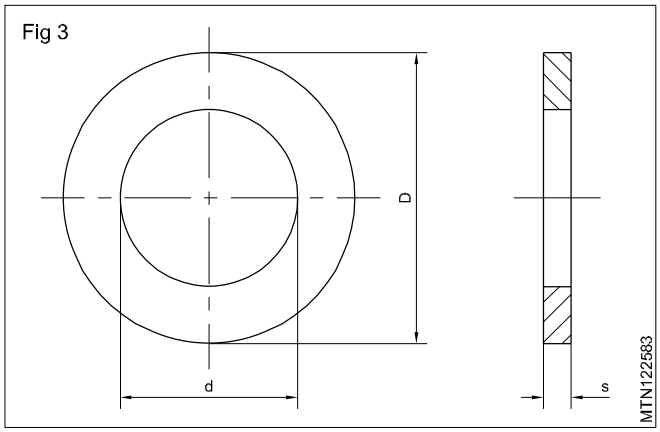
These washers are used for assemblies using machined components. These washers are available with chamber on one side or on both sides. They are heat treated and ground.

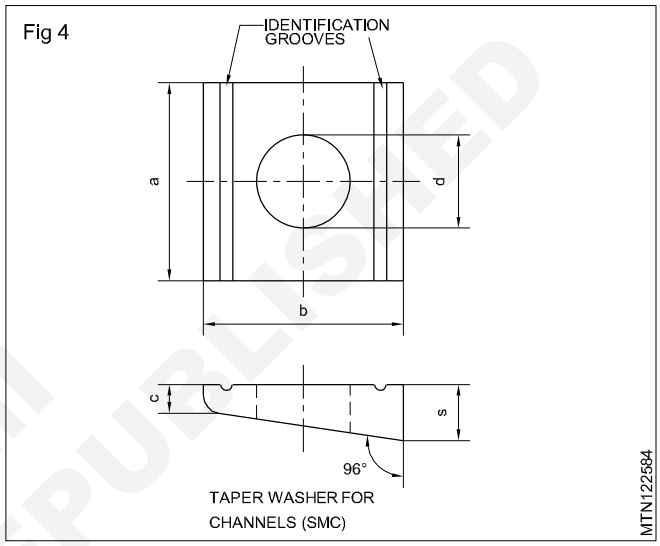
Punched washers

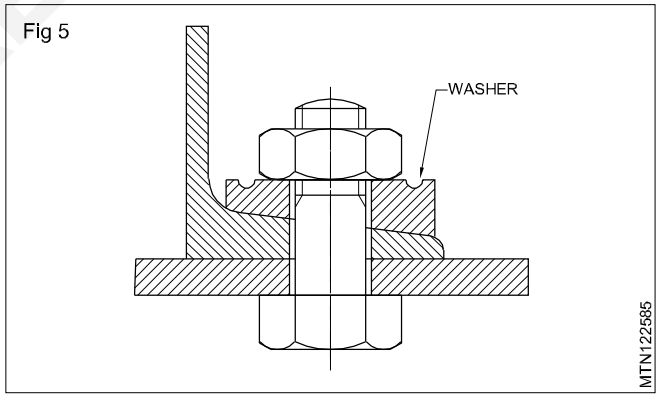
These do not have chamfers and are commonly used in structural fabrication work.

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.







Spring washers (Fig 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.

Tab washers (Fig 8)

These washers are used for locking the nuts.

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 6

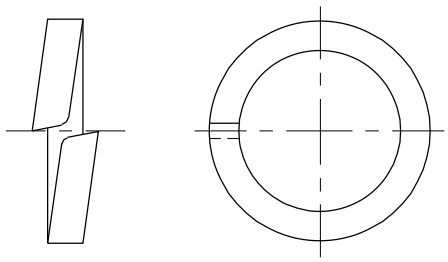


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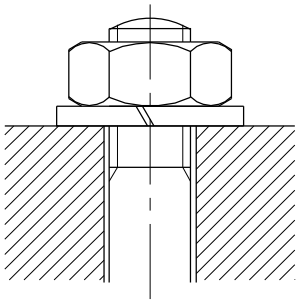
Fig 7



SPRING LOCK WASHER

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Fig 8

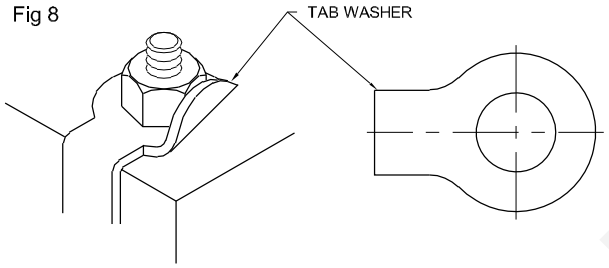

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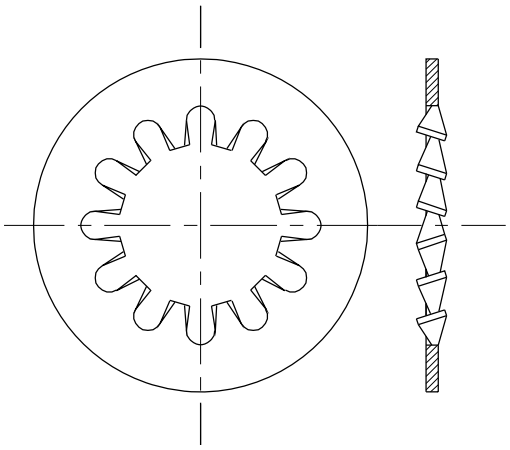
Fig 9



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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

Gasket

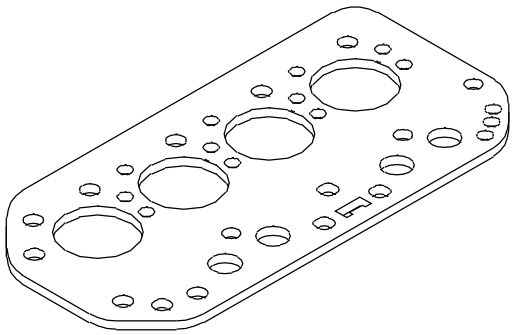
Objectives : At the end of this lesson you shall be able to
- **state the need of gaskets**
- **state the materials of gaskets.**

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 fiber, 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 different 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 separate lubricant on fluid

Types of oil seal

i Flexible lip ii Radial lip iii Rotary shaft seal

configuaration

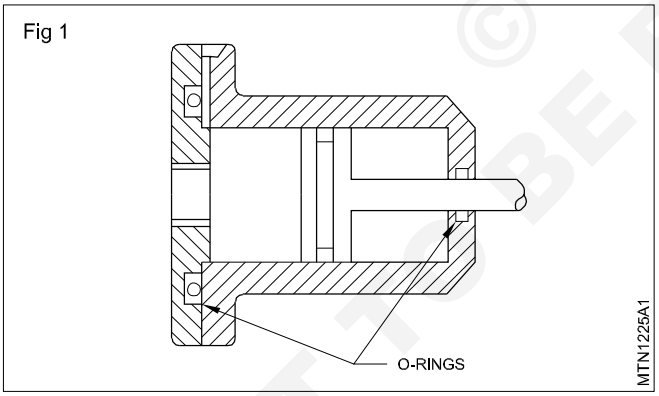
a Single lip b Double lip

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 contaminant. The contain potor (rotating) & stater (Stationary) member same bearing Isolator are of labyrinth construction of other use o-rings.

Fig 1



Specifications

Sealing orientation (Fig 2 & 3)

- Rod seals or shaft seals are type of radial seal.
- Radial seal are press fit into a housing bore with the sealing up contacting the shaft.
- Piston seals are radial seal. These seals are fit on a shaft with sealing lip contacting the housing bore. 'O' rings are external lip seals.
- Symmetrical seal works equally as a rod or piston seal.
- An axial seals axially against a housing or machine component.
- Material - Nylon, Rubber, polythen, PTFE etc.

Fig 2

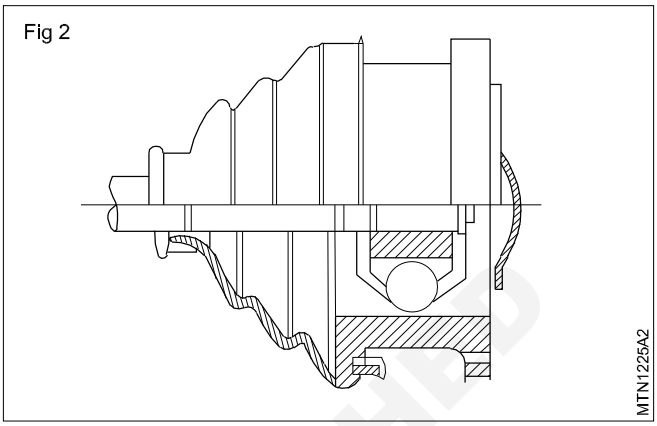
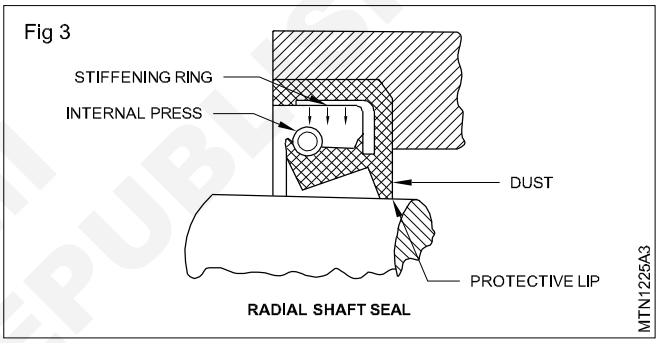


Fig 3



Sealants

Type of sealant: There are three types of sealant used.

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

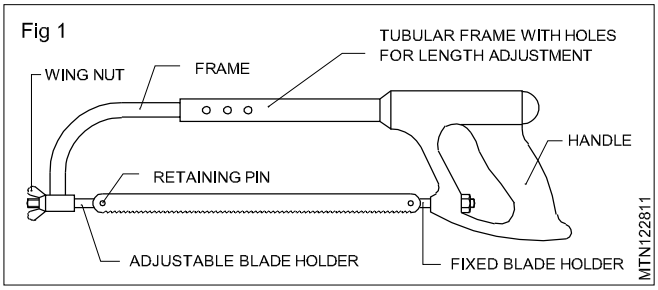
Hacksaw frame and blade

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.

The parts are identified in the (Fig 1)

Fig 1



Types of hacksaw frames

The two different types of hacksaw frames are solid frame and adjustable frames.

Solid frame: Only a particular standard length of blade can be fitted to this frame.

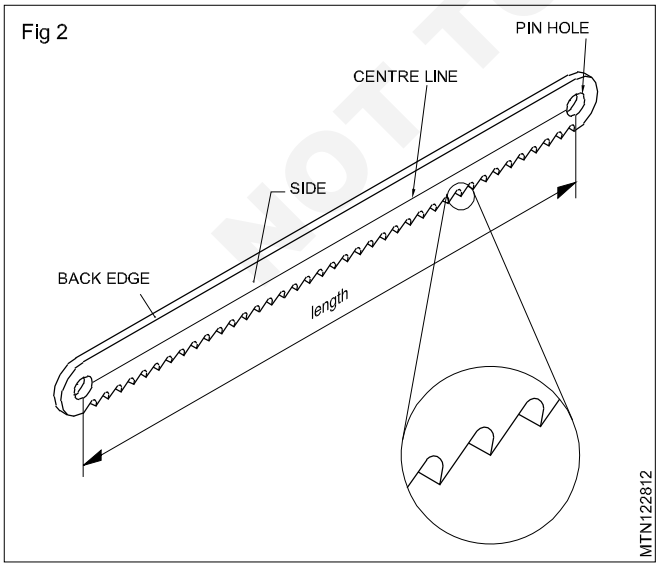
Adjustable frame (Flat type): Different standard lengths of blades can be fitted to this frame.

Adjustable frame (Tubular type): This is the most commonly used type. It gives a better grip and control, while sawing.

For proper working. It is necessary to have frames of rigid construction.

Hacksaw blades (Fig 2)

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 blades are available - all hard blades and flexible blades.

All hard blades

These are hardened to the full width between the pin holes.

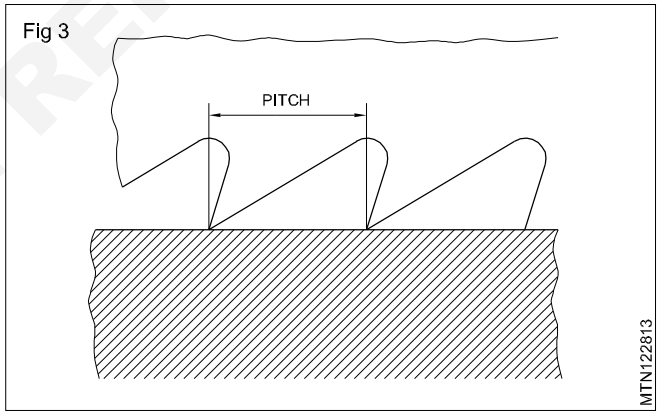
Flexible blades

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)

The distance between adjacent teeth is known as the pitch of the blade.

Fig 3



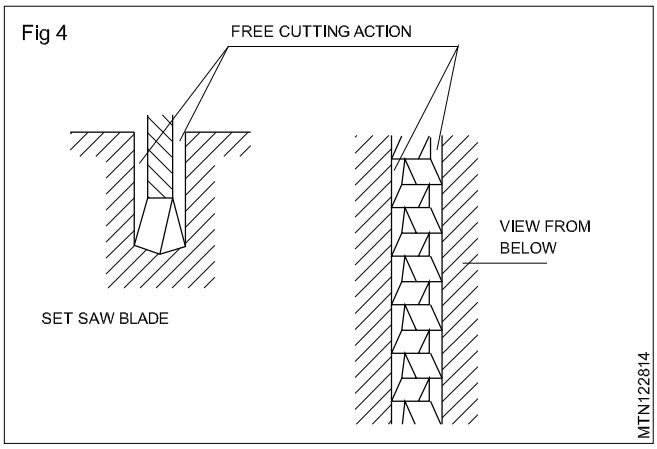
Classification	Pitch
Coarse	1.8 mm
Medium	1.4 mm & 1.0 mm
Fine	0.8 mm

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 broader than the thickness of the saw blade. This is achieved by the setting the saw teeth. There are two types of saw teeth settings.

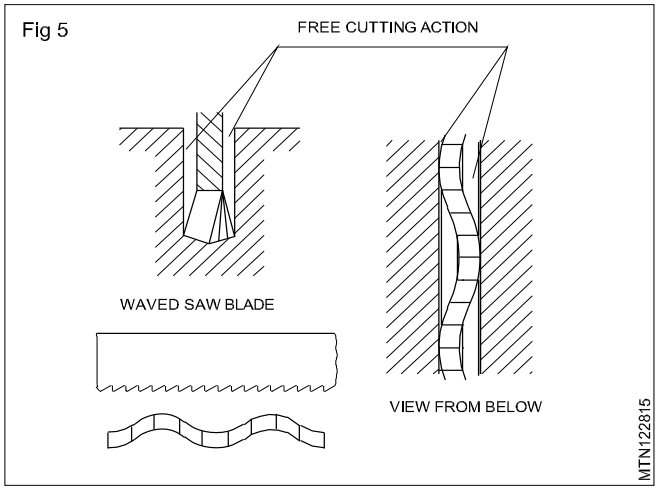
Staggered set (Fig 4)

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 1a). Fusion (Fig 1b) and Incision (Fig 1c)

Filing is a method for removing excess material from a work pieces by using a file which acts as a cutting tool. (Fig 2) shows how to hold a file. Files are available many shapes and sizes.

Parts of a file (Fig 3): The parts of a file as can be seen in Fig 3, are

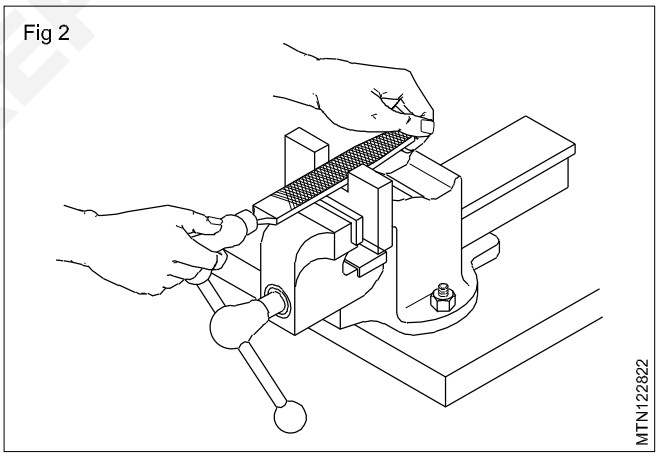
Tip or Point: The end opposite to tang.

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.

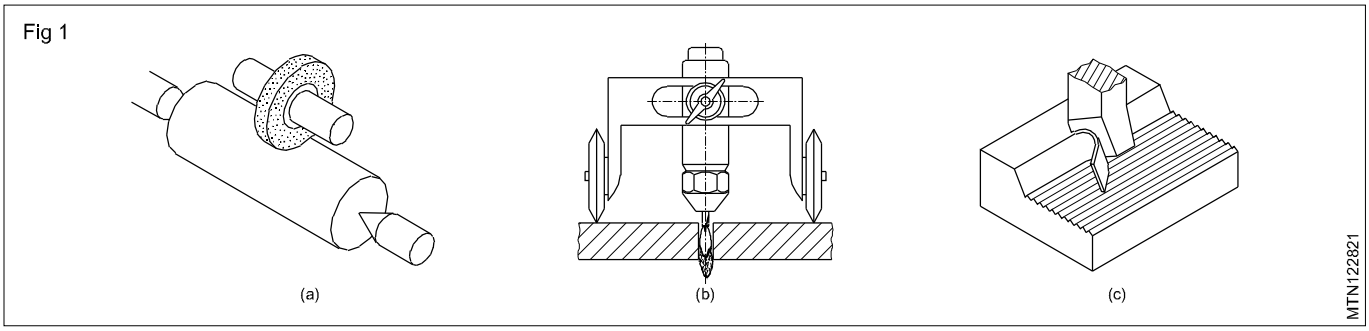
Shoulder: The curved part of the file separating tang from the body.



Tang: The narrow and thin part of a file which fits into the handle.

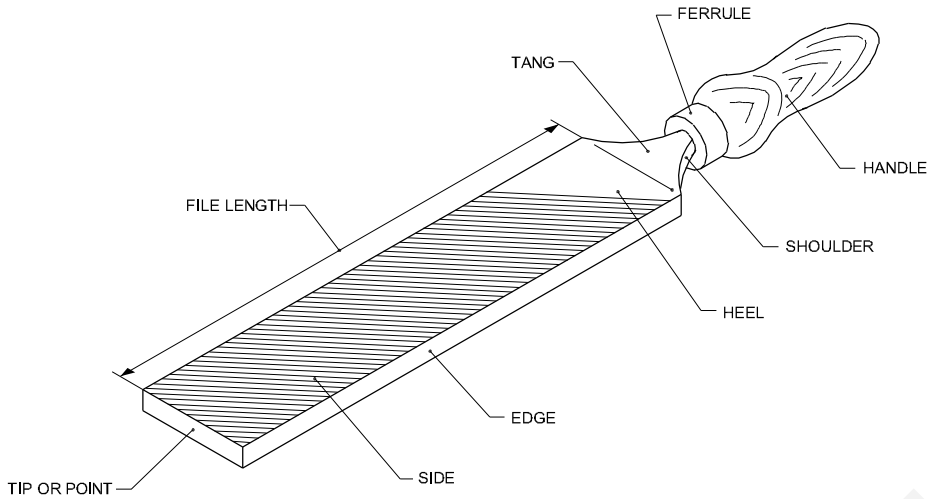
Handle: The part fitted to the tang for holding the file

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 hardened.

Fig 3



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.

1 Single cut 2 Double cut

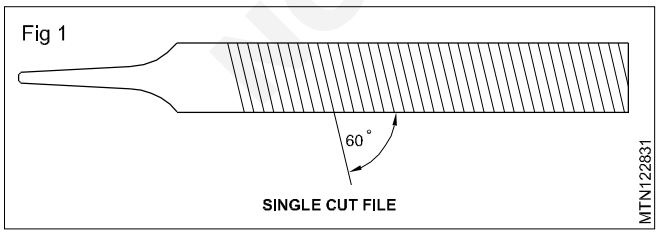
3 Rasp cut 4 Curved cut

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° 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.

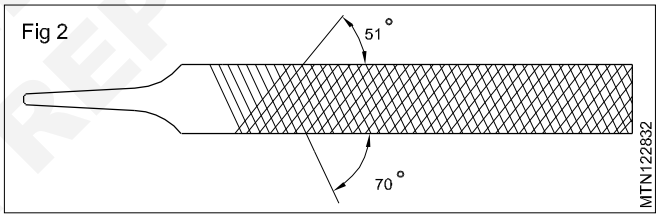
Fig 1



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°. The other cut, made diagonal to this, is known as UPCUT and is at an angle of 51°. This removes stock faster then the single cut file.

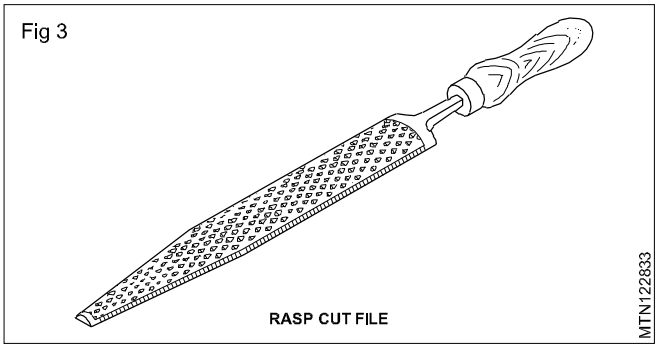
Fig 2



Rasp cut 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.

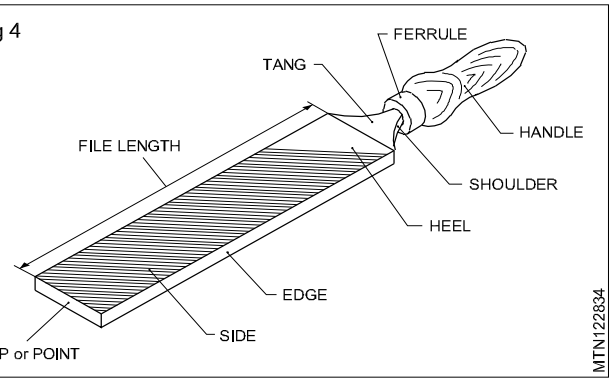
Fig 3



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.

Fig 4



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.**

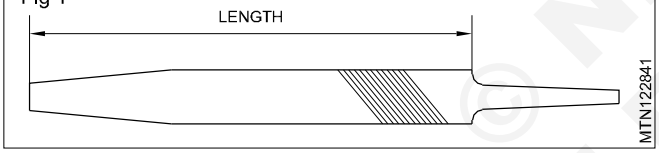
Files are manufactured in different types and grades to meet the various needs.

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)

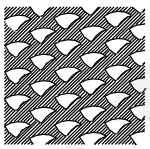
File grades are determined by the spacing of the teeth.

Fig 1



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.

Fig 2

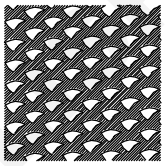


A bastard file (Fig 3) is used in cases where there is a heavy reduction of material.

Fig 3

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.

Fig 4

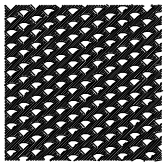


A smooth file (Fig 5) is used to remove small quantity of material and to give a good finish.

Fig 5

A dead smooth (Fig 6) file is used to bring to accurate size with a high degree of finish.

Fig 6



The most used grades of files are bastard, second cut, smooth and dead smooth. These are the grades recommended by the Bureau of Indian Standards. (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.

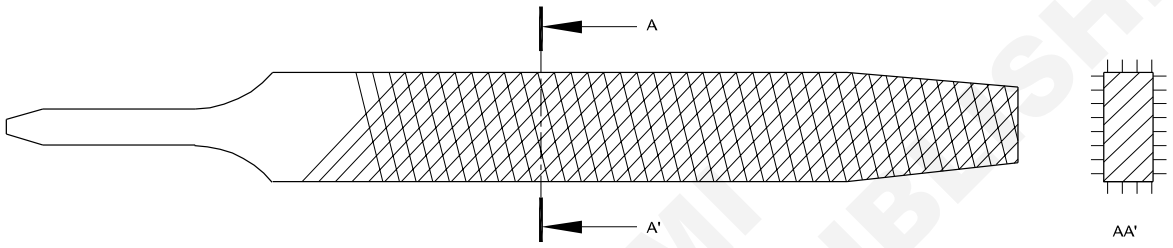
Flat files

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



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.

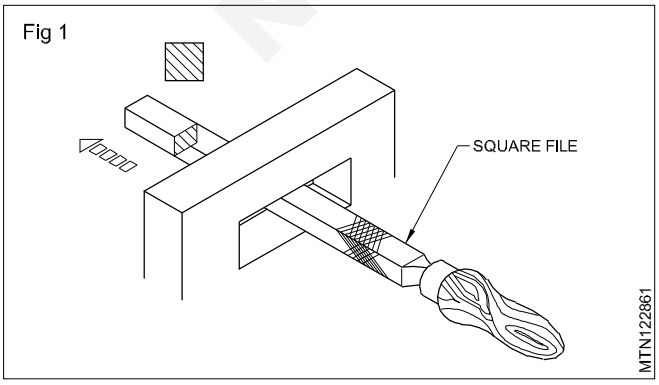
The shape of files is stated by its cross section.

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 section. It is used for filling square holes, internal square corners, rectangular opening, keyways and spines. (Fig 1)

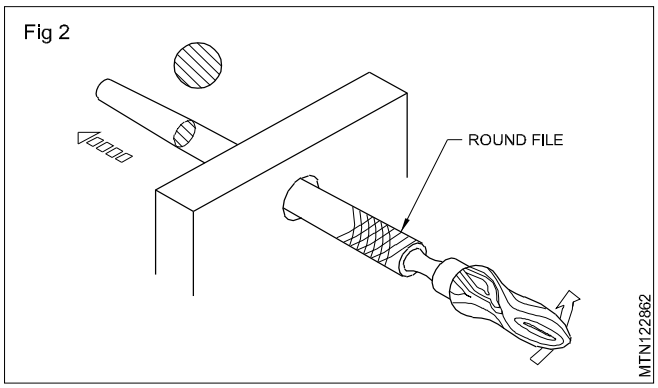
Fig 1



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)

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 3

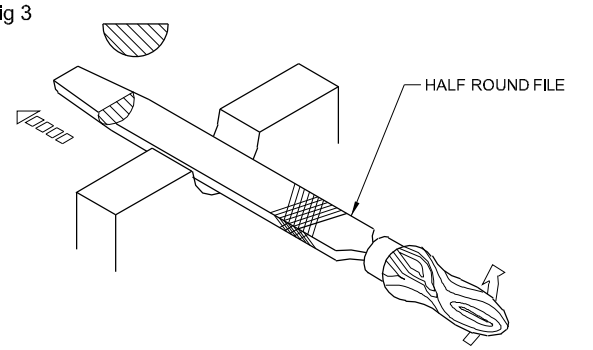


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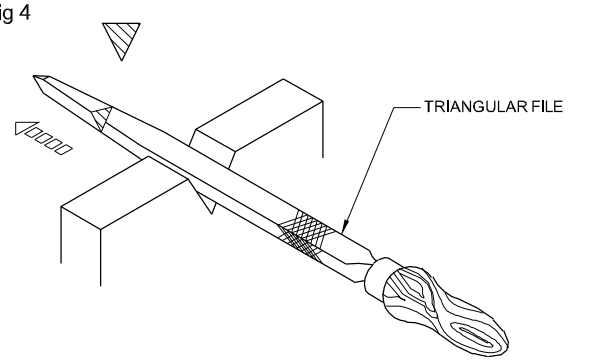
Fig 4



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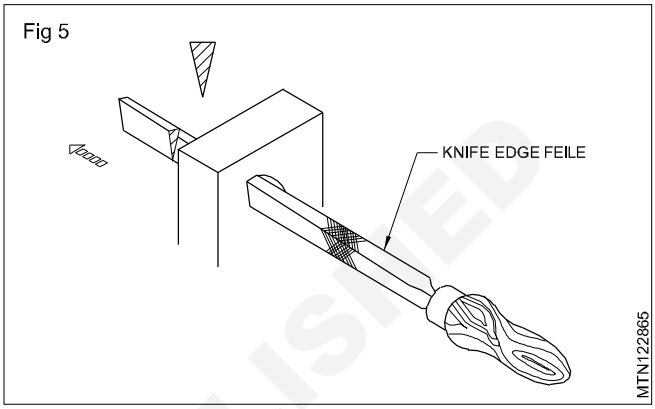
Knife-edge File

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)

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.

Fig 5



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Off- hand grinding with bench and pedestal grinders

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

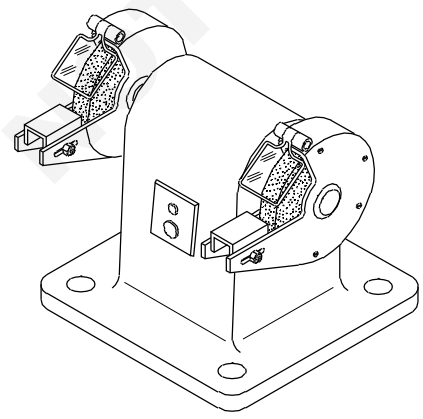
Off-hand grinding is performed for rough grinding of jobs and resharpening of

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)

Fig 1



BENCH GRINDER

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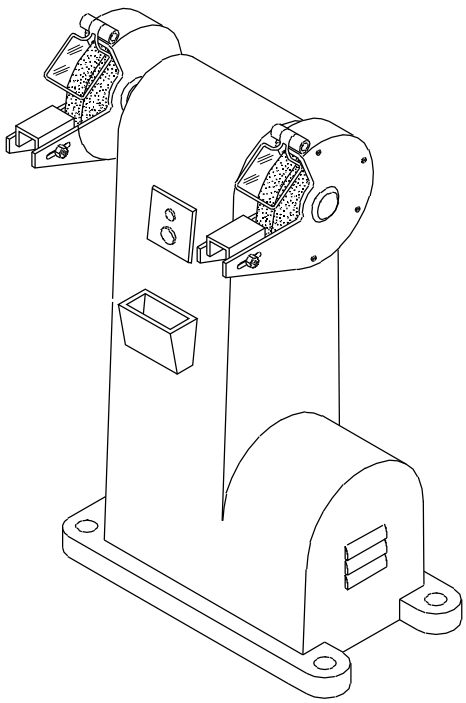
Fig 2



PEDESTAL GRINDER

MTN122872

Bench grinders

Bench grinders are fitted to a bench or table, and are useful for light duty work.

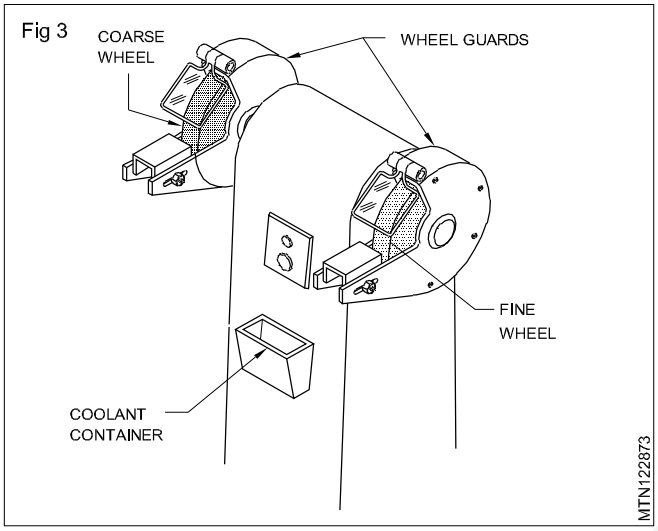
Pedestal grinders

Pedestal grinders are mounted on a base (pedestal), which is fastened to the floor. They are used for heavy duty work.

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)

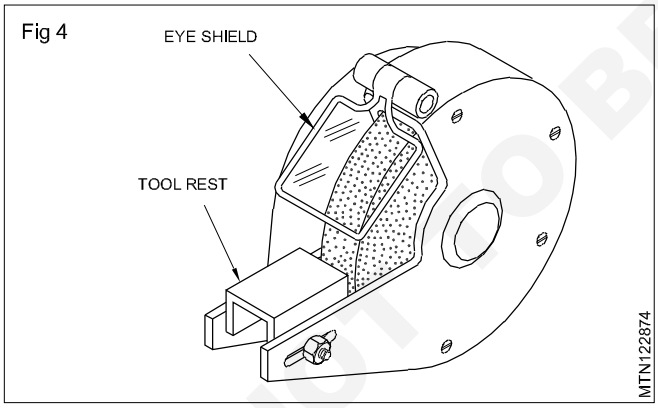
Fig 3



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)

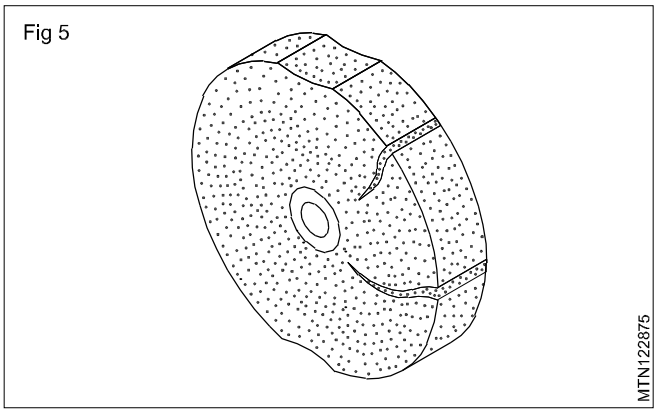
Fig 4



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)

Fig 5



Small jobs should be held with pliers or other suitable tools. (Fig 5)

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)

Move the work across the full face of the wheel to prevent uneven wearing of the grinding wheel. (Fig 7)

Fig 6

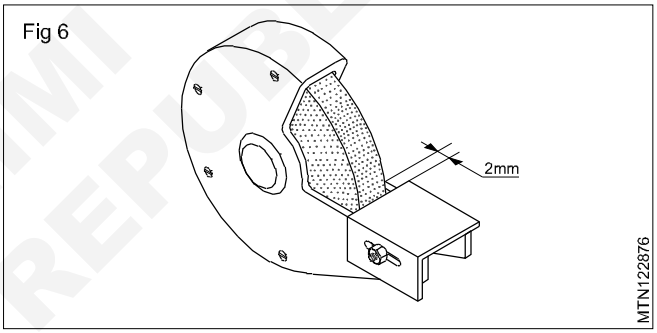
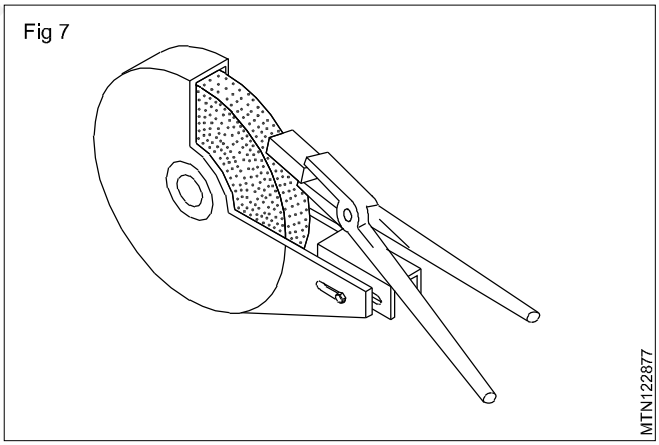


Fig 7



Safe working on off - hand grinders

Objective : 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?

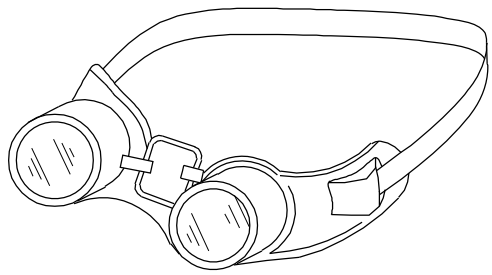
While working on off-hand grinders, it is important to observe the following safety measures.

Before Starting

Make sure the grinding wheel guards are in place.

Wear safety goggles while grinding. (Fig 1)

Fig 1



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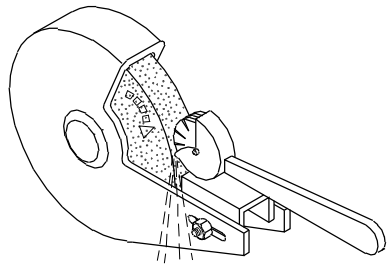
Do not work on grinding wheels which are loaded or glazed. Dress and true wheels whenever necessary. (Fig 2)

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.

Fig 2



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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)

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)

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).

Fig 1

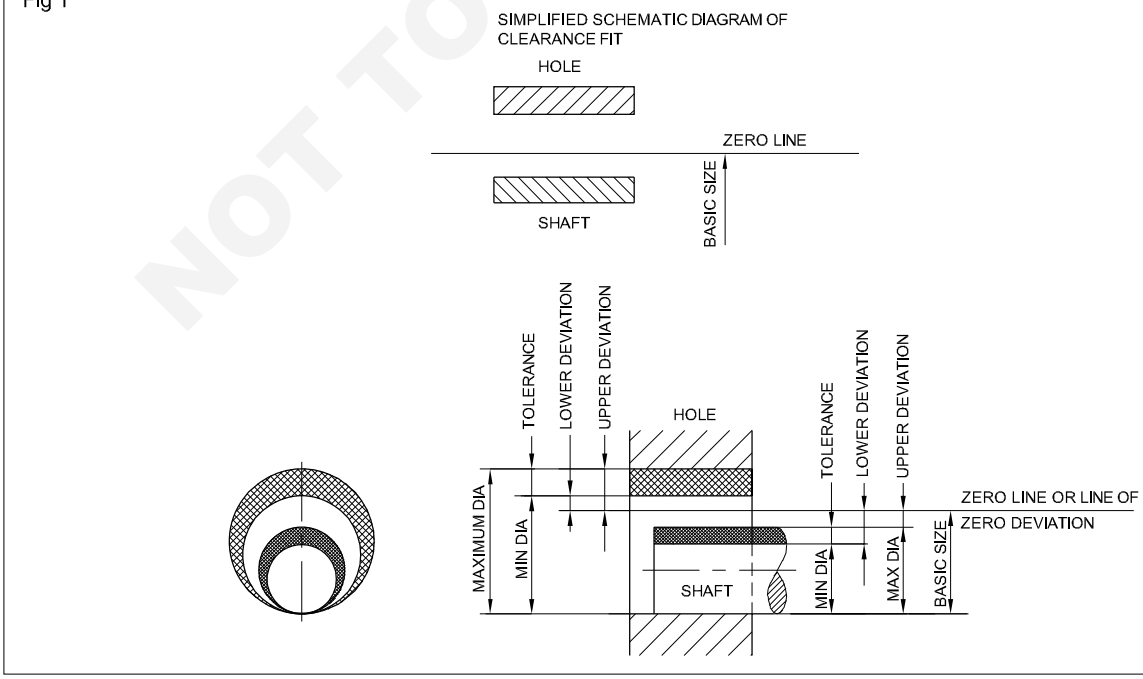

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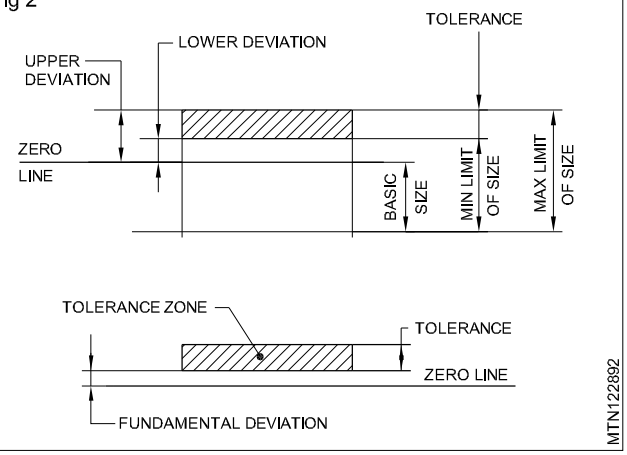
Fig 2



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

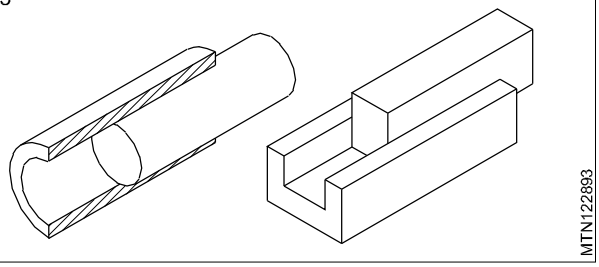


TABLE 1 (Examples)

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	-0.12 20-.021	-0.012	-0.021	19.988	19.979

Upper deviation

It is the algebraic 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 deviation 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)

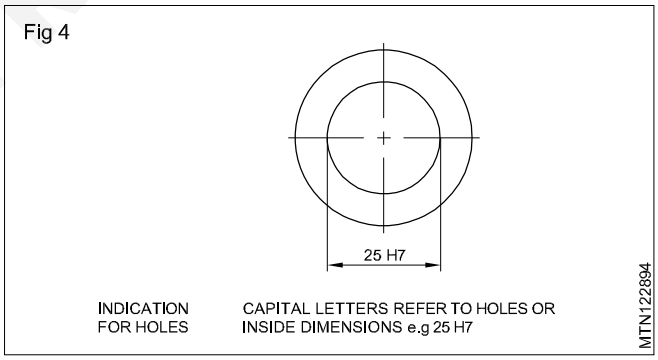
Zero line

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)

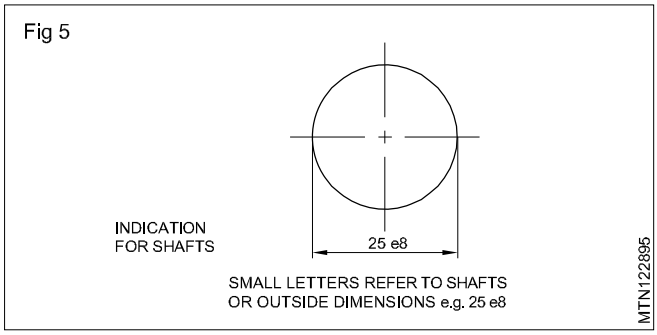
Fig 4



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)

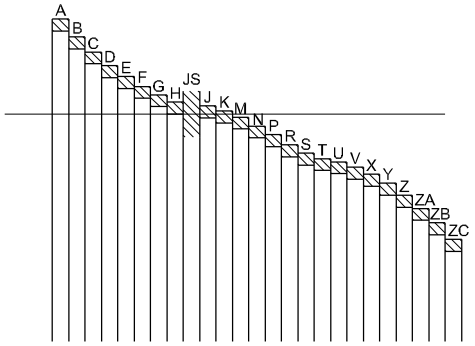
For shafts, the same 25 letter symbols but in small letters are used. (Fig 5)

Fig 5



The position of tolerance zone with respect to the zero line is shown in figs 6 and 7

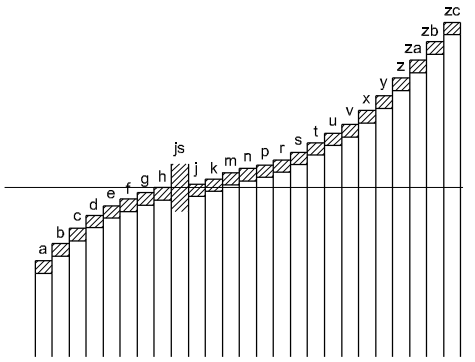
Fig 6



CAPITAL LETTERS INDICATE FUNDAMENTAL DEVIATION OF HOLES

MTN122896

Fig 7



SMALL LETTER INDICATE FUNDAMENTAL DEVIATION OF SHAFTS

MTN122897

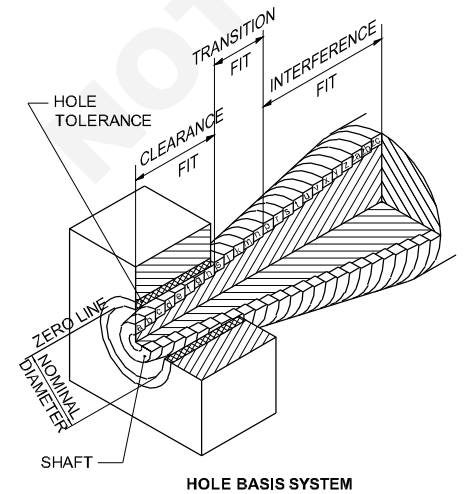
The fundamental deviations are for achieving the different classes of fits. (Fig 8 and 9)

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.

The grade of tolerance refers to the accuracy of manufacture.

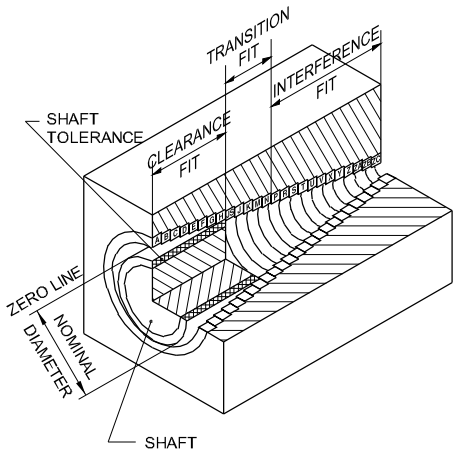
Fig 8



HOLE BASIS SYSTEM

MTN122898

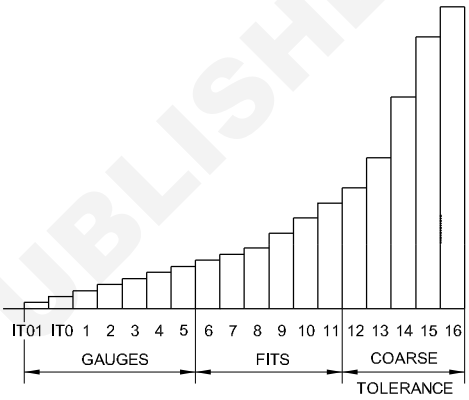
Fig 9



SHAFT BASIS SYSTEM

MTN122899

Fig 10



MTN12289A

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)

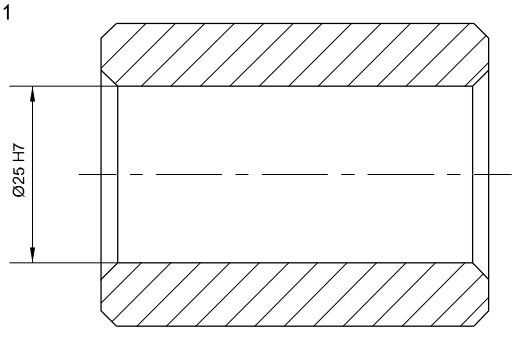
Toleranced size

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



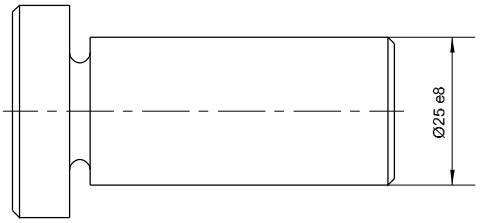
MTN12289B

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)

A very wide range of selection can be made by the combination of the 25 fundamental deviations and 18 grades of tolerances.

Fig 12



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.

As pointed out earlier, the permissible variation from the basic dimension is called 'DEVIATION'.

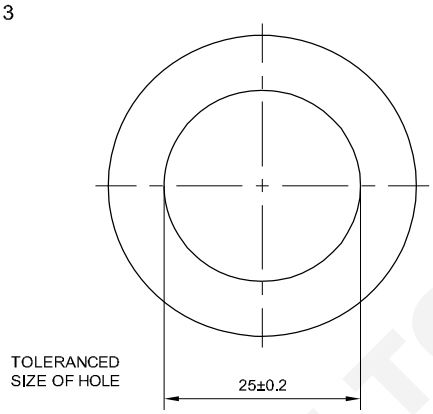
The deviation is mostly given on the drawing with the dimensions.

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.

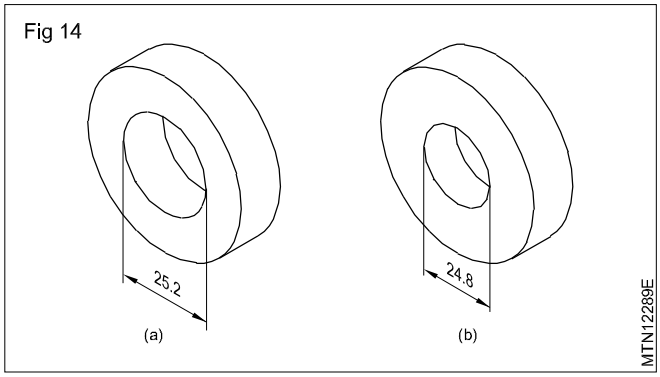
Fig 13



25.2 mm is known as the maximum limit. (Fig 14)

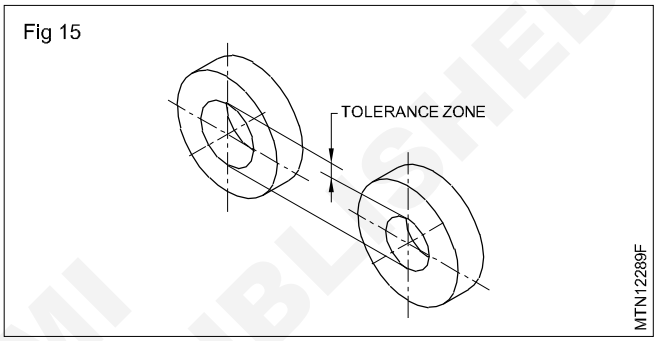
24.8 mm is known as the minimum limit. (Fig 14)

Fig 14



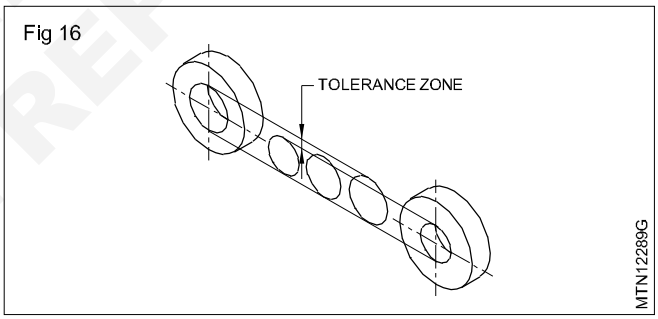
The difference between the maximum and minimum limits is the TOLERANCE. Tolerance here is 0.4 mm. (Fig 15)

Fig 15



All dimensions of the hole within the tolerance zone are of acceptable size as in Fig 17.

Fig 16



As per IS 696, while dimensioning the components as a drawing convention, the deviations are expressed as tolerances.

Drilling Machine (Portable Type)

Objectives: At the end of this lesson you shall be able to
- **state 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 of portable drilling machines: There are two types of portable drilling machines,

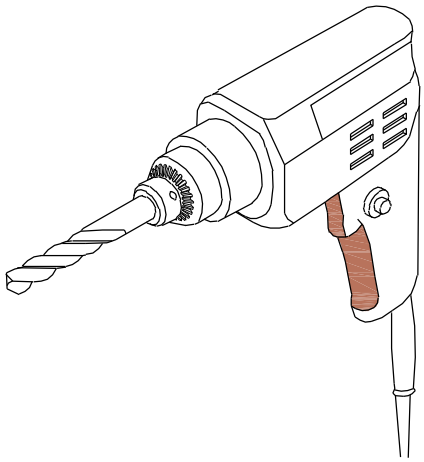
power operated and hand operated.

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



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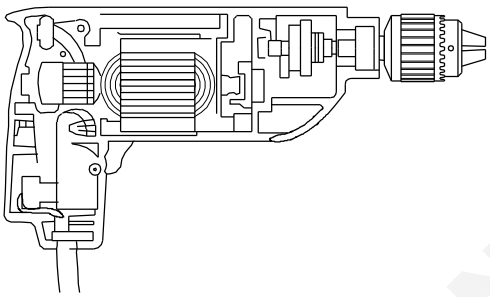
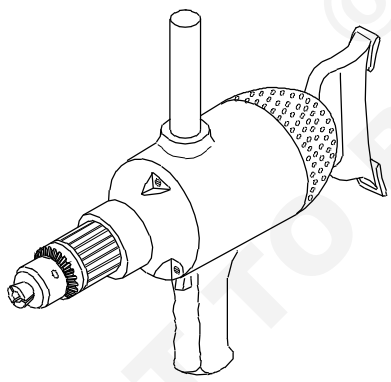
Electric hand drill (heavy duty) (Fig 2&3): This drill has an additional feature by which the drill speed can be varied through a system of gears. This is particularly useful for drilling larger diameter holes.

Fig 2



MTN122912

Fig 3



MTN122913

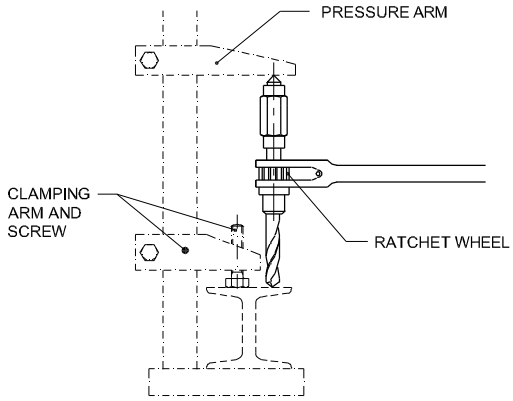
Hand operated drilling machines: Different types of hand operated drilling machines are shown below. They are used in structural fabrication, sheet metal and carpentry, particularly where electricity or pneumatic supply is not available.

The ratchet drilling machine (Fig 4) is commonly used in structural fabrication. Square head, taper shank drills are used on these machines.

The bevel gear type drilling machine (Fig 5) is used for drilling small diameter holes up to 6mm.

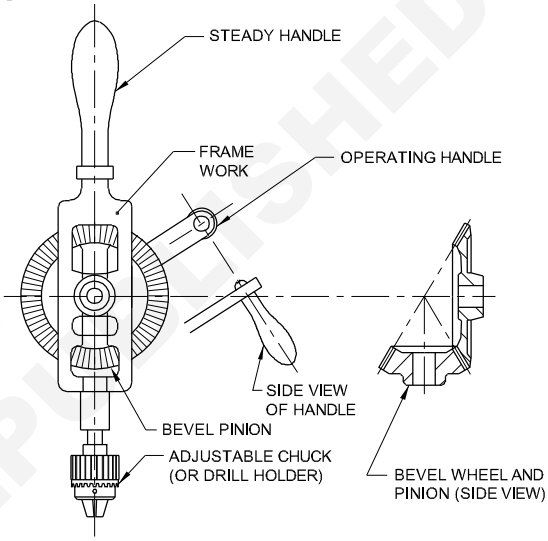
The breast drilling machine (Fig 6) is used for drilling holes of larger diameter as more pressure can be exerted. Drills between 6 mm to 12 mm can be used on these machines.

Fig 4



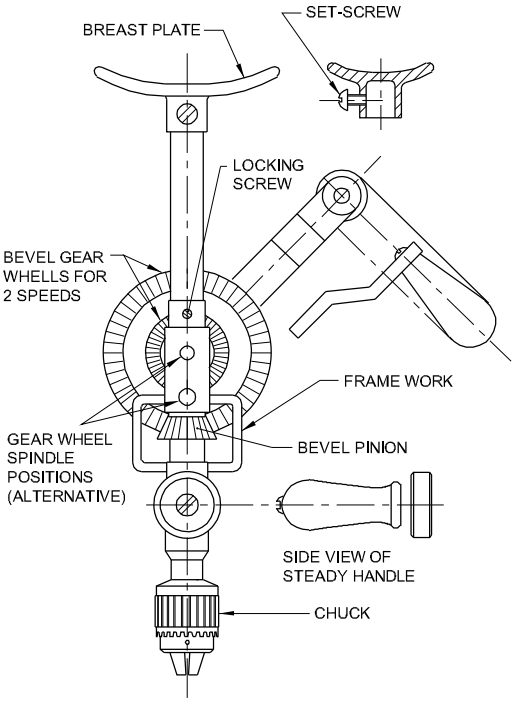
MTN122914

Fig 5



MTN122915

Fig 6



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Drilling machines (Bench type)

Objectives: At the end of this lesson you shall be able to
- **state the types of drilling machines**
- **identify the parts of bench type, pillar type and radial drilling machines and state the features.**

Types of drilling machine: The principle types of drilling machines are:

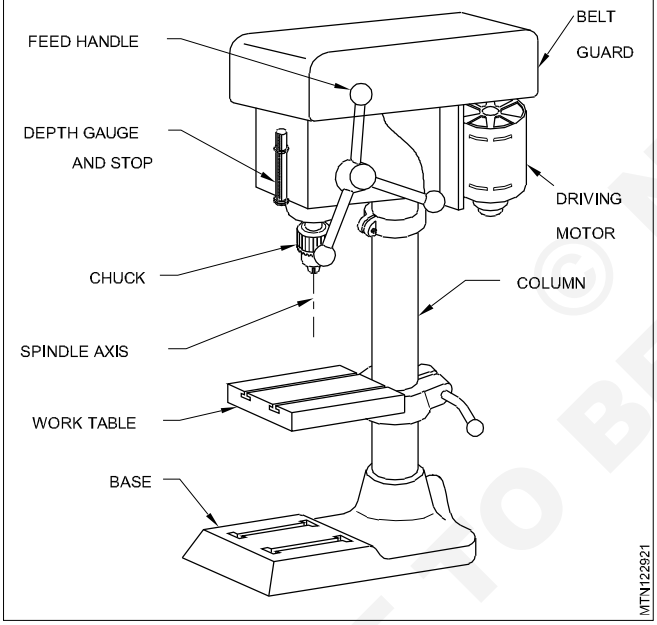
- the sensitive bench drilling machine
- the pillar drilling machine
- the column drilling machine
- the radial arm drilling machine (radial drilling machine).

(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)

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.

Fig 1



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.

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)

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 machines are available in different sizes.

Large machines are provided with a rack and pinion mechanism for moving the table for setting the work.

Fig 2

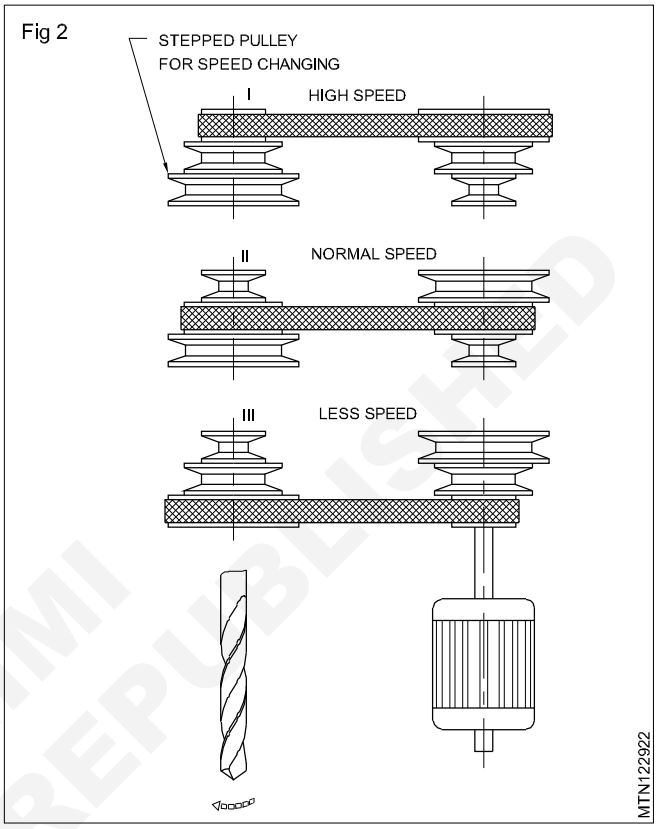
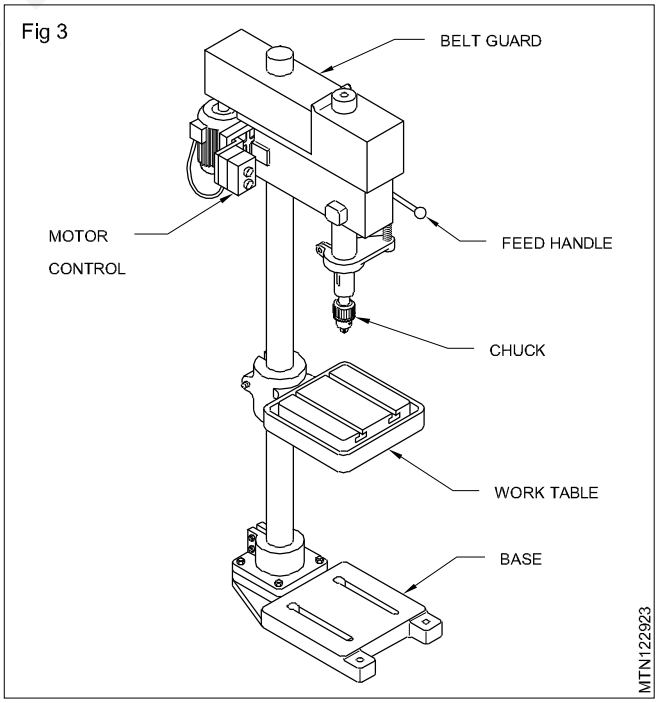


Fig 3



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

The radial drilling machine has a radial arm on which the spindle head is mounted.

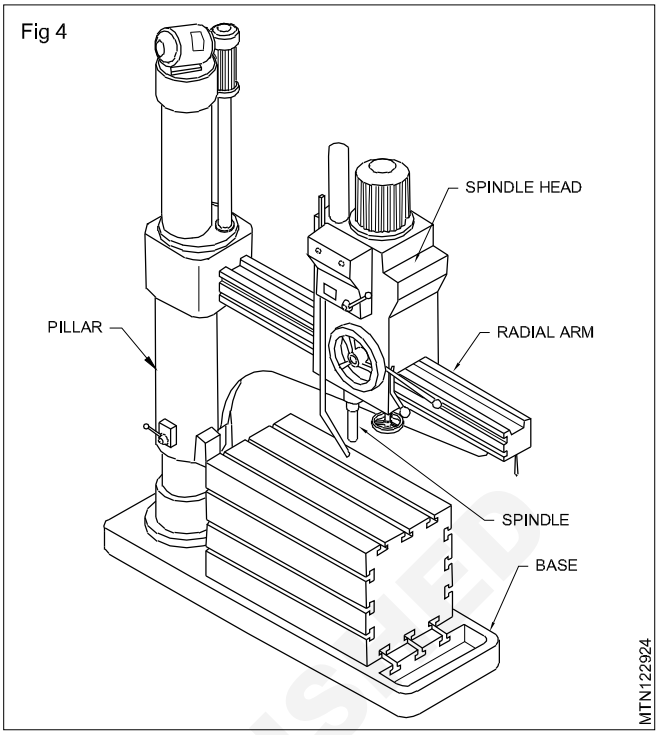
The spindle head can be moved along the radial arm and can be locked in any position.

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.

Fig 4



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 formula between 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

$$V = \frac{n \times d \times \pi}{1000} \text{ m/min}$$

$$n = \frac{v \times 1000}{d \times \pi} \text{ r.p.m}$$

n = r.p.m

v = cutting speed in m/min

d = diameter of drill in mm

b = 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 LC/MC steel/ Alloy steel	 35-45 20-30
Thermosetting plastic (low speed due to abrasive properties)	5-8

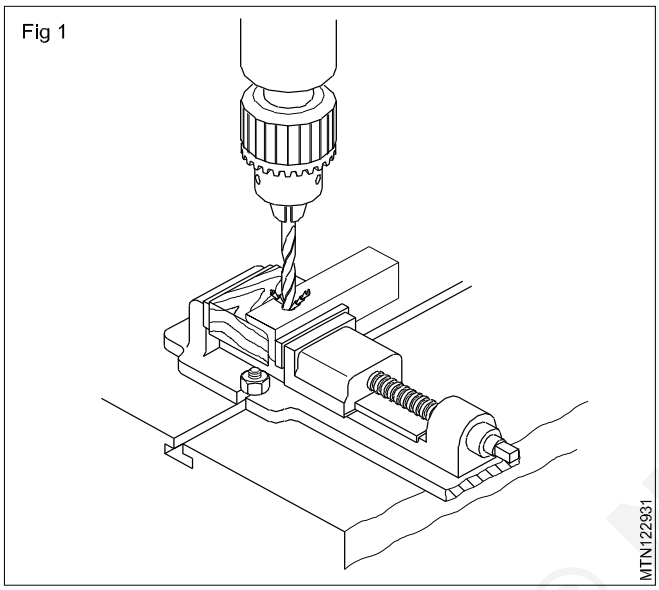
Work - holding devices

Objectives: At the end of this lesson you shall be able to
- **state the purpose of work-holding devices**
- **state 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)

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): 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 (Fig 4) and it is necessary to determine the clamping method according to the work.

Fig 2

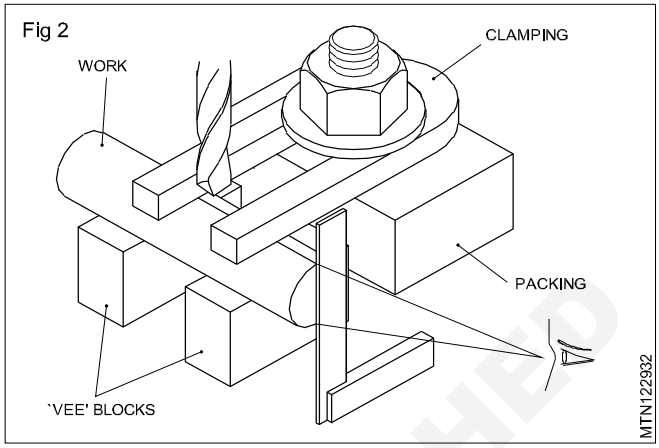


Fig 3

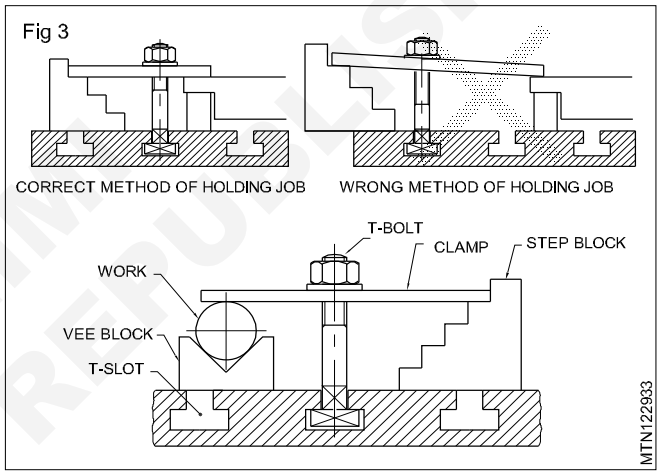
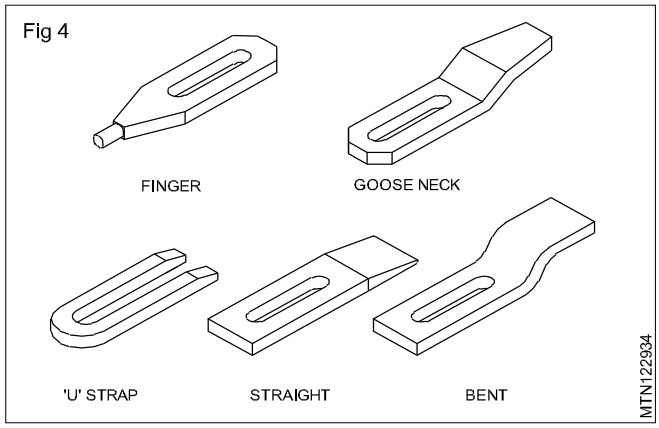


Fig 4



Drill - holding devices

Objectives: At the end of this lesson you shall be able to
- **state 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 on 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 spindle 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)

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.

Use a drift remove drills and sockets from the machine spindle. (Fig 3)

Fig 2

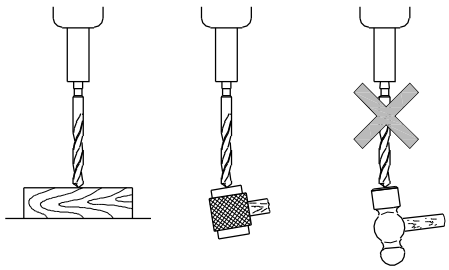
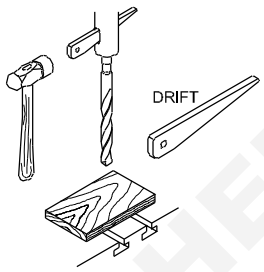


Fig 3



While removing the drill from the sockets sleeves, don't allow it to fall on the table or jobs. (Fig 4)

Fig 1

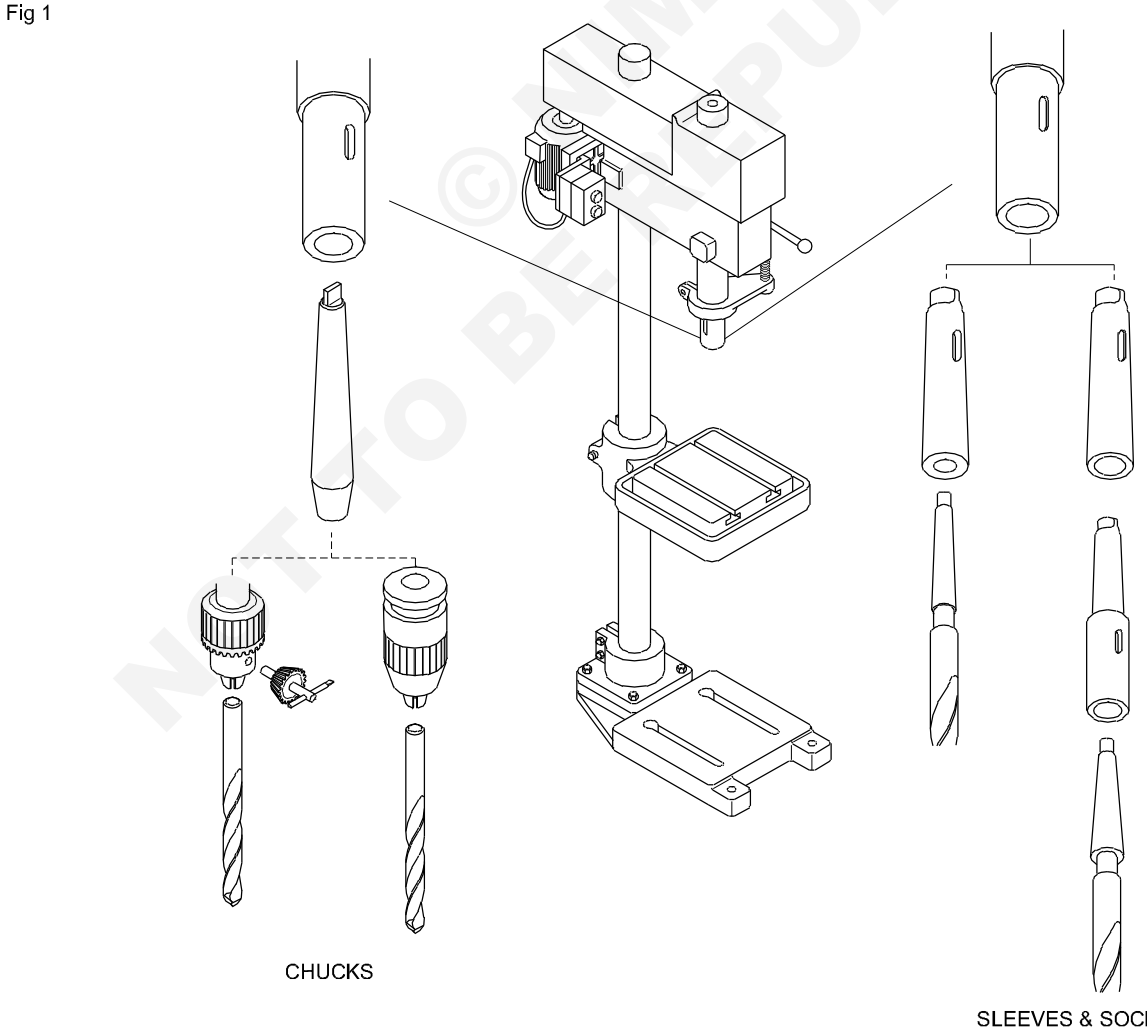
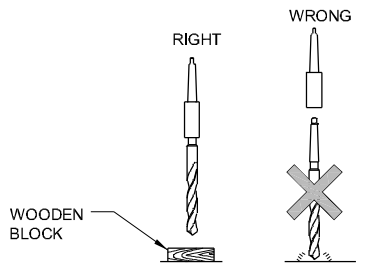


Fig 4



REMOVING A TAPER SHANK DRILL

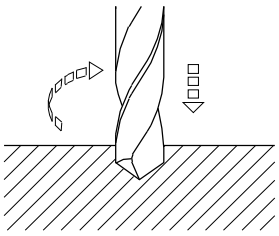
Drill bits

Objectives: At the end of this lesson you shall be able to
- **state the functions of drills**
- **identify parts of a drill and their function.**

Function of drills

Drilling is a process of making holes on workpieces. The tool used is a drill. For drilling the drill is rotated with a downward pressure causing the tool to penetrate into the material (Fig 1)

Fig 1

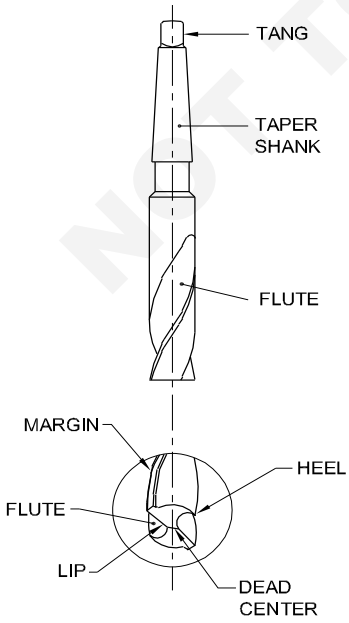


Parts of a Drill (Fig 2): The Various parts of a drill can be identified from Fig 2.

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.

Fig 2



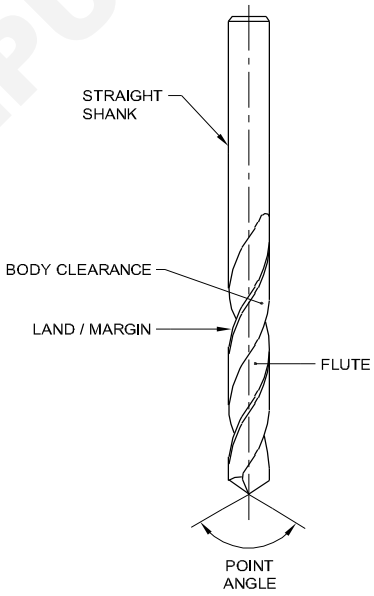
Taper shanks, used for larger diameter drills, and straight shank, used for smaller diameter drills.

Tang: This is a part of the taper shank drill which fits into the slot of the drilling machine spindle.

Body (Fig 3): 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.

Fig 3



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 allow 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.

Hand taps and wrenches

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.

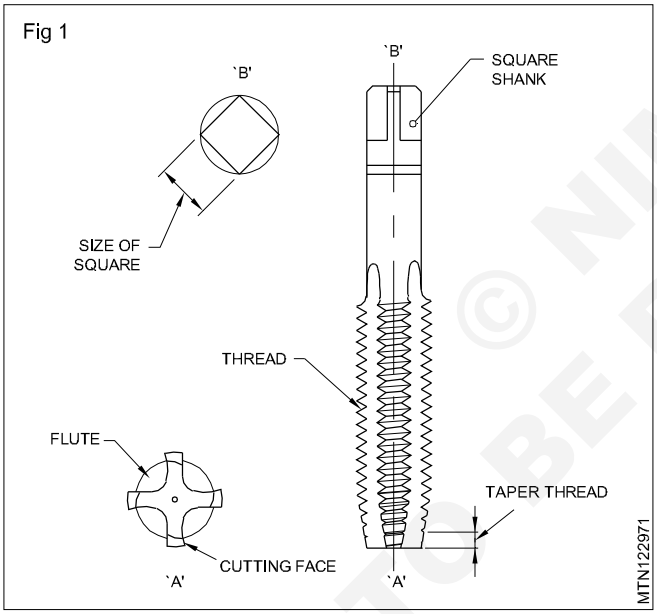
Features (Fig 1)

They are made from high carbon steel of high speed steel hardened and ground.

Threads are cut on the surface and are accurately finished.

To form the cutting edges, the flutes are cut across the thread.

Fig 1



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.

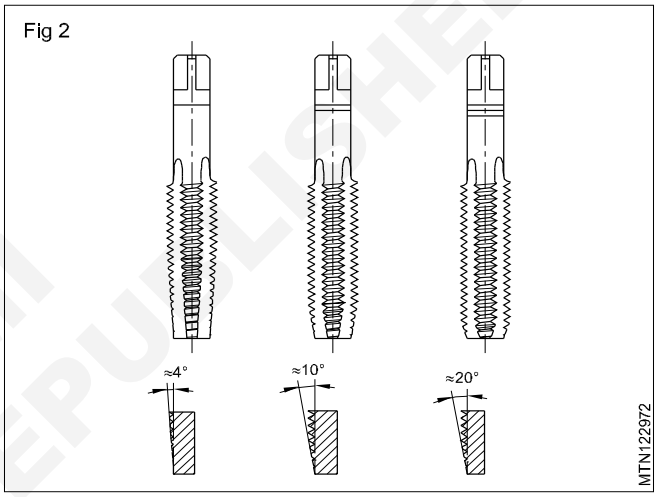
Markings are also made to indicate the type of tap i.e first, second final or plug tap.

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
- plug or bottoming tap

These taps are identical in all features except in the taper lead.

Fig 2



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 3)

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

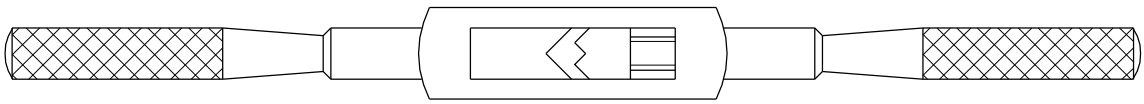
1 Double ended adjustable wrench

2 T handle tap wrench and

3 Solid type tap wrench.

1 Double ended adjustable wrench: Double ended adjustable tap Wrench or Bar Type Tap Wrench. This is shown in 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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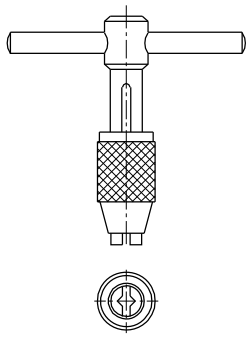
2 **T- Handle tap wrench (Fig 4):** These are small adjustable chucks with two jaws and a handle to turn the wrench. This tap wrench is useful to work in restricted places and is turned with one hand only. This is not suitable for holding large diameter taps.

Fig 4



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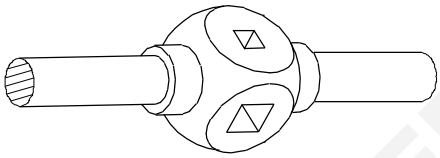
3 **Solid type tap wrench (Fig 5):** These Wrenches are not adjustable

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

Tap Drill size =

Major diameter = $\frac{1}{\text{No. of threads per inch}}$

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?

1 M 20 2 UNC 3/8

Refer to chart for determining the pitches of the thread.

TABLE FOR TAP DRILL SIZES - ISO METRIC

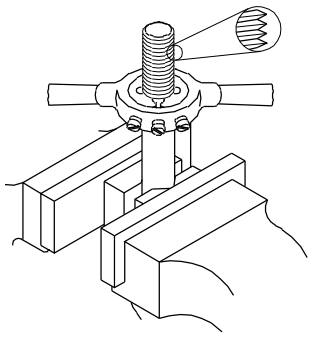
PITCH	0.25	0.3	0.35	0.4	0.45	0.5	0.6	0.7	0.75	0.8	1	1.25	1.5	1.75		2.5	3	3.5	4	4.5	5	5.55
1	0.85																					
1.1	0.95																					
1.2	0.96																					
1.4		1.10																				
1.6			1.25																			
1.8			1.45																			
2				1.60																		
2.2			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
- **state the use of each type of die**
- **name the different types of dies**
- **state the features 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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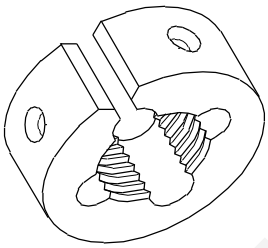
Types of Dies: The following are the different types of dies.

- 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.

Half Die (Fig 4)

Half dies are stronger in construction.

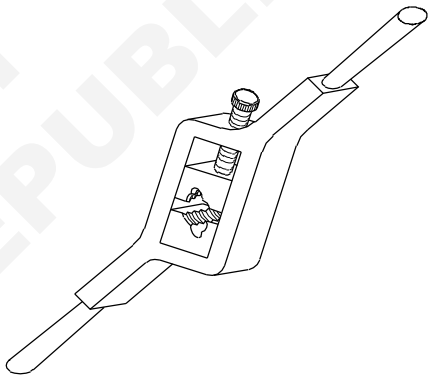
Adjustments can be made easily to increase or decrease the depth of cut.

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)

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.

Fig 3

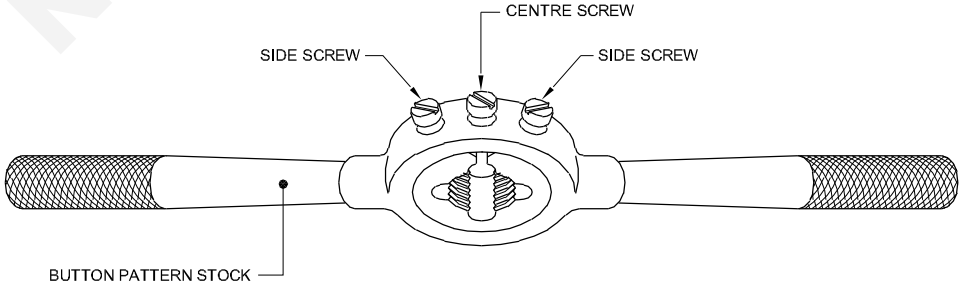

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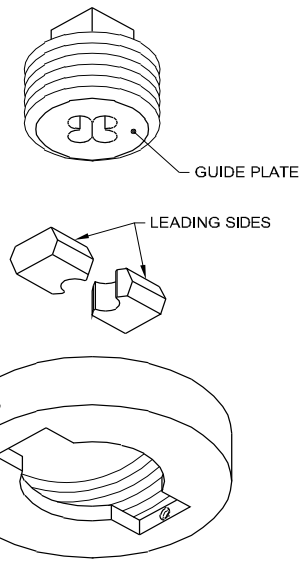
Fig 5



When the guide plate is tightened after placing the die pieces in the collar, the die pieces are correctly located and rigidly held.

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.

Die Nut (Solid Die) (Fig 7)

The die nut is used for chasing or reconditioning the damaged threads.

Die nuts are not to be used for cutting new threads.

The die nuts are available for different standards and sizes of threads.

The die nut is turned with a spanner.

Fig 7

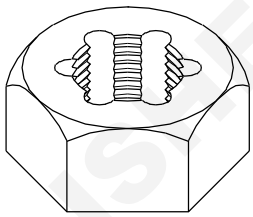
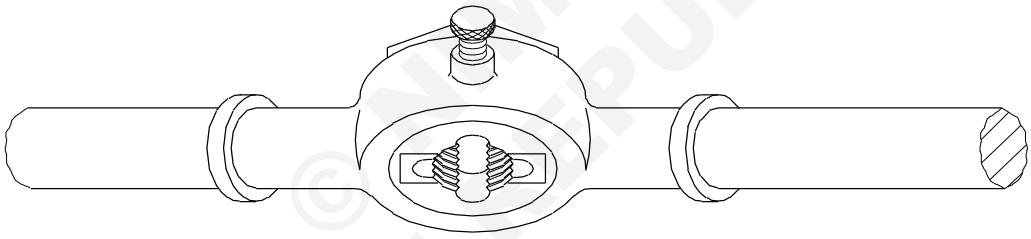


Fig 6

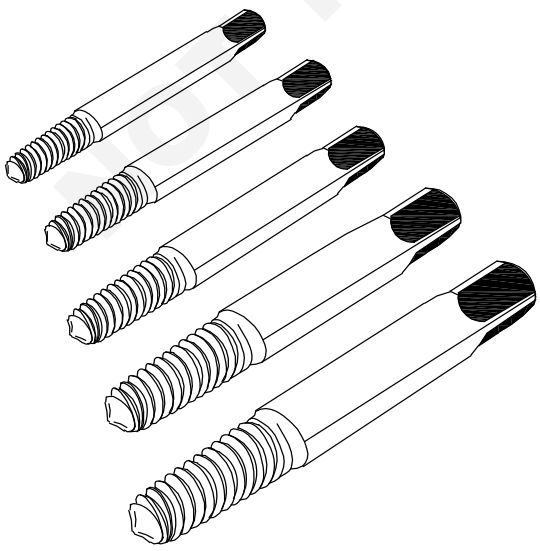


Screw extractor

Objective: At the end of this lesson you shall be able to
- **define screw extractor.**

Screw extractor (Fig 1)

Fig 1



SCREW EXTRACTOR

A screw extractor is a tool for removing broken or seized screws. A potential issue these extractors is that they may cause the fasteners to expand as they dig in, making it more difficult to remove, but they can make a reliable extraction on all but the most stuck fasteners.

To use after drilling a hole into the fastens, tap the screw extractor into the fastener, top the screw extractor into the hole using a hammer.

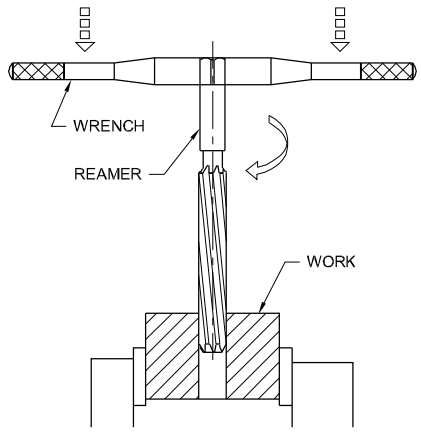
Reamers

Objectives: At the end of this lesson you shall be able to
- **define 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)

Fig 1



Advantages of 'reaming'

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

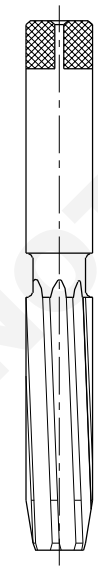


Fig 3

Reaming by using hand reamers is done manually for which great skill is needed.

Hand reamers have straight shanks with 'square' at the end for holding with tap wrenches. (Fig 2)

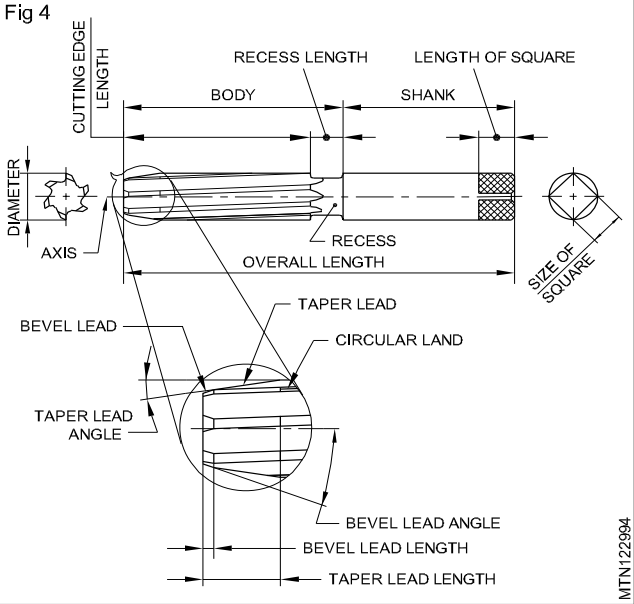
Machine reamers are fitted on spindles of machine tools by means of a floating chuck and are rotated for reaming.

Machine reamers are provided with Morse taper shanks for holding on machine spindles. (Fig 3)

Parts of a hand reamer

The parts of an hand reamer are shown in Fig 4.

Fig 4



Hole size for reaming

Objective: 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 practiced 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. (Table 1)

TABLE 1

Undersizes for reaming

Diameter of ready hole (mm)	Undersizes of bored board 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 = Reamer 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

Determining 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 surface finish, use a coolant while reaming. Remove metal chips from the reamer frequently advance the reamer slowly into the work.

Defects in reaming - Cause 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 are combination thereof.

- 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.**

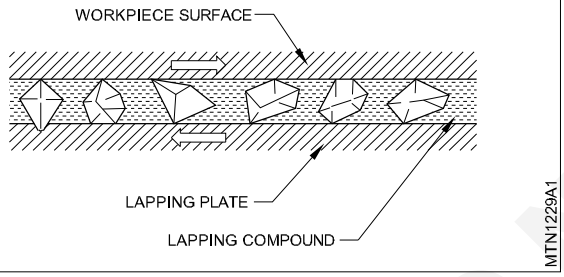
Lapping is a precision finishing operation carried out using line abrasive materials.

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.

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)

Fig 1

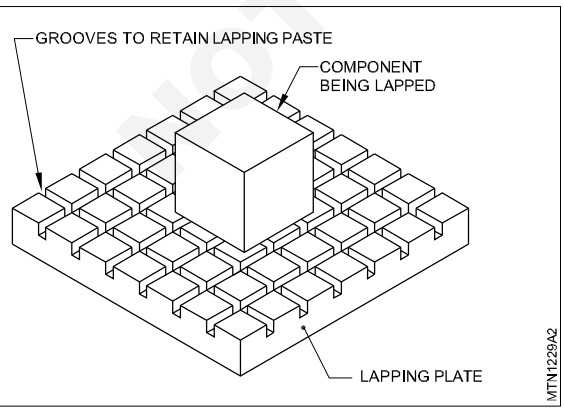


The lapping compound consists of the abrasive particles. Suspended in a vehicle such as oil, paraffin, grease etc.

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.

Fig 2



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.

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 can 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
- **state the different types of lap materials**
- **state the qualities of different lap materials**
- **state the different types of abrasive materials used for lapping**
- **distinguished between the application of different lapping abrasives**
- **state the function of lapping vehicles**
- **state the solvents used for 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
- Aluminium oxide
- Boron carbide
- Diamond.

Silicon carbide: This is an extremely hand abrasive. Its grit is sharp and brittle. While lapping the sharp cutting edges continuously 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-ferrous metals 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.

Introduction to electricity

Objectives: At the end of this lesson you shall be able to
- **describe electricity**
- **describe conductors, insulators and semi conductors.**

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.

Conductors Insulators and Semiconductors

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.

Ohm's Law

Objectives: At the end of this lesson you shall be able to
- **define EMF, PD, Current and resistance and state their units**
- **state the units of each term**
- **name the instruments used for measurement**
- **define ohm's law**
- **explain close circuit, open circuit and short circuit**
- **distinguish of AC and DC meters**
- **explain pire wheel.**

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 the voltage.

The voltage developed by a source such as a battery of a generator is called its 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 passes 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 "W" Bigger units are Kilo ohms and Mega ohms.

1 K W = 10^3 ohms

1 Mega W = 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.

Electrical measuring instruments and electrical circuits

Objectives: At the end of this lesson you shall be able to
- **explain the connection of an ammeter in the circuit**
- **state the use of an ammeter**
- **explain the care to be taken of an ammeter**
- **explain the connection of a voltmeter**
- **explain the use of a voltmeter**
- **explain the care to be taken of voltmeters**
- **explain the connection of an ohmmeter**
- **state the use of an ohmmeter**
- **explain the care to be taken of ohmmeters**
- **explain the maintenance of meters**
- **state simple electric circuit**
- **state open electric circuit**
- **state short electric circuit**
- **state series circuits & parallel circuits**
- **list the types of resistance**
- **explain resistance symbols used in wiring diagram.**

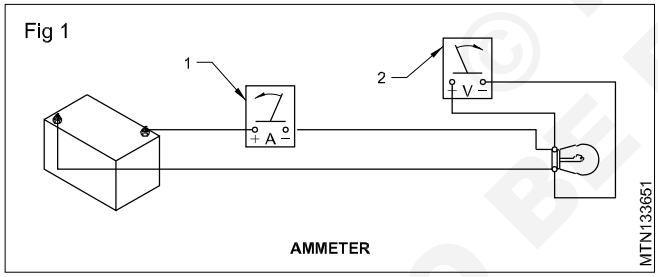
There are three basic types of meters used to test the electric circuit and accessories. The following meters are used in automobiles.

- Ammeter
- Voltmeter
- Ohmmeter

Ammeter (Fig 1): 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.

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 (1) is also known as resistance meter.

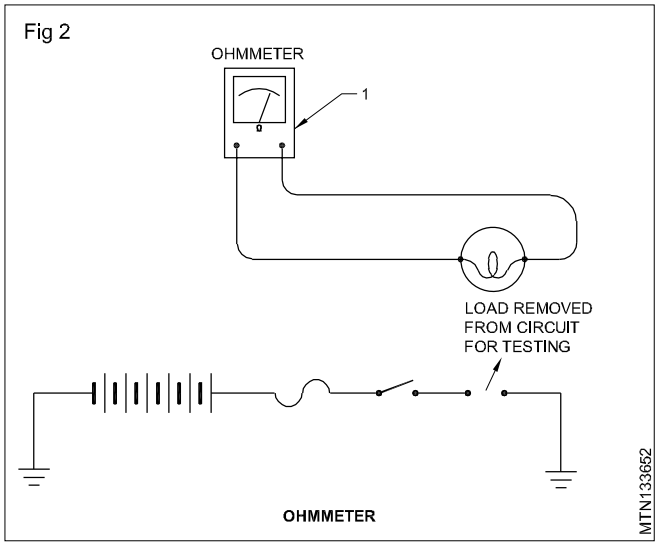
It is not fitted permanently on the vehicle but is used separately whenever required.

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

Fig 2



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.

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)

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 :

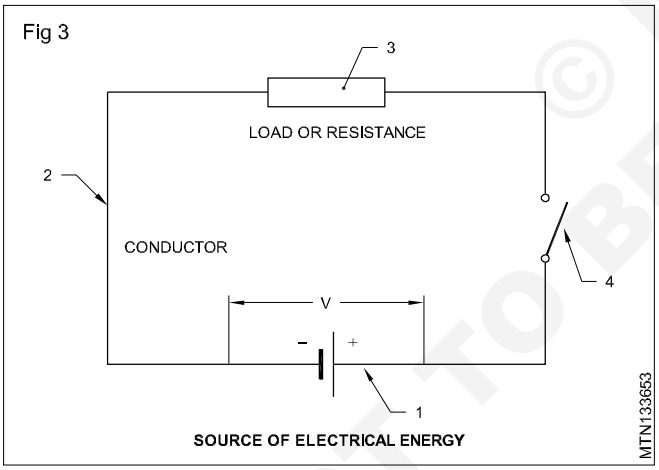
– a voltage source (1)

– connecting wires (conductors) (2)

– a load (lamp or motor) (3)

– switch (4).

Fig 3



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.

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 4

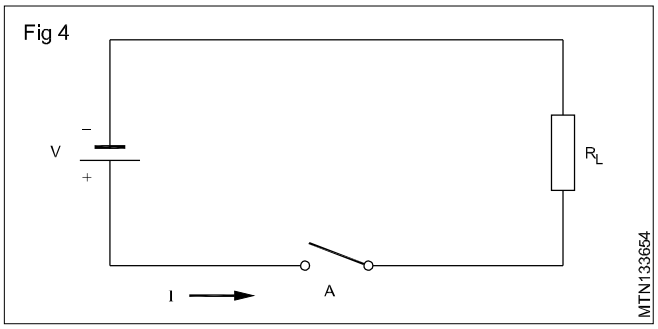
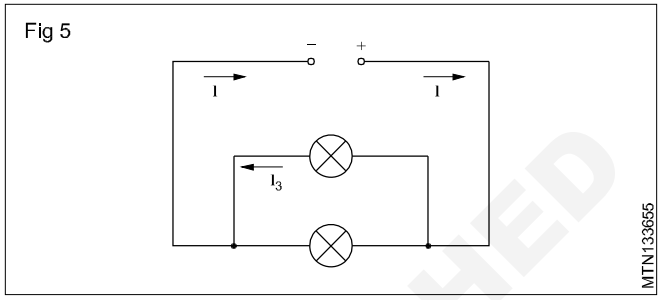


Fig 5



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. If three resistances R_1, R_2, R_3 are connected in series then the total resistance R is given by the formula $R = R_1 + R_2 + R_3$.

$$\text{Resistance(R)} = \frac{\text{Voltage(V)}}{\text{Current(I)}}$$

$$\text{Current(I)} = \frac{\text{Voltage(V)}}{\text{Resistance (R)}}$$

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

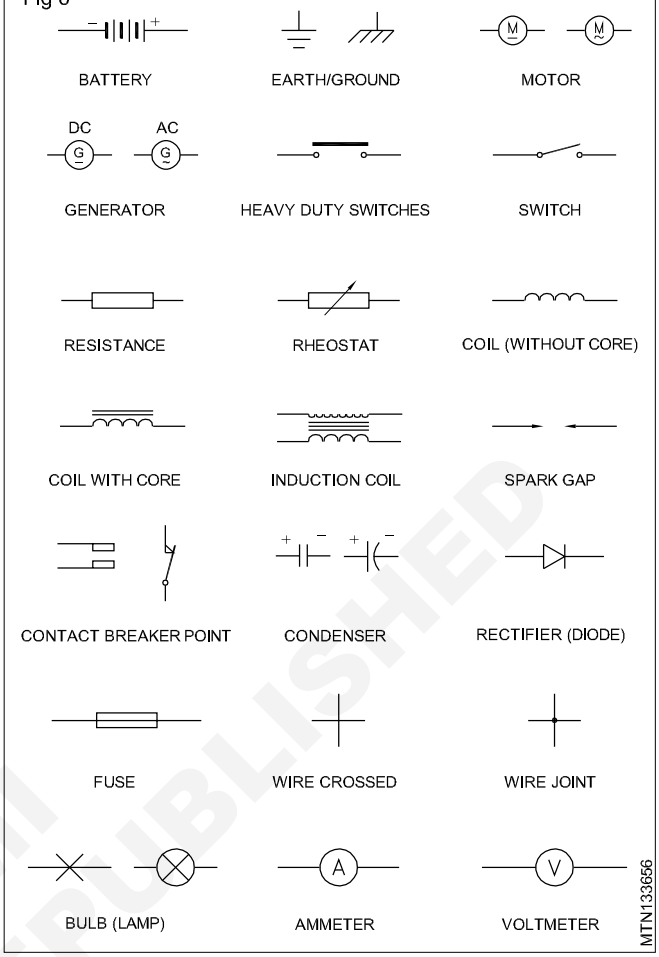
Range : Above 1,00,000 Ohm (100 k.Ohms).

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.**

Function of 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;

i Ordinary multimeters having passive components.

ii Electronic multimeters having active and passive components. 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.

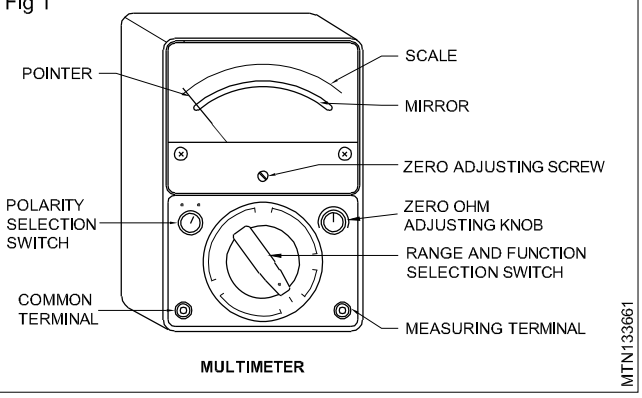
There are several types of multimeters available in the market, manufactured by various manufactures. Each model differs from the others by the extra facilities available. It is a versatile tool for all automobile. With proper usage and care, it could give service for many years.

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



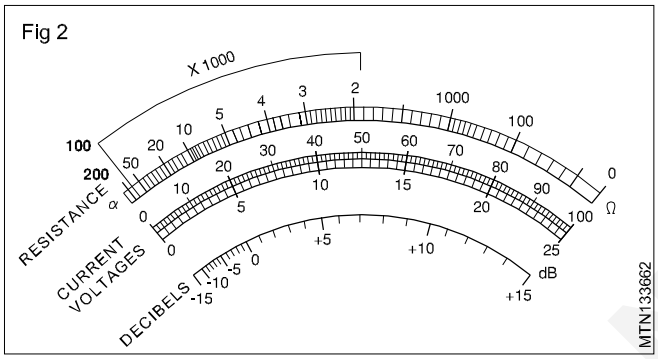
MULTIMETER

Scale of multimeter: Separate scales are provided for;

- Resistance
- Voltage and current.

The scale of current and voltage are uniformly graduated (Fig 2)

Fig 2



The scale for resistance measurement is non-linear. That is, the divisions between zero and infinity (∞) 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

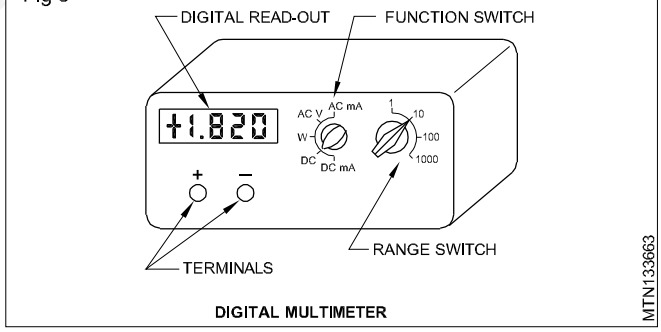
Shunt (parallel) resistors are used to provide multiple ranges so that the meter can measure resistance values from very small to very large values. For each range, a different value of shunt resistance is switched on. The shunt resistance increases for the higher ohm ranges and is always equal to the 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.

Digital multimeter (DMM)

In a digital multimeter the meter movements is replaced by a digital read - out. (Fig 3) 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.

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.

Fig 3



DIGITAL MULTIMETER

Resistors

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

- **name the types of resistors, construction and power rating**
- **state the meaning of tolerance in resistor**
- **find the value of a resistor using colour code**
- **state the application and types of resistor leads.**

Fixed value resistors

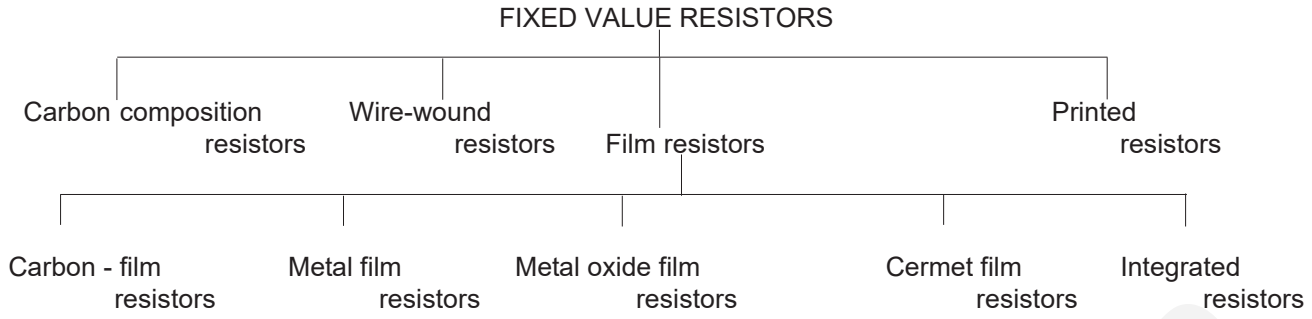
Its ohmic value is fixed. This value cannot be changed by the user. Resistors of standard fixed values are manufactured for use in majority of applications.

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.

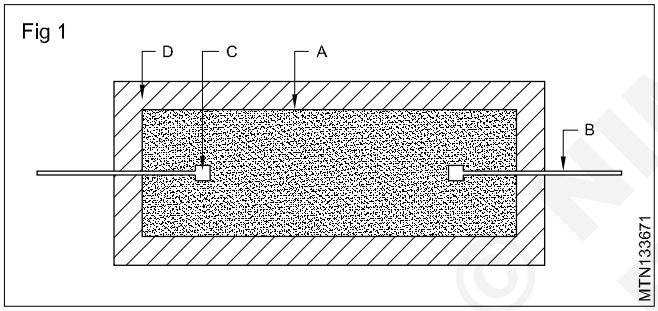
Fixed value resistors can be classified based on the type of material used and the process.

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.

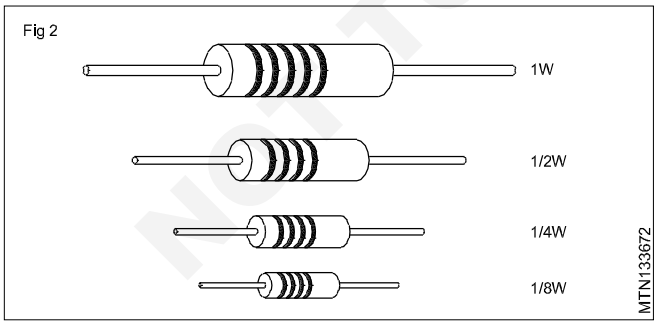


A mixture of finely powdered carbon or graphite(A), filler and binder is made into rods or extruded into desired shapes. Leads(B) made of tinned copper are then attached to the body either by soldering or embedding(C) in the body. A protective layer/tube(D) of phenolic or Bakelite is moulded around the assembly. Finally its resistance value is marked on the body. (Fig 1)

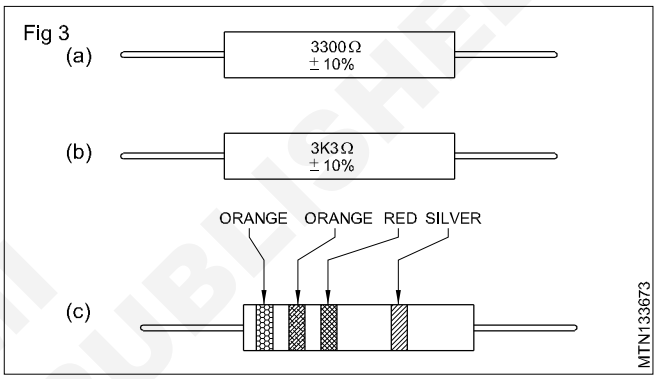


Resistor values - coding schemes (Fig 2)

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. Table 1 at the end of this lesson illustrates the physical appearance of most commonly used fixed value resistors. 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.

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

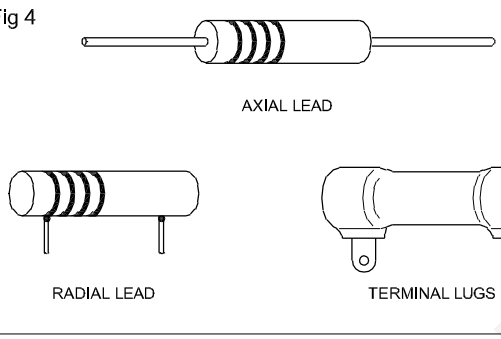
Tolerance: In bulk production/ manufacturing of resistors, it is difficult and expensive to manufacture resistors of particular exact values. Hence the manufacturer indicates a possible variation from the standard value for which it is manufactured. This variation will be specified in percentage tolerance. Tolerance is the range (max -to- min) within which the resistance value of the resistor will exist.

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.

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



Fuse

Objectives: At the end of this lesson you shall be able to
- **state the need of a fuse in the circuit**
- **explain the construction of a fuse**
- **list out the types of fuses**
- **explain the working of fuses**
- **explain the circuit with and without a fuse**
- **explain 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.

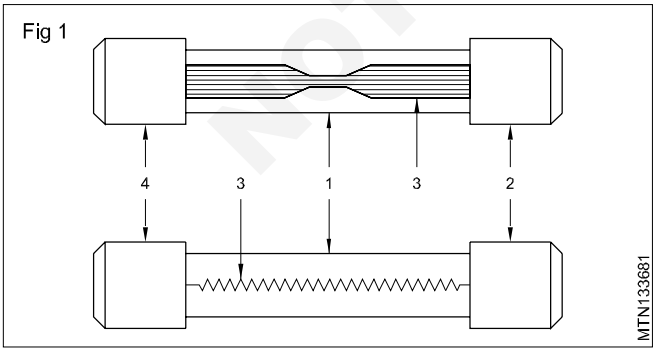
In automobiles, this heating effect is utilized in heaters, bulbs and gauges etc.

The heating effect in the circuit is limited by the fuse. If this limit is not controlled, the circuit an accessories will be overloaded causing severe damage to them.

Purpose of fuse (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.

Fig 1



Construction

Fuse elements are of lead-tin or tin-copper alloy wire in strip of correct amperage for each circuit.

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.

The glass is foggy white or black the fuse is blown out due to short circuit.

Circuits protected with fuse

- Headlight circuit
- Tall - light circuit
- Number - plate circuit
- Panel lamp circuit
- Interior lamp circuit
- Side indicator circuit
- Horn circuit
- Wiper circuit

- Dashboard / panel instruments circuit
- Header and air conditioner
- Charging circuit
- Radio
- Cigarette lighter
- Reverse lamp

Circuits without fuse

- Starting circuit
- Ignition circuit
- Fuel pump
- Stop - light circuit
- Oil pressure lamp circuit
- Ignition warning lamp circuit.

Fuse rating and colour

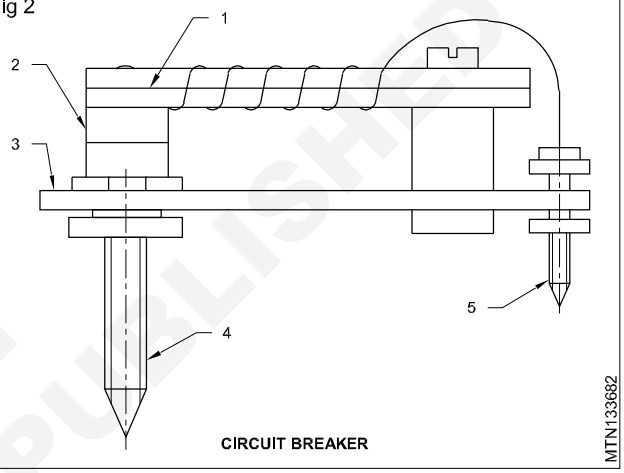
Rating	Colour
3 Amp	Violet
5 Amp	Tan
10 Amp	Red
20 Amp	Yellow
25 Amp	White
30 Amp	Light green

Circuit Breaker (Fig 2): These units are regarded as a non- replaceable type of fuses. Generally fitted in the headlight circuit, it consists of a bimetallic strip (1) with moving contact (2). A fixed contact (3) is provided with the terminals (4) & (5). The strip (1) bends as soon as the current exceeds the maximum permissible value for the electrical component concerned. This way it opens the points to break the circuit. When this type of device is used in the lighting circuit, the lamp will light and then go out. Thus giving an indication of a faulty circuit. The circuit breakers are made in ratings up to 50 amps.

Rectifiers are provided inside the meter to convert AC to DC in the AC measurement circuit.

Ballast resistor: A ballast resistor is a resistor inserted into a circuit to compensate for different changes in a circuit. A resistor that has the property of increasing in resistance as current flowing through it increases, and decreasing in resistance as current flows through it decreases.

Fig 2



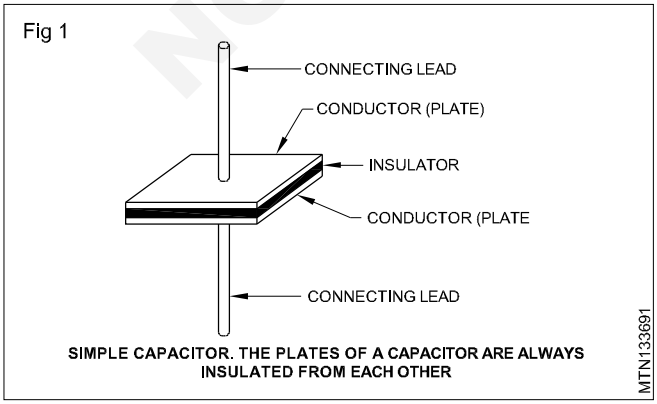
Capacitors

Objectives: At the end of this lesson you shall be able to
- **describe a capacitor**
- **brief construction and function of a capacitor**
- **brief how does a capacitor store energy**
- **state the units of capacitance**
- **state parallel and serial 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'.

Capacitance: 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) & a volt is the unit of voltage (V).

Capacitors are widely used as parts of electrical circuits in many common electrical devices. Ex. Ignition circuit.

Parallel Capacitors: Capacitors connected in parallel will add their capacitance together.

$C_{total} = C_1 + C_2 + ... + C_n$

A parallel circuit is the most convenient way to increase the total storage of electric charge.

The total voltage rating does not change. Every capacitor will 'see' the same voltage. They all must be rated for at least the voltage of your power supply. Conversely, you must not apply more voltage than the lowest voltage rating among the parallel capacitors.

$$C_{total} = \frac{1}{\frac{1}{C_1}+\frac{1}{C_2}+...+\frac{1}{C_n}}$$

Series Capacitors: Capacitors connected in series will have a lower total capacitance than any single one in the circuit.

This series circuit offers a higher total voltage rating. The voltage drop across each capacitor adds up to the total applied voltage.

Series capacitors are generally avoided in power circuits

Total capacitance: When capacitors are connected in series, the total capacitance is less than the smallest capacitance value, because;

- The effective plate separation thickness increase
- The effective plate area is limited by the smallest plate.

The calculation of total series capacitance is analogous to the calculation of total resistance of parallel resistors.

Fig 2

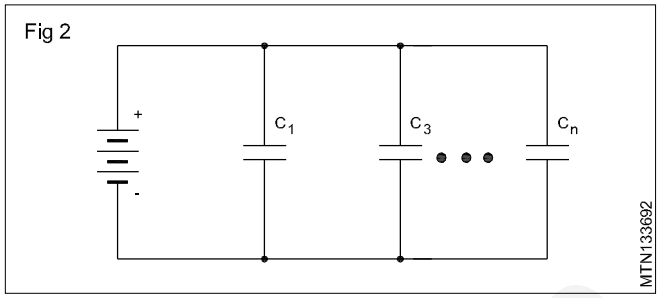
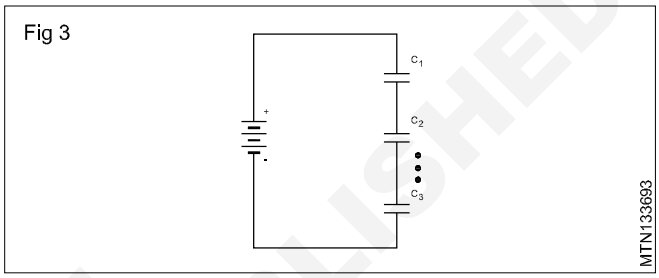


Fig 3



Tracing of auto electrical components in a circuit

Objectives: At the end of this lesson you shall be able to
- **describe automobile cables**
- **state the colour coding in wiring**
- **state the purpose of colour coding.**

Description of automobile 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 and wirings

In automobiles a number of electric circuits are connected to the battery which is quite complicated.

The large number of cables are braided into a single harness 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 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.

Colour coding: The colour coding for electrical system provides easy identification each circuit vehicles conform to the colour coding standard when used in conjunction with the wiring diagram. The colour coding may vary from model to model. But the colour coding adopted for a particular model is clearly given on the makers wiring diagram.

Standard colour coding

Standard colour coding should be adopted for motor vehicle wiring. In every electrical unit, three wires or conductors are used to enable the circuit to be completed, i.e., feed wire, switch wire and return wire. In vehicles, the metal chassis is used for return wire

(ground return), in some case the switch is incorporated in the unit. In some units, the switch is placed in the return side of the unit instead of on the feed side. Certain accessory circuits are fed through the ignition switch and certain auxiliary lighting circuits through the side and tail lamp switch.

Main feed colour: There are seven main feed colours, each of which is allocated to a particular circuit. Feed wires are braided in the main circuit colour, switch wires are braided in the main colour but carry also a coloured tracer woven spirally into the braiding, return or ground leads are black.

1 **Brown:** Battery circuit interior light, horn, control box, ammeter, ignition switch.

2 **Yellow:** Generator circuit - generator terminals to control box terminals and ignition warning light.

3 **White:** Ignition circuit - all units which are wired through the ignition switch and which are essential for the starting and running of the vehicle and which are not fused, i.e., electric control pump, starting motor, solenoid switch, etc.

4 **Green:** Fused auxiliary circuits which are feed through the ignition switch, i.e., stop lamps, fuse gauge, direction indicators, windshield wiper, etc.

5 **Light green:** Flasher unit to flasher indicator waving light.

6 **Blue:** Headlamp circuit fed from terminal on lighting switch. Included in this circuit are fog lamps, panel lights, door lights, etc., which are only required when the side lamps are switched on.

7 **Black:** All ground wired. If a unit do not internally grounded or is mounted on an insulated portion of the vehicle, a cable must be connected from the body of the unit to a good ground point on the chassis.

Cable sizes: Cable size are indicated by the number of strands of wire followed by the diameter of each strand measured in thousands of an inch, e.g. 14/0.12, i.e., fourteen strands of twelve thou' wire (30 SWG)

On 12 volt systems, as generally used on the vehicles, the current carrying capacity of cables having copper conductors can be reckoned as follows

Cable size	Current carrying capacity (amps)
44/0.012	22
28/0.012	14
14/0.012	7

The following cable sizes should generally be used when rewiring the vehicle.

Main battery feed circuit	44/0.012
Main charging circuit	28/0.012
Field circuit	14/0.012
Ignition circuit	14/0.012
Accessories	14/0.012
Side and tail lamps	14/0.012
Head lamps	28/0.012

Circuit tracing

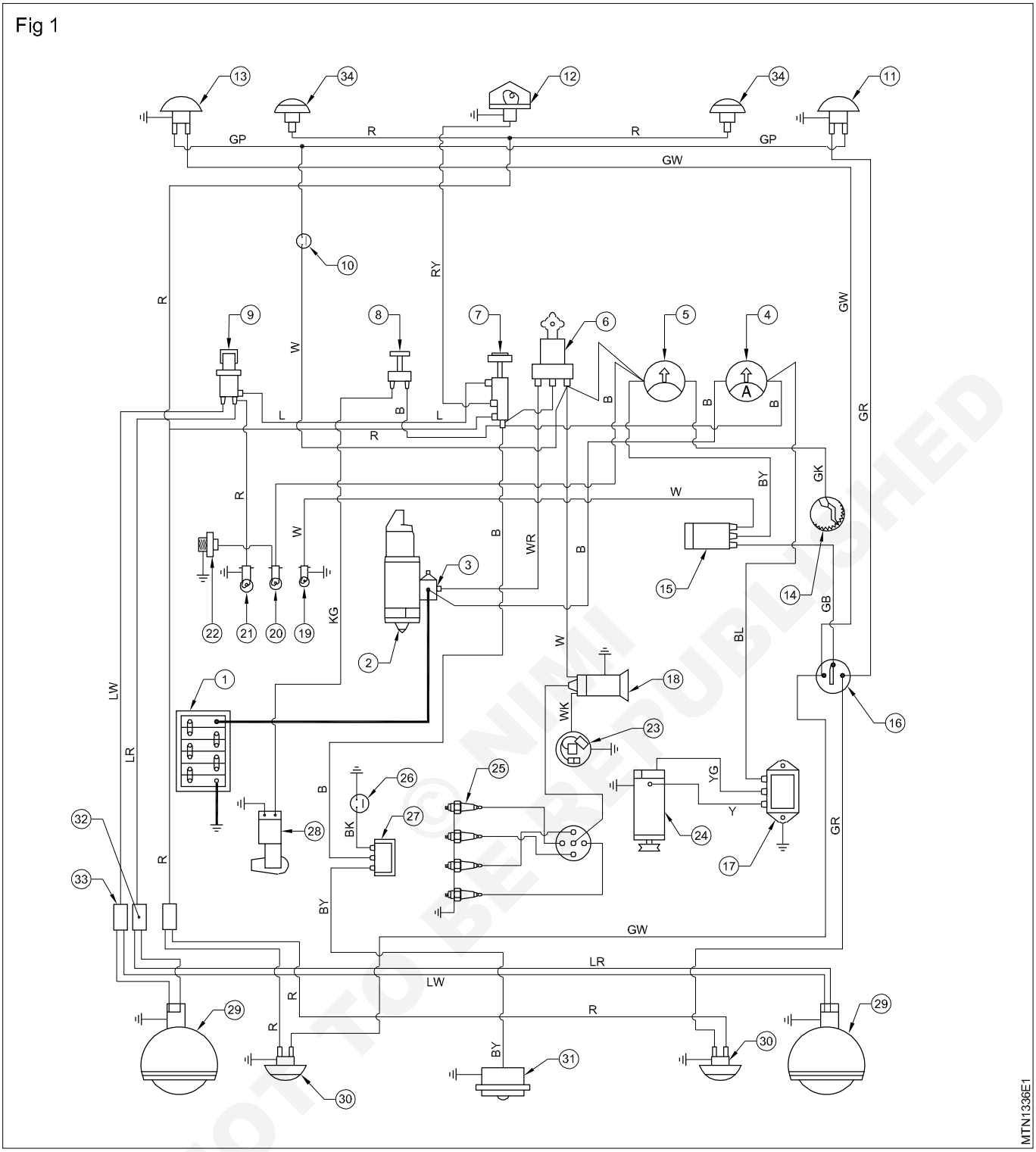
The tracing or checking of the car wiring system is considerably simplified if the principle of feed wire, switch wire and return wire is considerably accepted. The feed wire must be interpreted as being from the extreme limit of the run, i.e., from the terminal post of the battery to its destination on the switch or control. A feed wire can comprise two or three distinct sections of various size cables and each section can be utilised as a section of more than one independent feed.

For switch wire circuits, a similar layout is adopted which would start from the appropriate lighting switch terminal to a junction box or multiple snap connector, following through the destination via a joint at a further snap connector and finally coupled to the lamp unit by a further feed wire.

The return circuit is mainly by way of the vehicle chassis and is coupled to the battery terminal post by means of a short length of heavy starter size cable or heavy flexible woven copper braid.

Electrical continuity must be maintained correctly. A suitable sized bonding or ground coupling must be used where electrical coupling is likely to be impaired by resistance or intermittent contacting. Usually, the switch is placed on the insulted side of the circuit but sometimes it is inserted on the ground side of the unit as with the steering - column horn switch which is coupled direct to the horn or through the horn relay. Bu adopting these methods, considerable length of cable is saved and more compact wiring is done.

Fig 1



Battery

Objectives: At the end of this lesson you shall be able to
- **state classification of cells**
- **explain the construction of a lead acid battery**
- **explain the chemical action during discharging**
- **explain the chemical action during charging**
- **explain maintenance of a battery**
- **explain testing of a battery**
- **explain battery selection and rating**
- **explain battery charging method**
- **explain advantages of maintenance free battery.**

Scan the QR code to view the video for this exercise

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.

- Voltaic 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 (Fig 1&2)

Fig 1

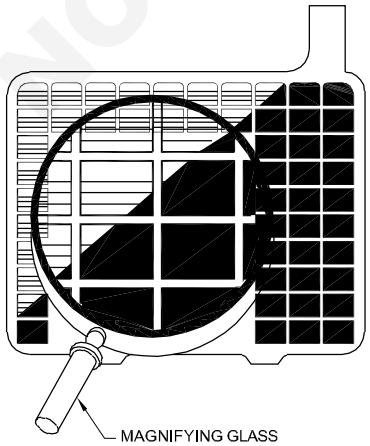
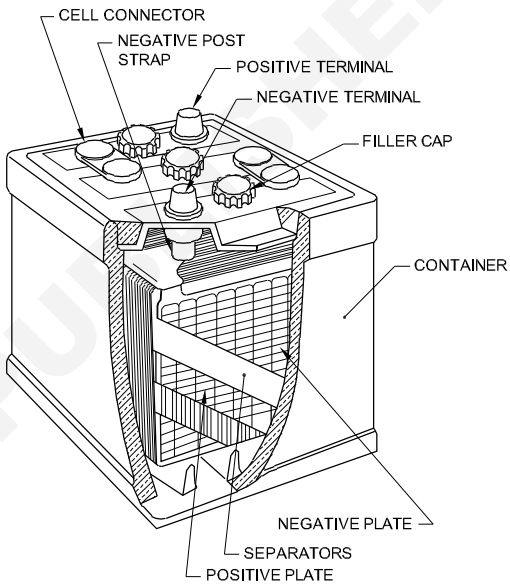


Fig 2



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.

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

alternatively, and in between the plates, separators 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 out.

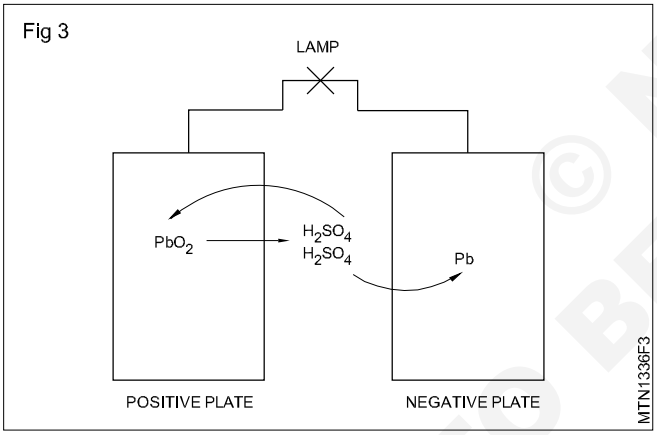
Chemical Reactions

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.

$$\underset{\text{(+ve)}}{PbO_2} + \underset{\text{(electrolyte)}}{2H_2SO_4} + \underset{\text{(-ve)}}{Pb} \rightleftharpoons \underset{\text{(+ve)}}{PbSO_4} + \underset{\text{(water)}}{2H_2O} + \underset{\text{(-ve)}}{PbsO_4}$$

Fig 3



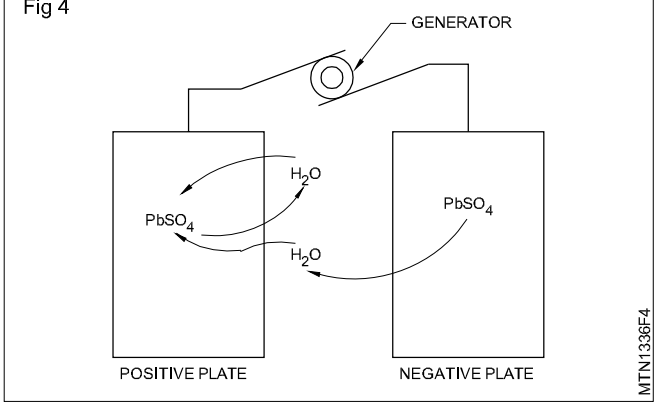
Charging (Fig 4)

When the battery is charged 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.

$$\underset{\text{(+ve)}}{PbSO_4} + \underset{\text{(water)}}{2H_2O} + \underset{\text{(-ve)}}{PbSO_4} \rightleftharpoons \underset{\text{(+ve)}}{PbO_2} + \underset{\text{(Electrolyte)}}{2H_2SO4} + \underset{\text{(-ve)}}{Pb}$$

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.

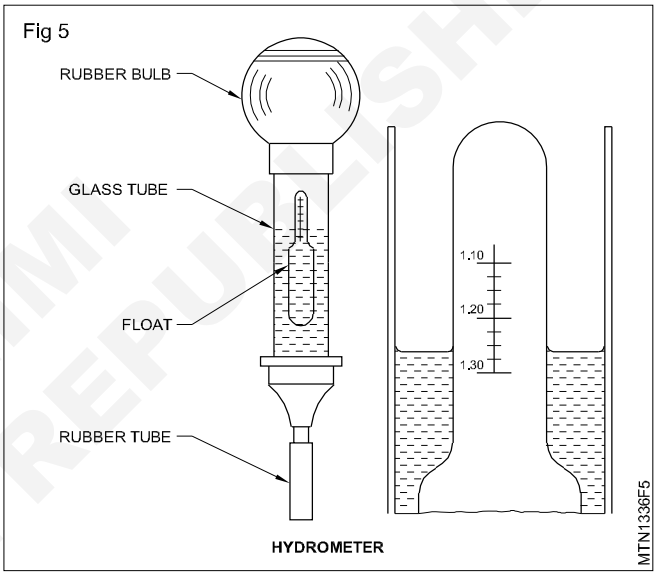
Fig 4



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.

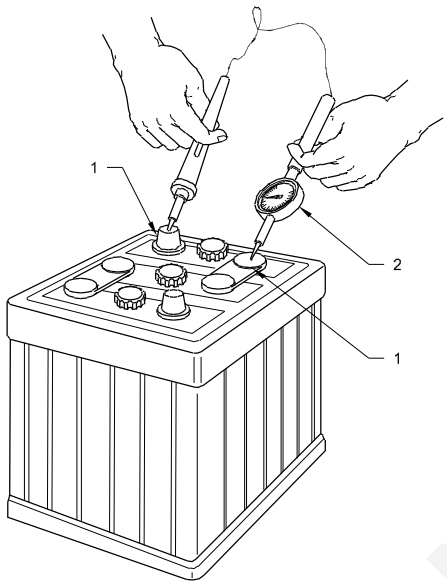
Keep the battery terminals always tight and clean.

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.

Fig 6



The current required to crank on engine can range from 150A to over 500A 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.

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 importance 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	1300 Diesel vehicles
60 Amps 12V	2.5 Lit LCV
80 Amps 12V	4 Lit medium
120 Amps 12V	6 Lit Diesel HCV
180 Amps 12V	6 Lit 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.

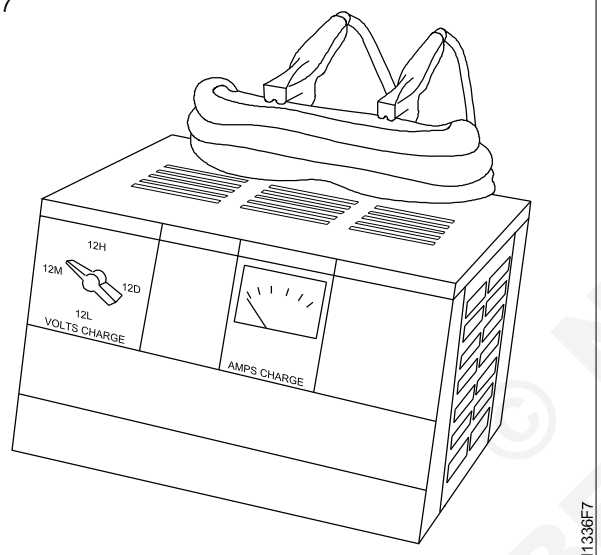
Battery is fully charged when over a two hour period at a low charging rate in amperes all cells are gassing freely and no change in specific gravity occurs. For the most satisfactory charging, the lower charging rates in amperes are recommended.

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

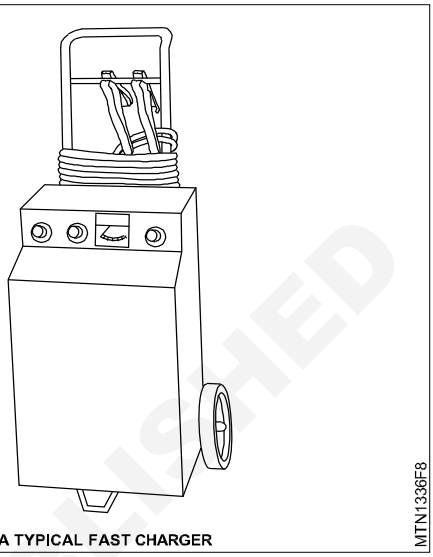


A TYPICAL SLOW CHARGER

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 through out the life.
- Seal construction ensures no leakage of electrolyte from terminal or casing.

Benefits

- Saving of 100 liters 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.

Solenoid & relay

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

- **define a relay**
- **classify relays according to the operating force and function**
- **explain the function of current sensing relay & Voltage sensing relay**
- **state solenoid and its application**
- **describe a solenoid switch and its function.**

Relay: A relay 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.

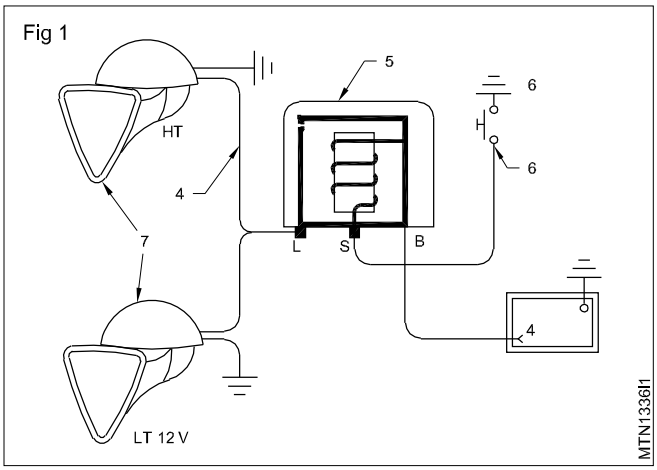
There are relays that are sensitive to conditions of voltage, current, temperature, frequency or some combination of these conditions.

Classification of relays: 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 some 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 upper 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).

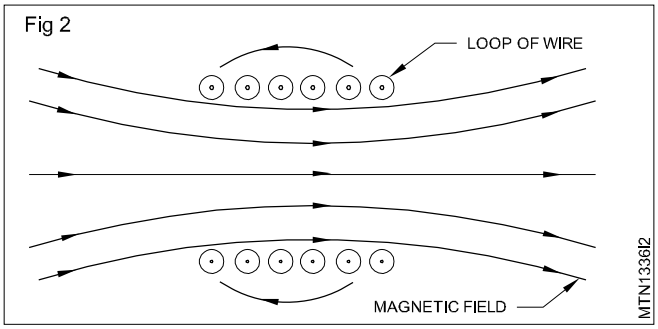
Voltage sensing relay: A voltage sensing relay is used where a condition of under - voltage or over - voltage may cause a damage to the equipment. For example, these types of relays are used in voltage stabilizers. Either a proportional AC voltage derived from a transformer or a proportional DC derived 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 wrapped around a metallic core, which produces a uniform magnetic field in a volume of space. (Fig 2)

Application

Need for solenoid switch: The solenoid 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 battery and the staring motor.

Fig 2

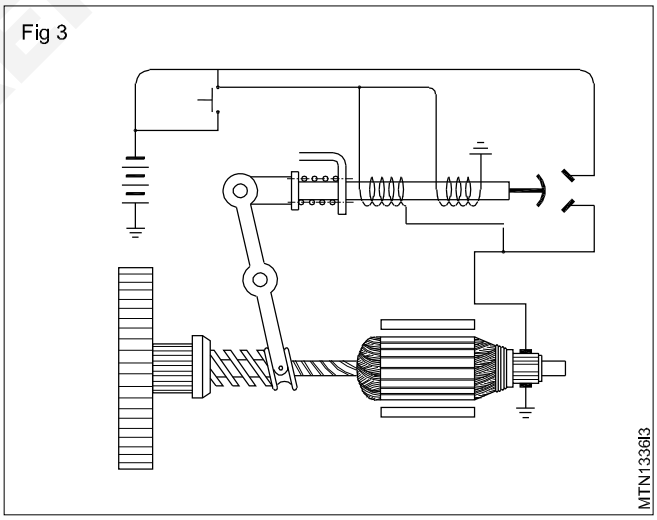


Construction of solenoid switch (Fig 3): In a solenoid there are two windings, a pull-in winding (1) and a hold - in winding (11). The pull - in winding (10) is wound with thick wires (series winding) and the hold - in winding (11) is of thin wires (shunt winding). The pull-in winding (10) is connected to the starter switch (3) in the solenoid.

The hold in winding (2) is connected 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).

Function of solenoid switch: When the starter switch (Fig 3) (3) is turned, current flows the battery to the solenoid windings (1) and (2). This energises the windings which pull the plunger (5). The plunger (5) operates the 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 starter motor.

Fig 3



Diodes

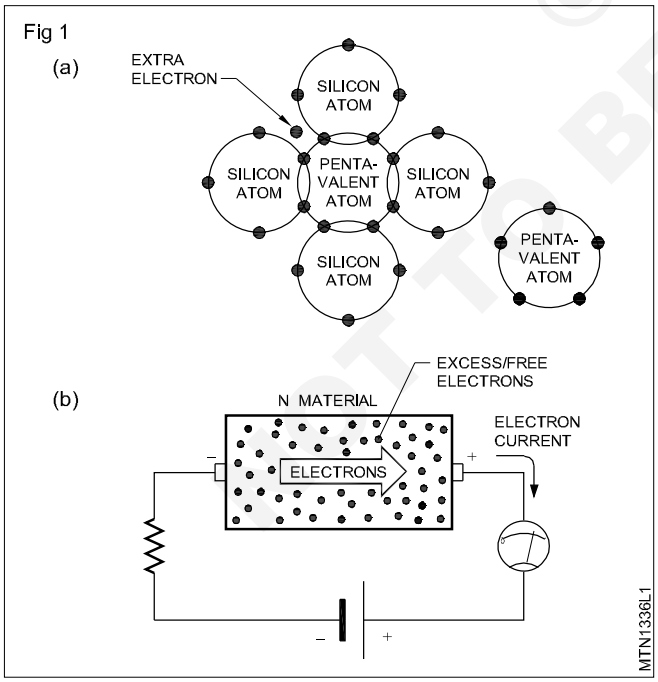
Objectives: At the end of this lesson you shall be able to
- **state the meaning of semiconductors**
- **state how P and N materials are formed**
- **state the unique property of a PN junction**
- **list the different classifications of diodes**
- **state the polarity**
- **list a few type numbers/code 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.**

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.

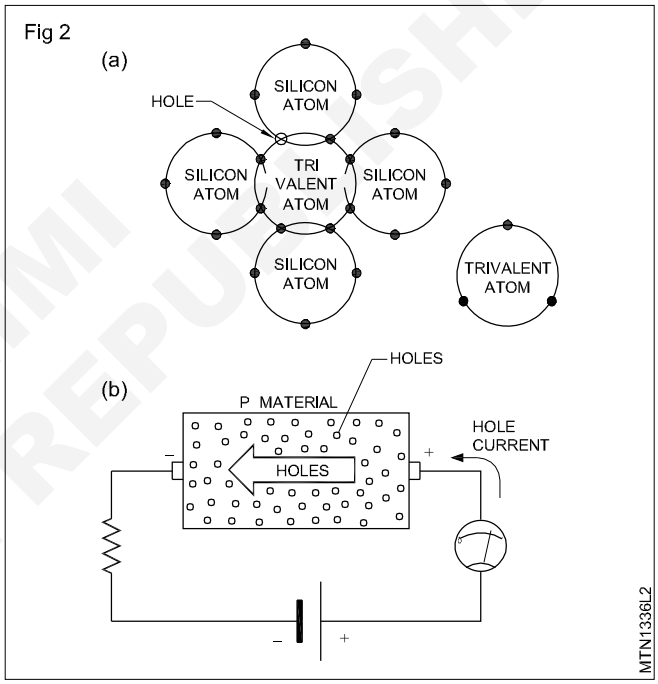
Fig 1



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

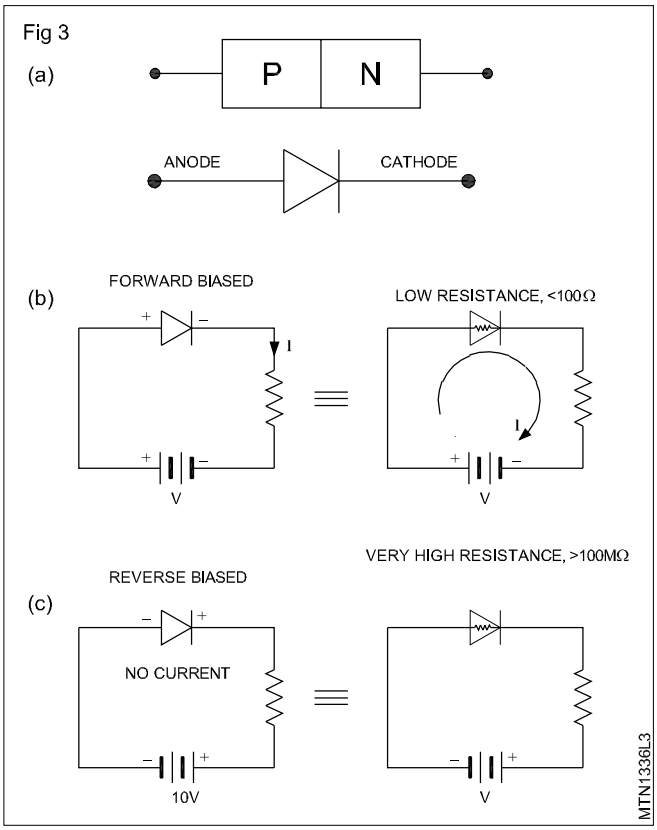


P-N junction

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 milli watts 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.

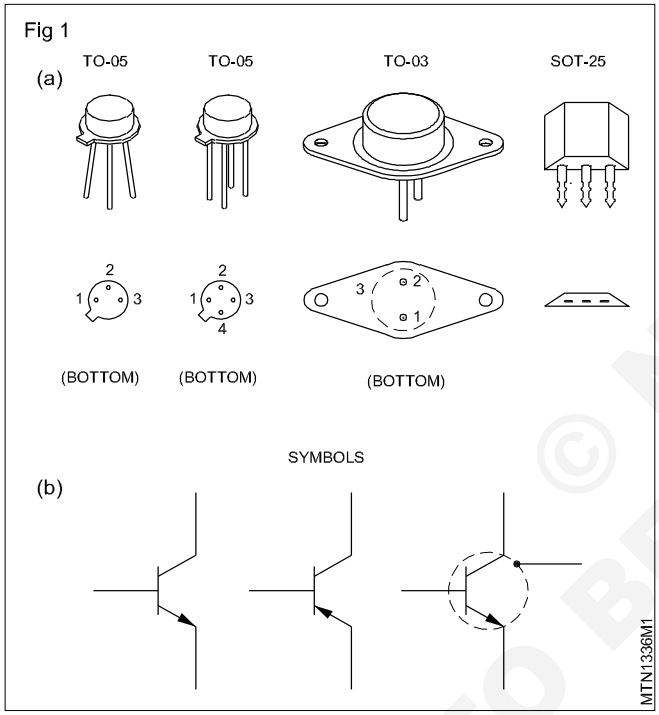
Type number or diode code number: Unlike resistors, capacitors or inductors, the diodes do not have any value that can be printed or coded on its body. The other reason for this is, there are almost innumerable types of diodes with varied current handling and other specifications. Hence, instead of printing 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

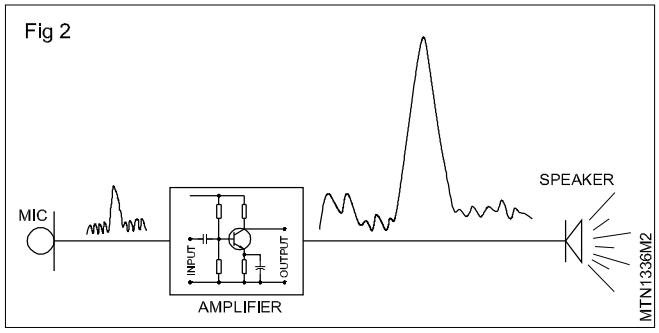
Objectives: At the end of this lesson you shall be able to
- **state the two main uses of transistors**
- **list the advantages of transistors over vacuum tubes**
- **list the important classifications of transistors**
- **state the use of a transistor data book**
- **state about Thyristor and characteristics of SCR**
- **explain working of SCR**
- **describe a thermistor and its usage.**

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.

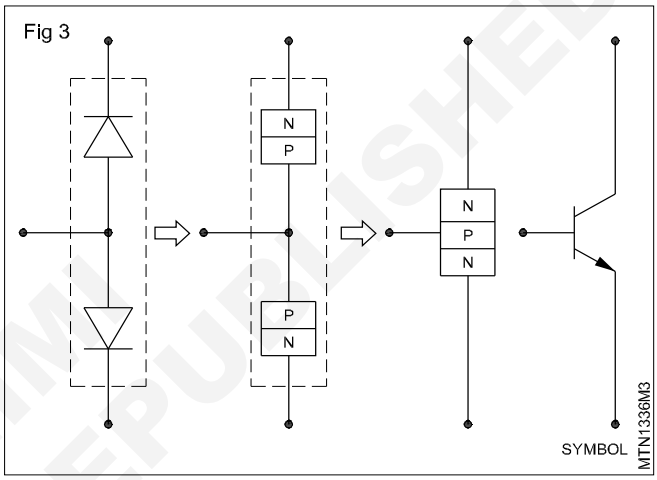


Transistors are mainly used for enlarging or amplifying small electric/electronic signals as shown in Fig 2. The circuit which uses transistors for amplifying is known as a transistor amplifier.

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 obsolete 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 (Fig 4)

– Light in weight

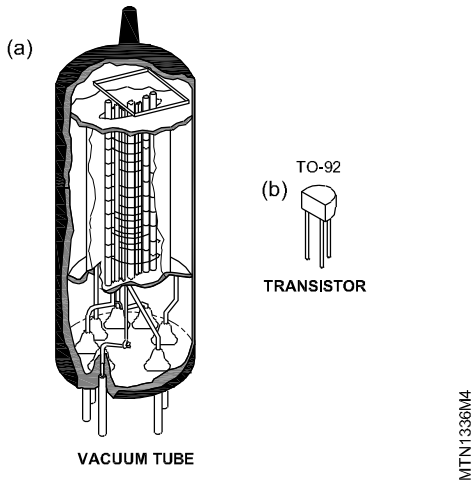
– Minimum or no power loss in the form of heat

– 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.

Fig 4



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.

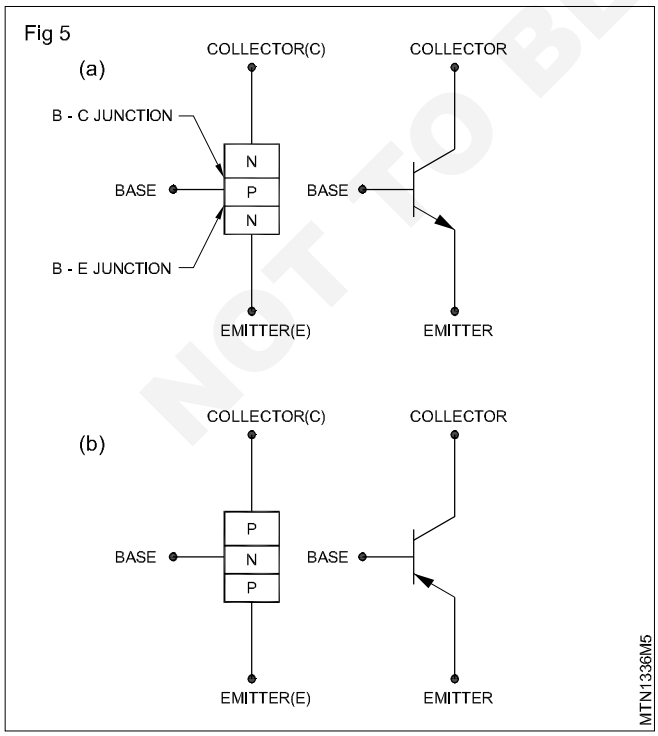
Transistor data books give information about the semiconductor used in any particular transistor.

2 Based on the way the P and N junctions are organized as shown in Fig 5

– NPN transistors

– PNP transistors

Fig 5



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.

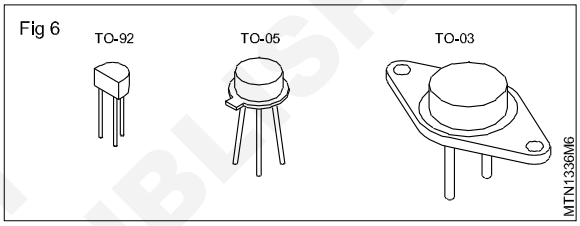
Whether a transistor is PNP or NPN can be found with the help of transistor data book.

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.,

Low power transistors	Medium power transistors	High power transistors
(less than 2 watts)	(2 to 10 watts)	(more than 10 watts)

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.

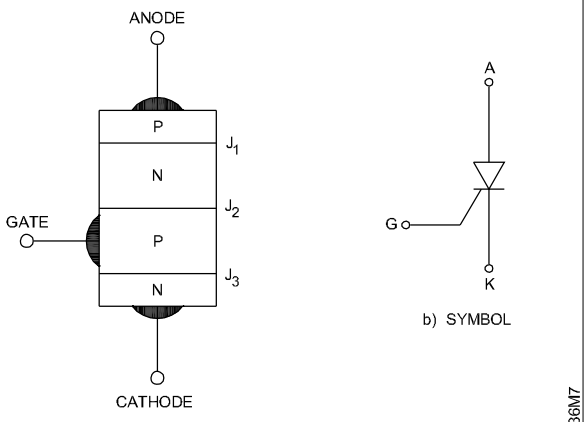
Thyristor and the characteristics of SCR

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



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.

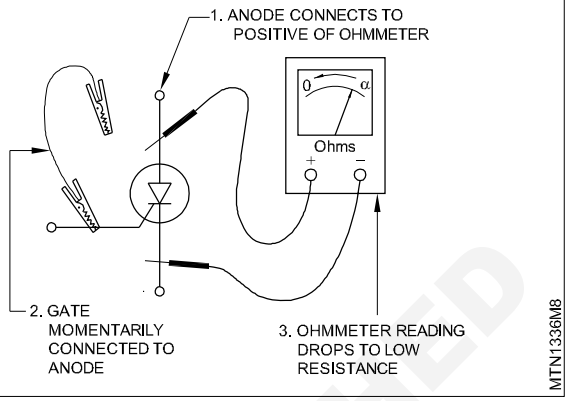
This is necessary for maintaining the required amount of carrier flow across the junctions; otherwise, the device will return to the blocking state as soon as the anode-to-cathode voltage is reduced. The holding current is usually lower than, but very close to the latching current; its magnitude is in 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 40ohm.

Fig 8



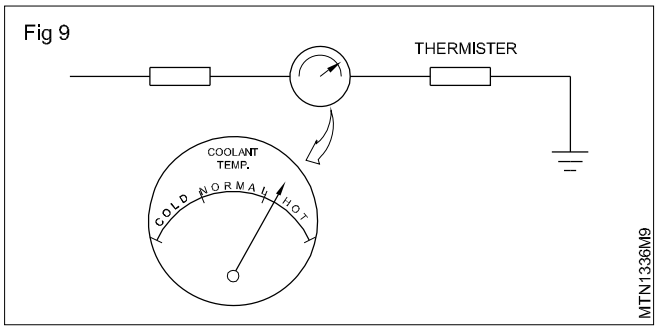
Thermistor: It is also semiconductor device used in most vehicles today. They are named because they are actually a temperature sensitive resistor. It is made of powdered nickel, cobalt, copper, iron and manganese which has been fused together at a higher temperature. The electrical resistance of a thermistor 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 co-efficient (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.

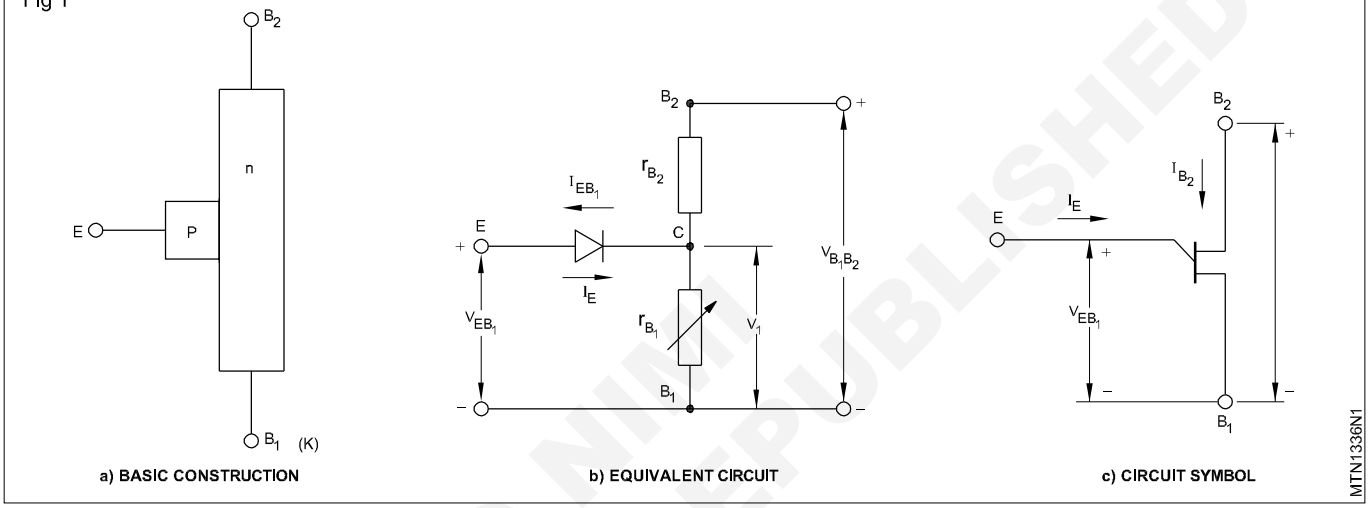
Uni-Junction Transistor (UJT)

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} (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**
- **state about JFET, its construction and working**
- **explain about biasing a JFET.**

Field Effect Transistor (FET): The main difference between a Bi-polar transistor and a FET is, bi-polar transistor is a current controlled device.

In simple terms it means that the main current in a bipolar transistor is controlled by the base current.

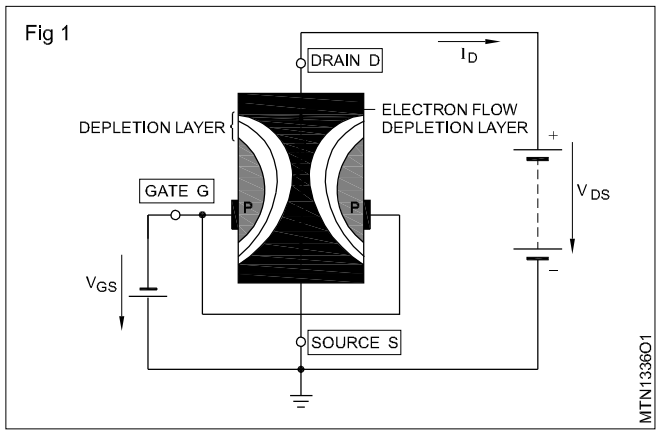
FET is a voltage controlled device.

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.

If the main current flow is only through the N-doped material,then such a FET is referred as a P-channel or P type FET.The current through the P-doped material in the P-type FET is only by holes.

Fig 1

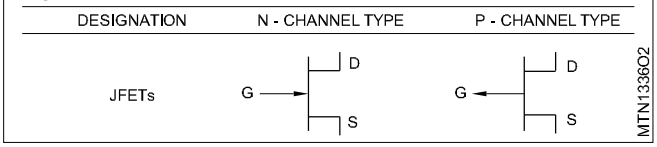


Unlike in bipolar transistors in which the main current is both by electrons and holes.In contrast in FETs depending on the type (P or N type) the main current in either by electrons and holes and never both.for this reason FETs are also known as Unipolar transistors or unipolar device.

Junction 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 Fig.2.

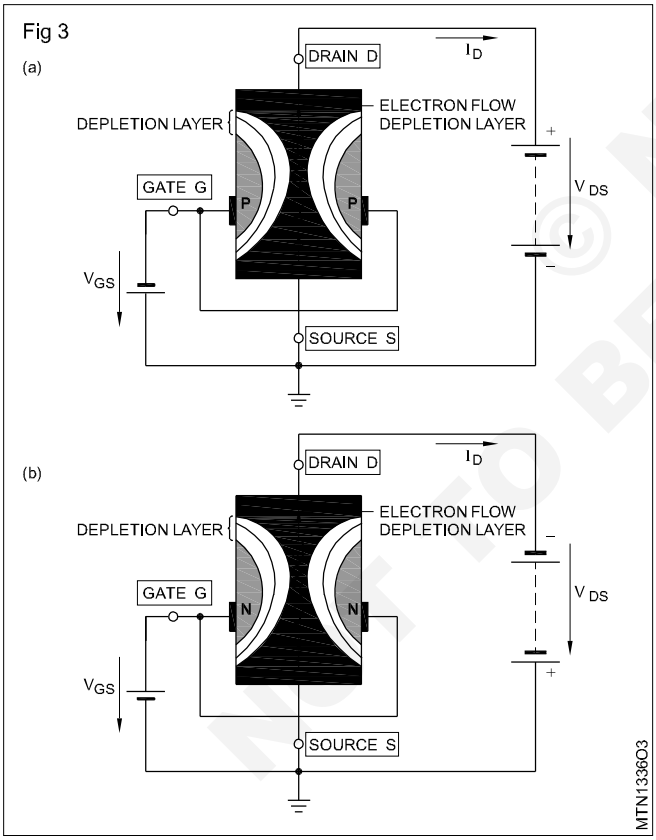
Fig 2



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 drain terminal, D.

A p-channel FET will be 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.

Biasing a JFET: 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.

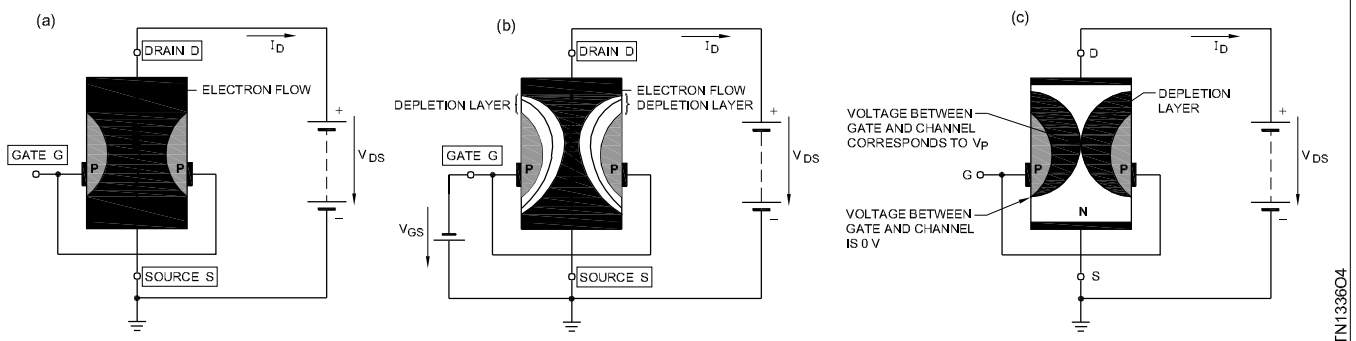
This depletion region decreases the width of the channel causing the drain current to decrease.

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 referred 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.

Fig 4



Metal Oxide Semi-conductor 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.**

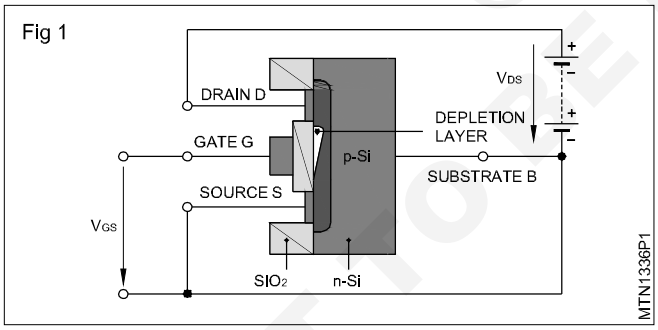
In MOSFETs, control is via an insulating layer instead of a junction (as in JFETS). This insulating layer is generally made of silicon dioxide, from which the very name MOSFET is derived /(Metal Oxide Semi-conductor). Sometimes the MOSFETs are also referred to as Insulated-gate FET, for which the abbreviation 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

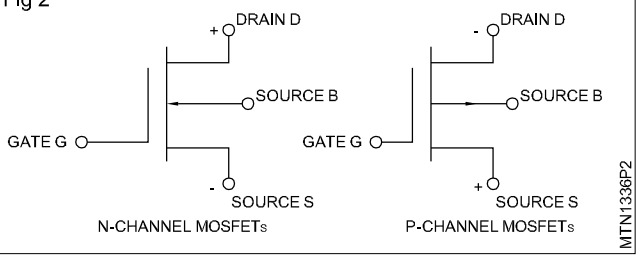
Designations and circuit symbols

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.

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.

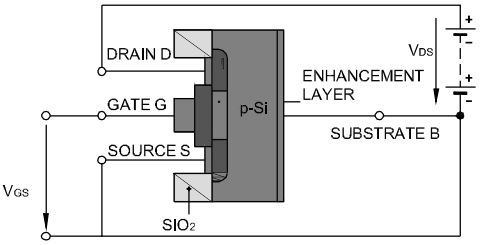
Fig 2



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



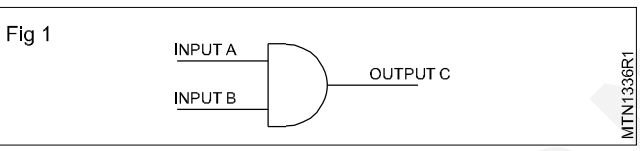
Basic logic gates

Objective: 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.**

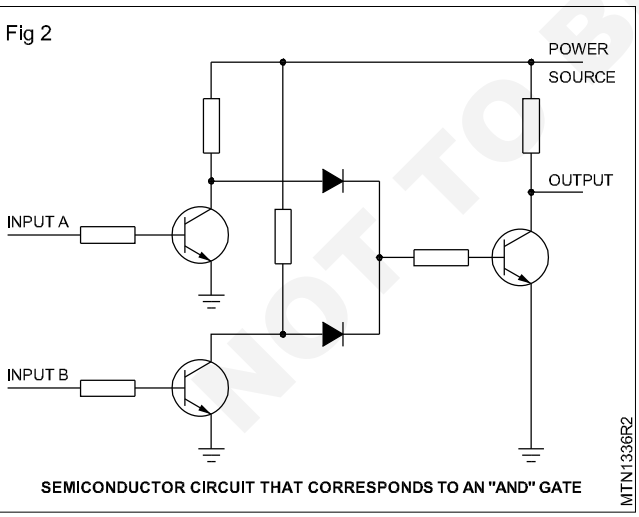
Logic circuits (Fig 1): Digital ICs are made up of many different elements. Most important of these are transistors. This transistor circuits are called logic circuits or digital circuits and are made up of combinations of different types of so-called gates. These gates have the special ability to logically 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).

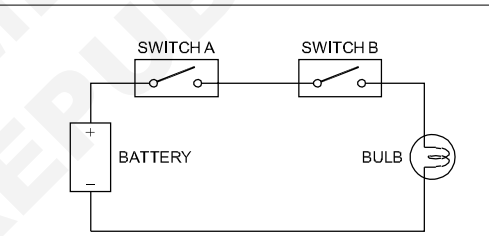
Fig 2



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.

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.

Fig 3



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 to 6)

Fig 4 shown the symbol for an "OR" gate, its corresponding semiconductor circuit, and an equivalent mechanical circuit.

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.

Fig 4

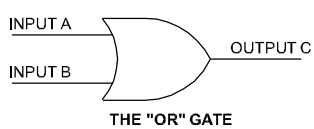


Fig 5

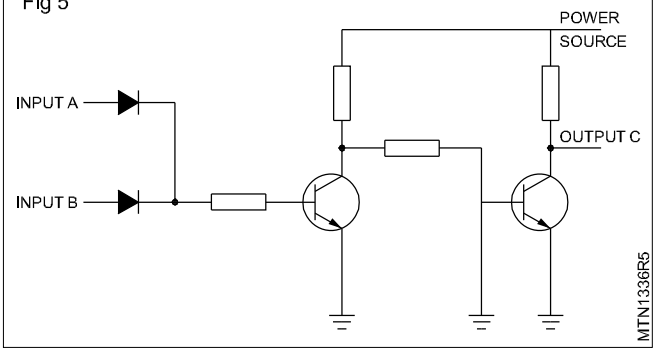
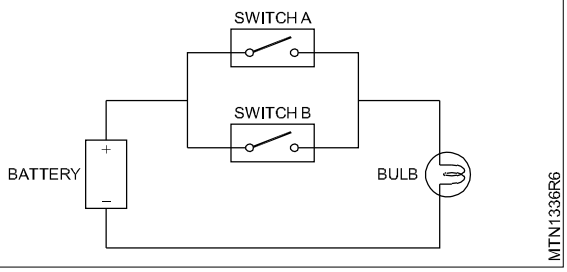


Fig 6



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).

In the mechanical NOT circuit, the light bulb does not go on if switch A is closed. When switch A is opened the relay closes and the bulb is turned on.

Fig 7

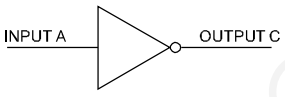
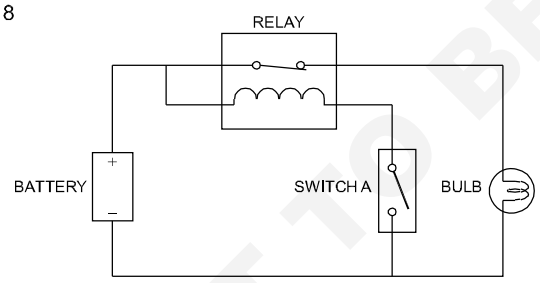


Fig 8



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)

“NAND” is a combination of “AND” gate and a “NOT” gate as shown in (Fig 10).

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 9

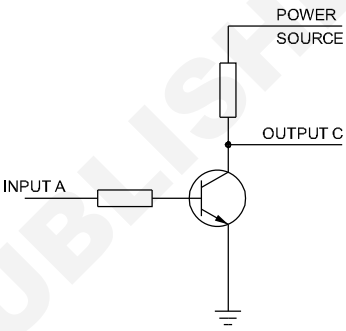


Fig 10

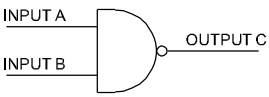
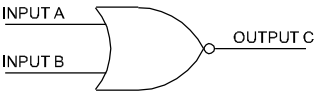


Fig 11



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**
- **state the features of a blowpipe and their functions**
- **state the use of a cylinder trolley**
- **state the features of a spark lighter**
- **distinguish between the hose connections for oxygen and acetylene regulators and blow pipes.**

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.

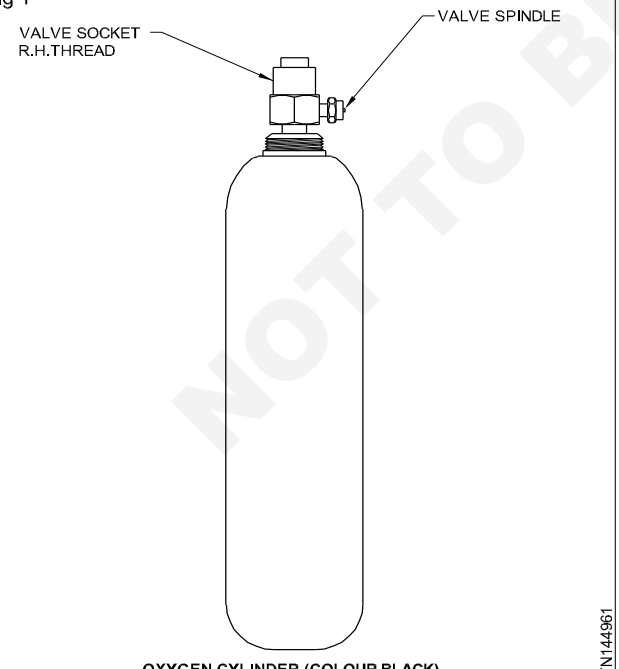
Oxygen gas cylinders (Fig 1)

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

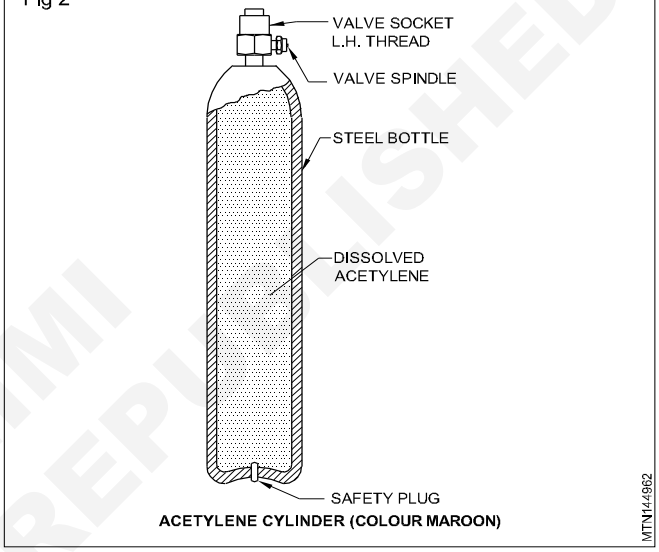
Fig 1



OXYGEN CYLINDER (COLOUR BLACK)

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.

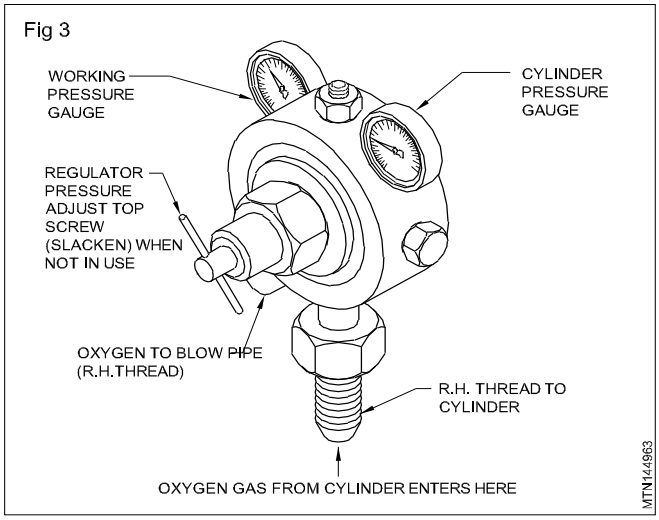
Fig 2



ACETYLENE CYLINDER (COLOUR MAROON)

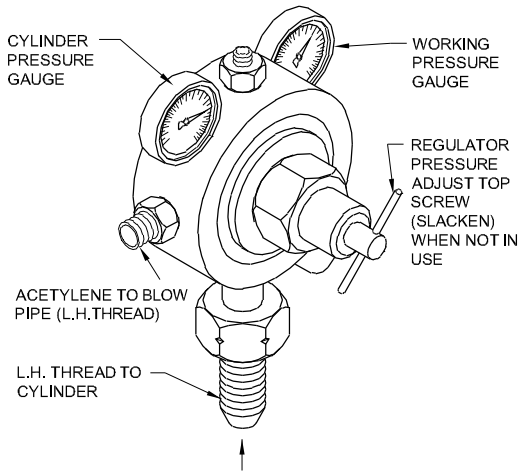
Pressure regulators for oxygen: The regulator is used to reduce and control the oxygen cylinder gas pressure to a suitable working pressure and maintain constant rate of gas flow for the blowpipe. The regulator has right hand screws threads. (Fig 3)

Fig 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)

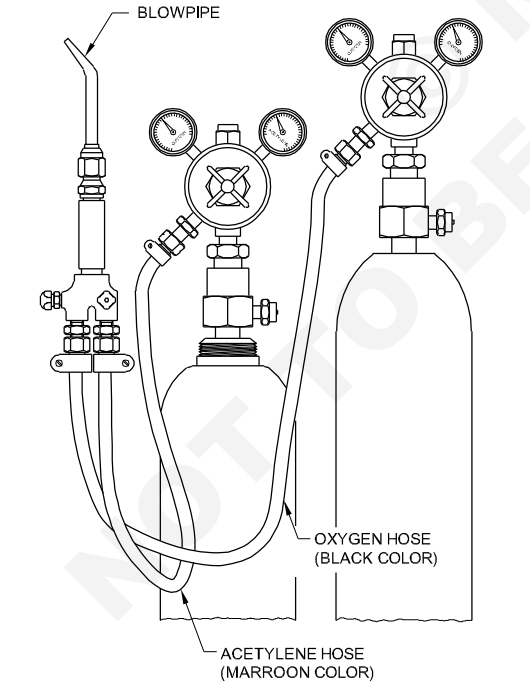
Fig 4



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)

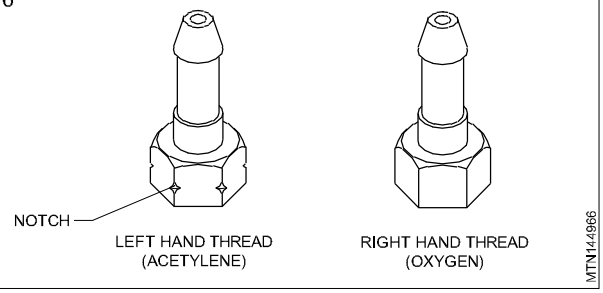
Fig 5



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

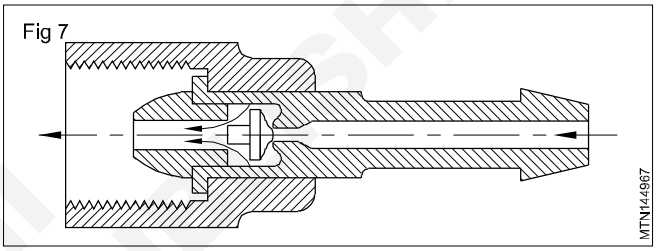


Hose pipe connections for blowpipes: This has the shape of a connecting union and is fitted with a non-return disc to prevent flash-back and backfire during welding. (Fig 7)

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.

Fig 7



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 mixing chamber, and a neck - pipe with a nozzle.

Fig 8

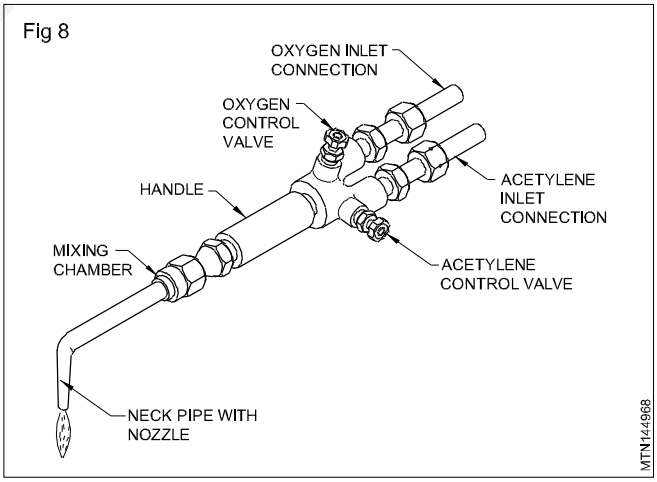
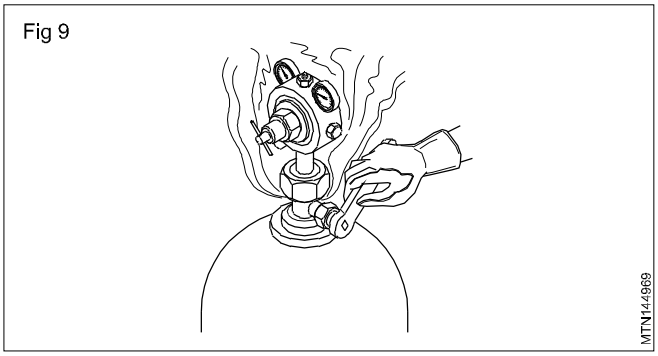


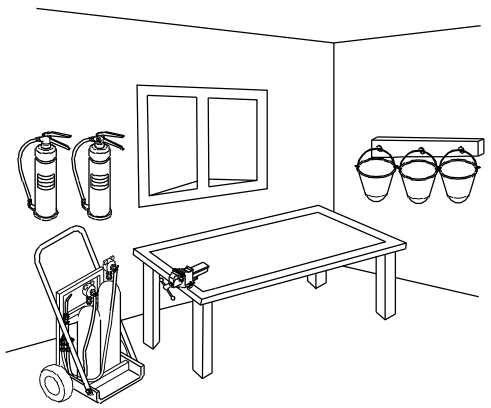
Fig 9



Always keep the working condition handy fire-fighting equipment to put off fires (Fig 10)

Keep the work area free from any form of fire.

Fig 10



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.

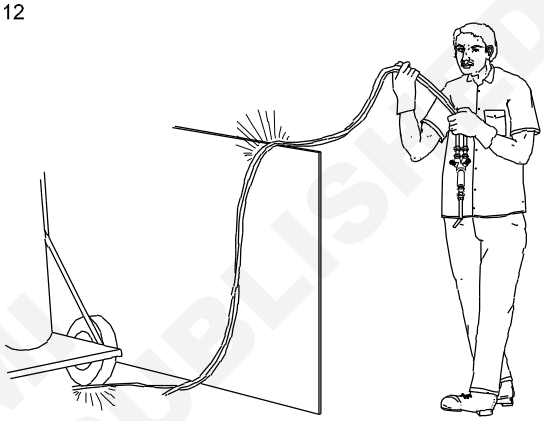
Safety for regulators (Fig 11)

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.

Fig 11

Fig 12



Safety for blowpipes

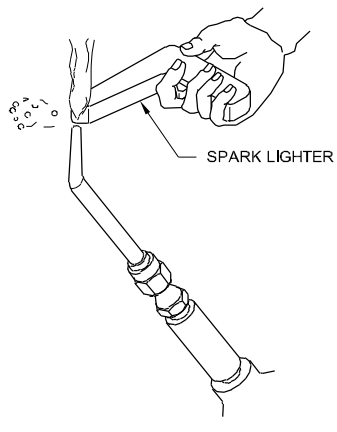
When a blowpipe is not in use put away from the flame and place the blowpipe in a safe place.

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)

While extinguishing the flame, shut off the acetylene valve first and then the oxygen valve to avoid a back fire.

Fig 13



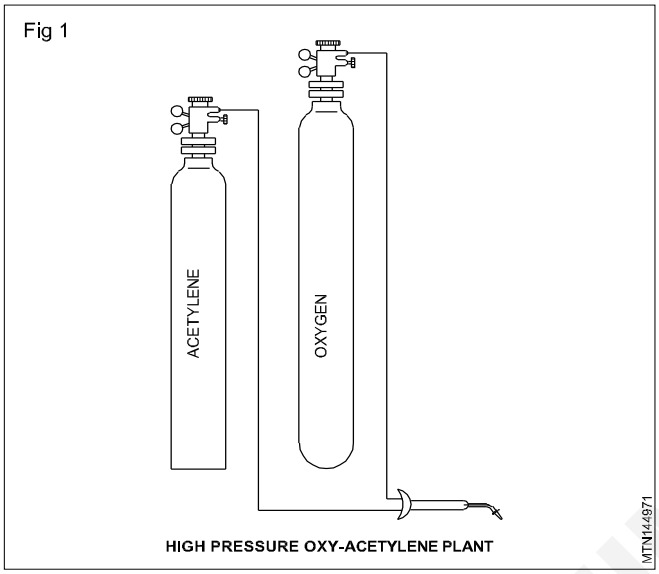
Systems of oxy-acetylene welding

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)

Dissolved acetylene (acetylene in cylinder) is a commonly used source.

Fig 1



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

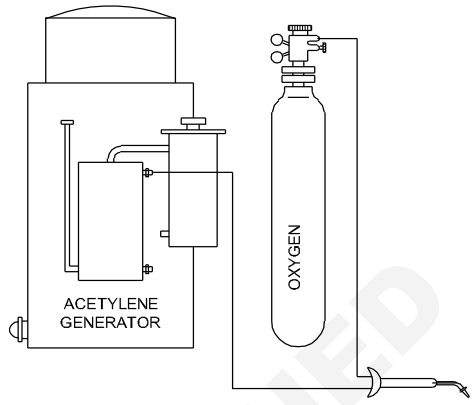
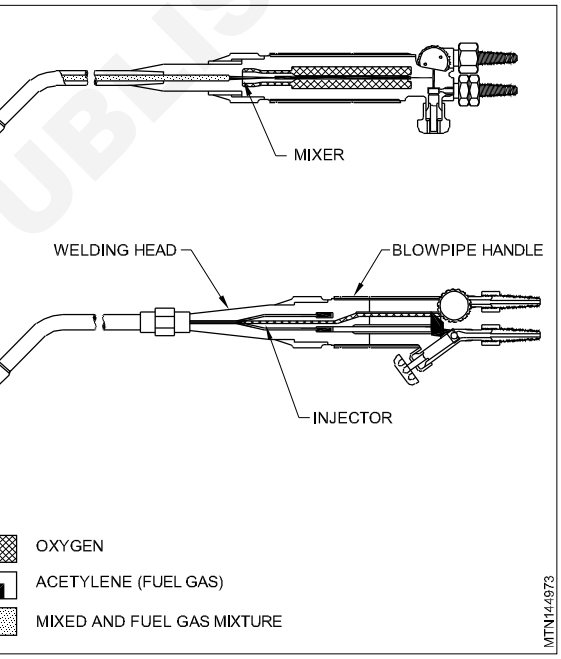


Fig 3



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 chamfering, provided satisfactory strength is attained. The joints have to be beveled 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 chamfering operations. The "J" joint is usually used in fillet welds.

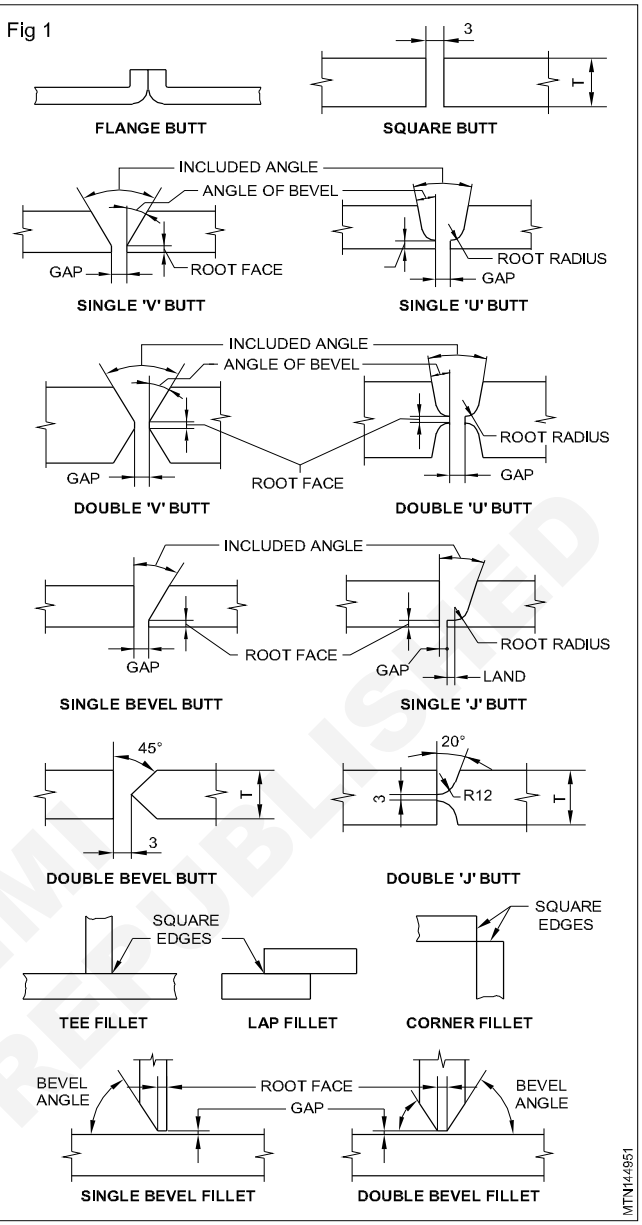
A root gap is recommended since the spacing allows the shrinking weld to draw the plates freely together in the butt joint. Thus, it is possible to reduce weld cracking and minimise distortion and increase penetration, by providing a root gap for some welded joints.

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 Fit up: Different edge preparations generally used in arc welding are shown in (Fig 1).

Fig 1



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.

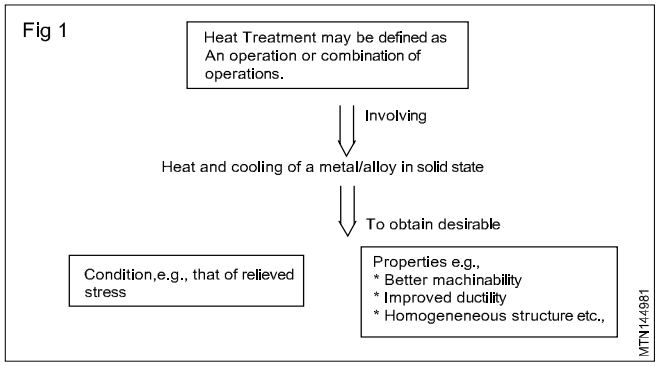
Definition of Heat Treatment (Fig 1): Some of the common industrial heat treatment operations are as follows:

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.

Fig 1



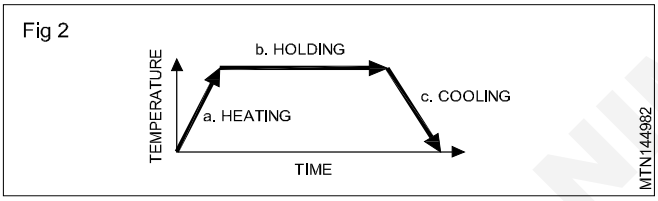
Stages of Heat Treatment (Fig 2)

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

- 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 carbo nitriding change the surface composition.

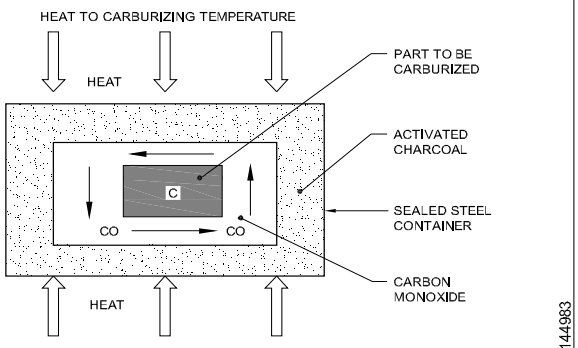
Carburising: Carburizing is a case-hardening process by which carbon is added to the surface of low-carbon steel. This results in a carburized steel that has a high-carbon surface and a low-carbon interior.

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

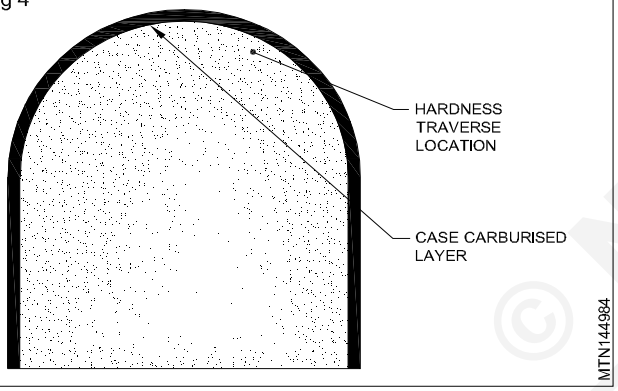
charcoal, wood charcoal energized by sodium, potassium and barium carbonate. A lid is fitted to the container made of heat resisting cast iron. The box with the contents is sealed with fire clay and is placed in muffle furnace at 900° - 920° C as shown in (Fig 3) and held for a period of time depending upon the case and held for a period of time depending upon the case depth required (Fig 4).

Fig 3



PACK CARBURISING PROCESS

Fig 4



After carburizing the component is hardened by reheating at 760 - 780°C followed by quenching in water or oil. Thus the case hardening improves surface hardness and the core toughness.

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.

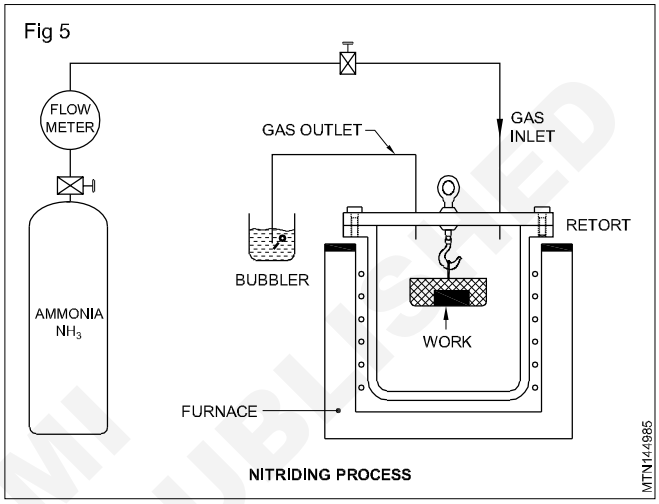
Advantage

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.

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.

Fig 5



NITRIDING PROCESS

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.

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.

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: gears	Cam shafts, oil pump gears, valves, Brake pad liner plates, A/T

Ministry of road transport & high ways and auto industry history and development

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 Organisations 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.

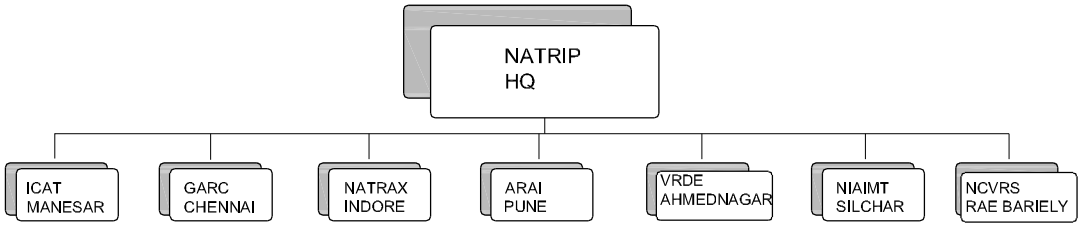
(NATRIP) aims at setting up of seven-of-the-art automotive testing and R&D centers across the country and thereby (Fig 1)

- 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.

Fig 1



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.

Auto industry history and development

Automobile plays a significant role in the personal transportation system. The advancement of two wheeler and three wheeler in this field of personal transport is a major rebellion. Two wheeler are fast, safe and easy way of transportation. It combines the exceptionally low operating costs along with the comfort and style. Basically two wheelers exist in three categories mopeds, scooters and motor cycle and three wheeler is a auto (petrol, diesel, electric and LPG, CNG).

Basically mopeds were designed to provide low powered, economic and easily drivable vehicle. Early mopeds were using pedelless starting system. This moped engine were able to produce very less power only for few miles. The first moped was launched 1912 and then moped and motor cycle equiped with pedal in 1915 moped and motor cycle's speed were differentiate in 1918 year by year included the new technology with moped and motor cycles. Earlier it was carburattor fuel system. Now a day two and three wheeler fuel system is used electronic and diesel and electric fuel system. All over the world many manufactures are developed their products better than other products.

Classification of two wheels and three wheelers

A large number of two or three wheelers are being used and manufactured in different countries of the world depending upon their capacity and market value, they are named as scooters, mopeds, motor cycle, three wheeler (auto rickshaw). The different types two wheelers on the basis of cubic capacity, weight and use are classified in the following ways,

1 With respect of use.
   - Auto cycle, mopeds
   - Scooters
   - Motor cycle

2 With respect to cubic capacity
   - 50 cc
   - 100 cc
   - 125 cc
   - 150 cc
   - 200 cc
   - 250 cc
   - 350 cc
   - 500 cc
   - 600 cc

3 With respect to make

- **Auto cycle:** Luna, TVS 50, Hero majestic, Bajaj - M50
- **Scooter:** Bajaj, Vespa, Priya, Chetak, Super, Lambretta, Pushpek, LML, kinetic, honda, Hero honda, TVS.
- **Motor Cycle:** Hero honda, Honda, Hero, Bajaj yamaha, Suzuki, Royal enfield, TVS, Bajaj, Mahindra.
- **Auto rickshaw:** TVS, Bajaj Re - Mahindra, Atul auto, Tuk - Tuk auto

4 With respect of fuel used

- Petrol
- Diesel
- Electric vehicle
- LPG / CNG

Auto rickshaw: There are two types of auto rickshaws in India. In order versions the engines were below driver seat while in newer versions engines are in the rear. They normally run on petrol, CNG, LPG, diesel or electric. The seating capacity of a normal rickshaw is four including the drivers seat.

Uses of hoists, jacks and stands

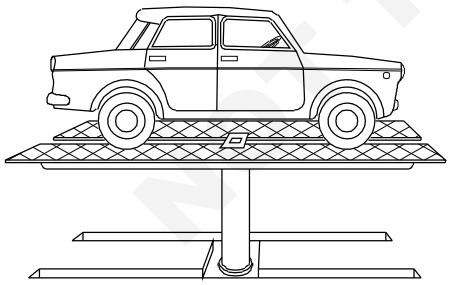
Objectives: At the end of this lesson you shall be able to
- **state the function of vehicle hoists**
- **state the function of engine hoists**
- **sate the function of jacks**
- **state the function of axes stand.**

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 (Fig 1): It is facilitate the servicing and repair 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

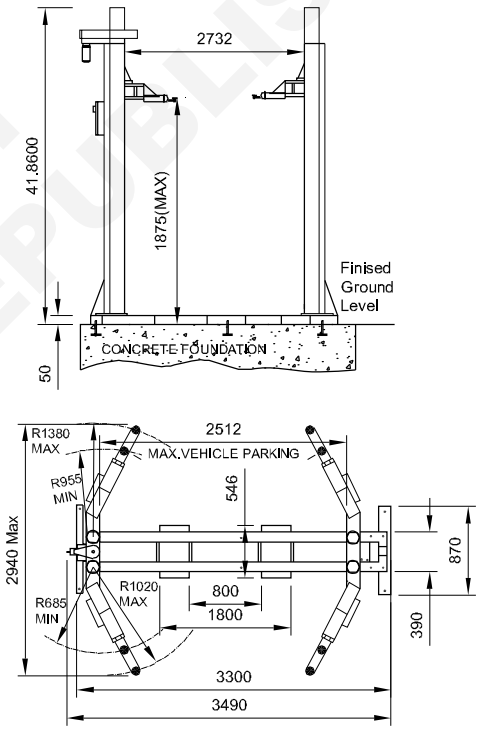


HYDRAULIC CAR HOIST

MTN155361

Two post hoist (Fig 2): It is operate 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



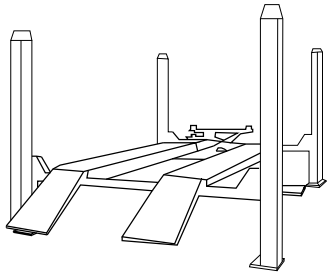
TWO POST HOIST

MTN155362

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.

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.

Fig 3



FOUR POST HOIST

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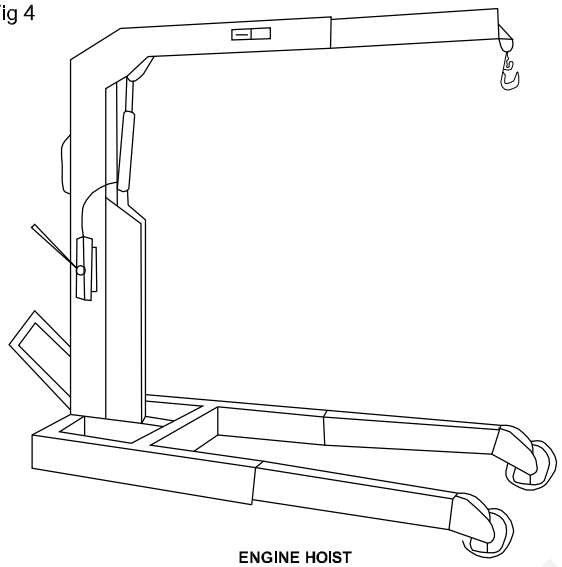
Fig 4



ENGINE HOIST

MTN155364

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.

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)

In raising front vehicle end off the floor by jacking, be sure to apply jack against front jacking bracket (1) (Fig 8).

In raising rear vehicle end off the floor by jacking, be sure to apply jack against the center portion of rear axle (2).

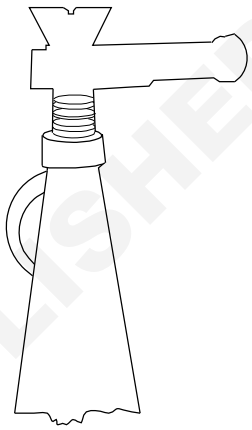
Caution

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.

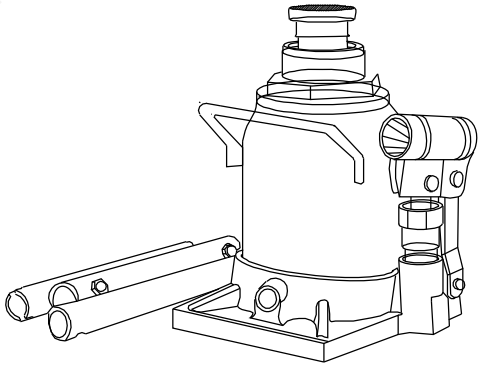
Fig 5



MANUAL TYPE LIFITING JACK

MTN155365

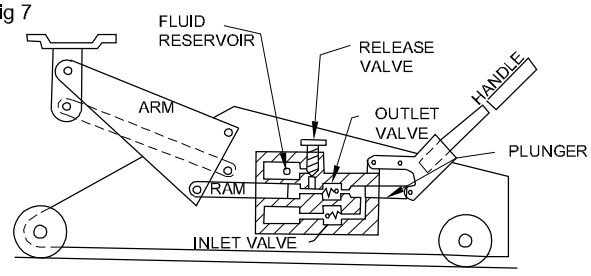
Fig 6



HEAVY DUTY BOTTEL TYPE LIFITING JACK

MTN155366

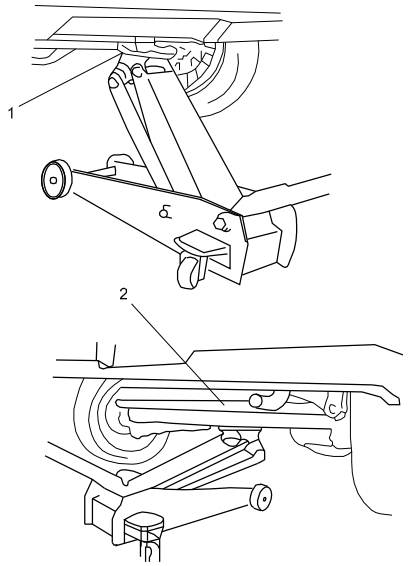
Fig 7



TROLLEY TYPE JACK

MTN155367

Fig 8



FLOOR JACK

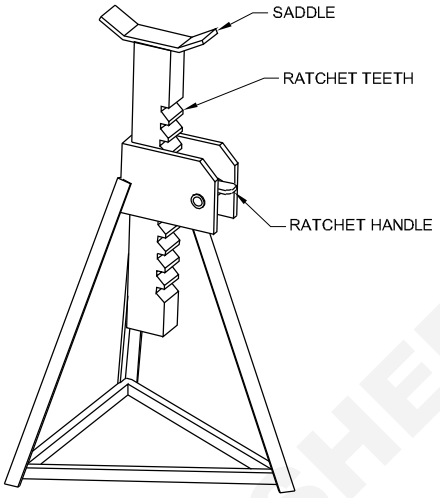
MTN155368

Axle stand (Fig 9)

It is always injure safety before starting the work under the lifted vehicle, Jack support 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.

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.

Fig 9



TYPICAL ADJUSTABLE JACK STAND

MTN155369

Automobile industries

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

- **listout different types of two wheeler manufacturer in India**
- **list out different models of two wheeler manufactured by different manufacturer.**

Vehicle control system is very complex, distributed a several electronic control modules and with a lot of interactions with other vehicle systems (bracing, heating and ventilation battery management, lighting, warning system, speed control and others)

- Electric machine control system
- Stability control system
- Battery management system
- Driver mode system
- Vehicle control system

The automotive plays a personal transportation system. The advancement of two & three wheelers transport is a major rebellion. Two wheelers are fast, safe and easy ways of transportation as well as fuel efficient machines.

So various manufacturers established research and development of their new products. Basically new trend is involved with pollution and economical.

Hero cycle company launched gear type fashionable cycle and e-cycle with option of pedal operation. Honda company launched e-scooters. Bajaj auto celebration with trumph motor cycle launched BS-VI complaint Activa-6G.

Bajaj, Mahandra, Piggo, TVS companies are launched electric operated auto rickshaw, petrol, diesel, CNG or LPG fueled engine also used in auto rickshaw. In auto rickshaw passenger safety door also provided in modern auto rickshaw audio or video systems provided for entertainment of driver of passengers. GPS is fitted with auto to final the location and route of travel.

Leading two and three wheeler manufacturers

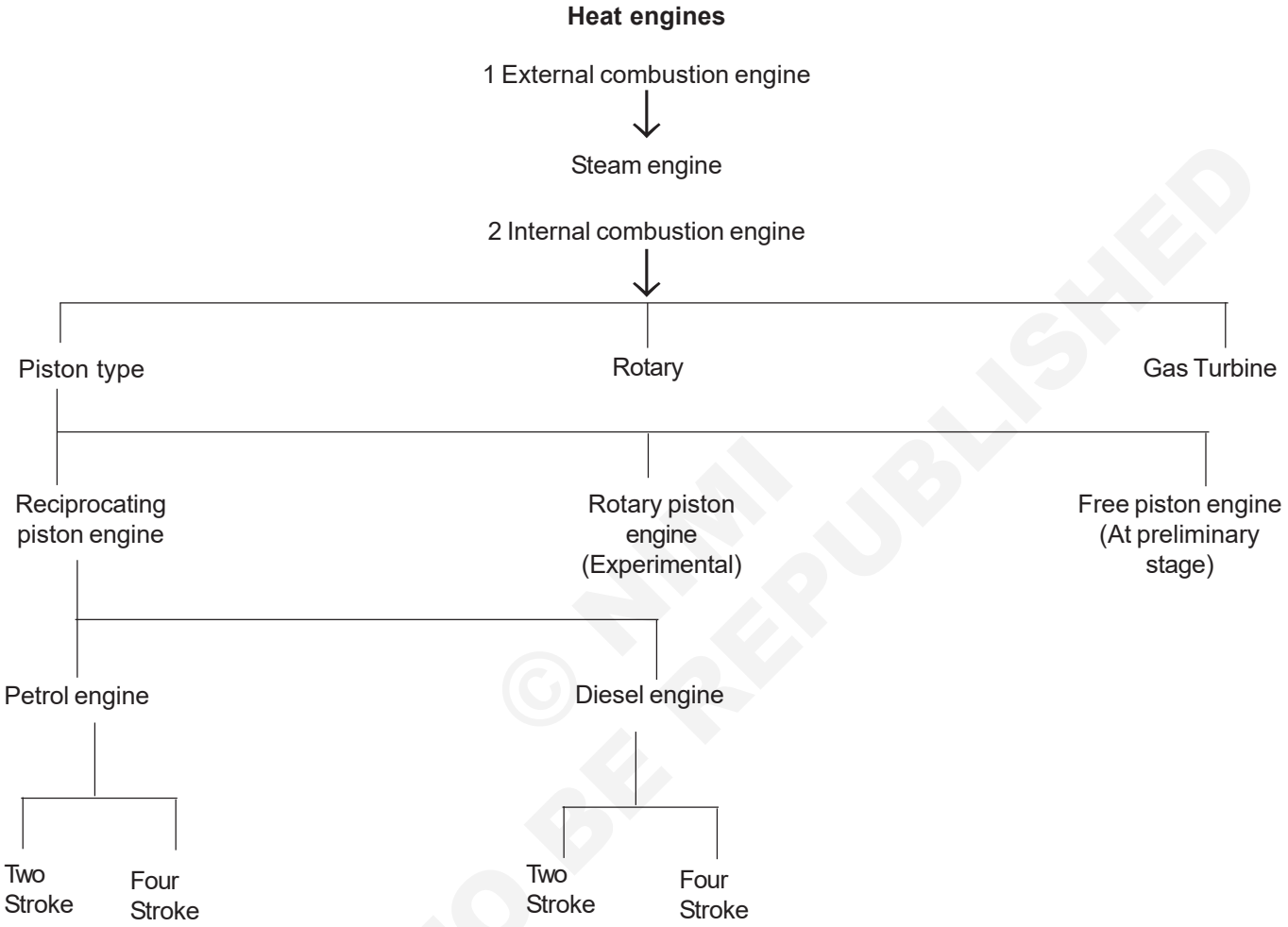
Sl. No	Name of the major two wheeler manufacturer	Name of the models available / manufactured in the India	Place of assembly/ manufacturing plant
1	Hero motorcorp	Karizma- 223CC Xtreme-150CC Hunk-150CC Impulse-150CC Achiever-150CC Ignitor-125CC Glamour programmed F1-125CC Glamour-125CC Super splenter-125CC Mastero-110CC Pleasure-102CC PassionXpro-110CC Passion pro-100CC Splendor ISmart-100CC Splendor pro-100CC Splendor NXG-100CC Splendor plus-100CC HF deluxe eco-100CC HF duluxe-100CC HF dawn-100CC	Haridwar Dharuhera (Haryana) Gurgaon (Haryana)
2	Bajaj auto limited	Avenger 200 DTS i-220CC Pulsar 200 NS - 200CC Pulsar 220 - 220CC Pulsar 180 - 180CC Pulsar 150 - 150CC Pulsar 130LS- 135CC New discover 150-150CC Discover 125 -125CC Discover 100 -100CC Platina 100 - 100CC	Maharastra Waluj, Aurngabad Chaken,pune <u>Uttranchal</u> Pant nagar,
3	TVS Motor company	Ninja 650R - 650 Ninja 300 - 300CC Motor cycles Apache series RTR-180CC Phonix 125 - 125 CC Max 4 R Star city plus - 110 CC Sport - 100CC	 Hosur, tamil nadu Mysure, Karnataka Nalagarh, Himachal pradesh

Sl. No	Name of the major two wheeler manufacturer	Name of the models available / manufactured in the India	Place of assembly/ manufacturing plant
		Neo x 31 Rock Z Tor max 150 Metro Star LX Victor GLX 125 - 125 CC Victor GX 100 - 100 CC Max 100 - 100 CC <u>Scooters</u> Jupiter - 110 CC Wego - 110 CC Scooty zest - 110 CC Scooty streak - 90 CC Scooty pep plus - 90 CC <u>Mopeds</u> XL HD - 2 storke - 70 CC XL Super - 2 storke - 70 CC	Karwang, indonesia
4	India Yamaha Motor Pvt.Ltd	Alpha Ray Z V max YZF R1 FZ1 YZF R15 FAZER FZS F1 FZ F1 FZS FZ SZ-S SZ-RR SS125 YBR 125 YBR 110 CRUX	Faridabad (Haryana) Surajpur (Uttar pradesh)
5	Honda Motor cycle & Scooter India Pvt. Ltd.	VT 1300 CX VFR 1200 F CBR 1000 RR CBR 1000R CBR 250 R CBR 150 R CB Trigger CB Unicorn CBF Stunner CB Shine	Manesar, Distt. Gurgaon Alwar, Rajasthan Karinayakanahalli Village, KasbaHobli, MalurTaluk,Karnataka

Sl. No	Name of the major two wheeler manufacturer	Name of the models available / manufactured in the India	Place of assembly/ manufacturing plant
		CB Twister Dream Yuga Dream Neo CD 110 Dream Activa 1 Aviator Dio Activa 125	
6	Royal Enfield Motors	Continental GT Thunder bird 300 /500 Classic Desert Strom Classic Battle Green Classic Chrome Classic 500 Classic 350 Bullet 500 Bullet Elecetra Bullet 350	Chennai
7	Mahindra two wheelers	Scooters Rodeo UZO 125 Rodeo RZ Duro RZ Flyte Kine-71 CC Motor Cycles Pantero Centuro CenturoRockstar	Zahirabad, Telegana Pithampura , Madhya Pradesh Haridwar Kandivali, Mumbai
8	Suzuki Motor cycle India Pvt. Ltd.	Scooters Lets - 110 CC Access- 125 CC Access- 125 CC(SE) Swish -125 CC Bikes Inazuma- 250 CC Gixxer- 150 CC GS150R- 150 CC Hayate- 112 CC Sling slot Plus SEU-125 CC Sling Slot Plus -SCD-125 CC Super Bikes GSX-R1000 -1000 CC V-Strom- 1000 CC Hayabusa- 1300 CC Bandit 1250SA- 1250 CC Intruder 1800 R	Gurgaon (Haryana)

Internal and external combustion engine

Objectives : At the end of this lesson you shall be able to
- **types of heat engine**
- **state the internal and external combustion engine**
- **difference between an internal and external combustion engine.**



Internal combustion engine

Internal combustion engine means, that fuel burns and takes combustion inside the cylinder, this definition including the two stroke and four stroke engine, spark ignition and compression ignition engine, wankel, austin engine.

External combustion engine

External combustion engine burns their fuel outside the engine cylinder. The heat energy developed during the combustion of fuel and is transmitted to the boiled water the boiled water developed as a stream pressure to steam, the steam press acts on the piston inside the cylinder. EX - steam engine.

Difference between internal and external combustion engine

Sl.No	Internal combustion engine	External combustion engine
1	Occupies less space.	Occupies more space.
2	Lighter in weight.	Heavier in weight.
3	High speed engine.	Slow speed engine.
4	Combustion of fuel takes place inside the engine.	Combustion of fuel takes place outside the engine.

5	Fuels used in when engine is not running.	Solid or liquid fuels used to form steam.
6	No loss of fuel when engine is not running.	Fuel has to burn even when the engine is not running for small halts.
7	Could be started or stopped at will.	Cannot be started unless steam is prepared which takes much time.
8	Temperature produced inside the cylinder is too high.	Works at comparatively low temperature.
9	Cooling arrangement necessary. it is steam jacketed.	No cooling of the cylinders required. Rather
10	Single acting.	Mostly double acting.
11	Exhaust gas temperature as high as 300°C.	The temperature of exhaust steam is quite low.
12	Thermal efficiency of diesel engine up to 40%.	Thermal efficiency up to 24% as that of petrol engine.

Classification of I.C engine

Objective: At the end of this lesson you shall be able to
- **state the classification of engine.**

Engines are classified according to the following factors.

Number of cylinders

- Single cylinder
- Multi cylinder

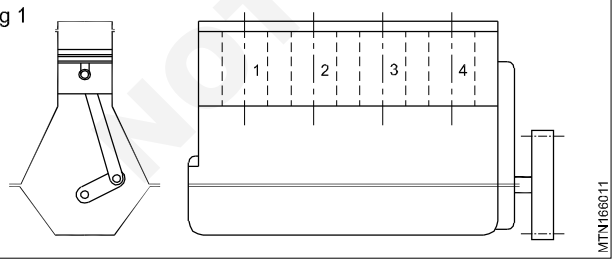
Arrangements of cylinders

- In-line engine (Fig 1)
- `V' shape engine (Fig 2)
- Opposed engine (Fig 3)
- Horizontal engine
- Radial engine (Fig 4)
- Vertical engine

Types of engines as per cylinder arrangement

In-line engines: In this type, the cylinders are arranged in one line. The length of the crankshaft is longer than that of the other types of engines, and hence a limited number of cylinders are used. Better balancing and more uniform torque is obtained in this type.

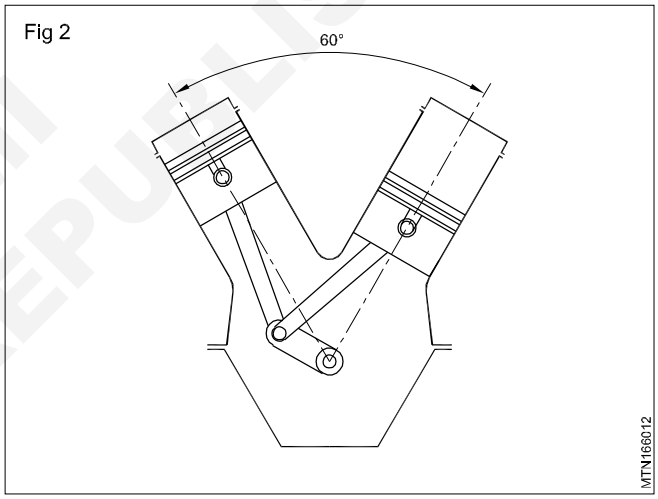
Fig 1



V engines

In this type, the cylinders are arranged in V shape at an angle, of usually 60°. This engine is more economical and compact. For multi-cylinder engines, the length of the crankshaft is much shorter than that of the in- line engine. In this type, the engine height is also lower than it is in the in-line engine.

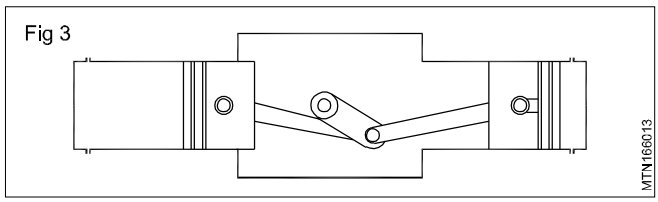
Fig 2



Opposed engines

In this type the cylinders are arranged horizontally opposite to each other. This provides better mechanical balance. This type of engine can run smoothly even at a much higher speed. It also gives higher output. The length of the engine is too much, and therefore engine has to be placed in the transverse direction in the vehicle.

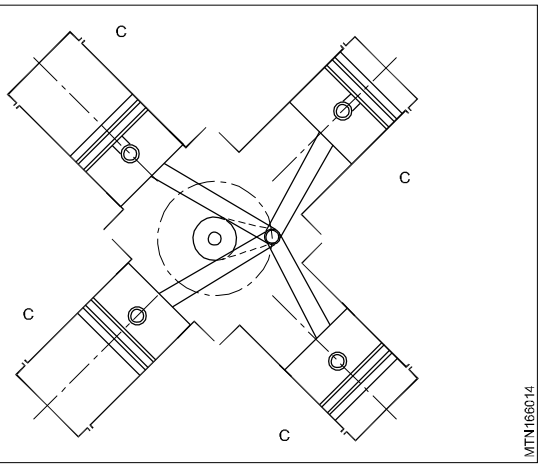
Fig 3



Radial engines

In this type, the cylinders are arranged radially. This type of engine is shorter, lighter and more rigid. Since it is rigid, a higher engine speed is possible and a higher combustion pressure can be obtained. This leads to high fuel efficiency. The radial type engines are used mostly in aeroplanes.

Fig 4



Types of engine as per number of cylinders

- **Single cylinder engines:** An engine which has only one cylinder is called a single cylinder engine. Since it is a single cylinder engine it cannot develop more power. It is normally used only in two wheelers like scooters and motor cycles.
- **Multi cylinder engines:** These engines have more than one cylinder. Two-cylinder engines are usually used in tractors.

Three or four cylinder engines are used in cars, jeeps and other vehicles. In heavy vehicles six-cylinder engines are used. A greater number of cylinders gives smoother engine operation.

Types of fuel used

- Petrol
- Diesel

Types of valve arrangements

- `I' head engine
- `F' head engine
- `L' head engine
- `H' head engine
- `T' head engine

Application of engine

- Constant speed engine
- Variable speed engine

Cooling system

- Air cooled engine
- Water cooled engine

Strokes of engine

- Four-stroke engine
- Two-stroke engine
- Rotary engine

Working of diesel engine

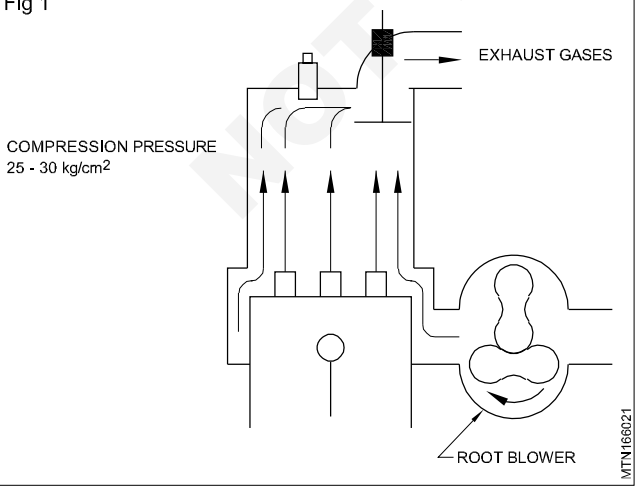
Objectives : At the end of this lesson you shall be able to
- **describe the function of a two-stroke diesel engine**
- **describe the function of a four-stroke diesel engine.**

Two stroke diesel engine

To produce power in a two stroke engine the following operation take place in the sequence given.

First stroke: Piston at BDC the scavenging port and outlet valve open (Fig 1). A root blower sucks in pure air and presses it through the scavenging port into the cylinder. The tangential layout of the scavenging port brings the air into a turbulent motion. The cylinder is completely flushed out in the direct current and filled with fresh air. The exhaust gases flow out towards the outlet valve.

Fig 1



As the piston moves up from BDC to TDC the scavenging port and outlet valve closed. The piston compresses the fresh air to the compression chamber. The air temperature increases intensively.

Second stroke: Piston at TDC (Fig 2) scavenging port and outlet valve closed. The fuel is directly injected into the cylinder with the help of a fuel injection pump and an injector fitted in the cylinder head. The fuel gets vaporised into an ignitable fuel air mixture by the hot air. After attaining the ignition temperature the mixture gets automatically ignited and burns. The heat increases the pressure in the combustion chamber. The gases get expanded and push the piston towards the bottom dead centre.

Four-stroke engine

To produce power in a four-stroke engine the following operations take place in the sequence given.

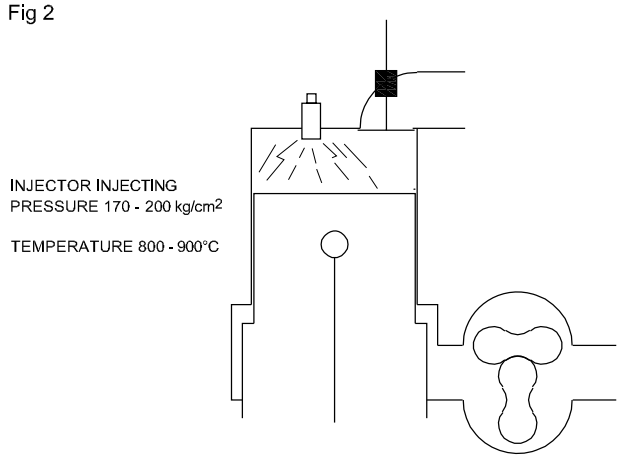
Suction stroke

The piston moves from TDC to BDC (Fig 3). A vacuum is created inside the cylinder. The inlet valve opens while the exhaust valve remains closed. The charge air enters into the cylinder.

Compression stroke (Fig 4)

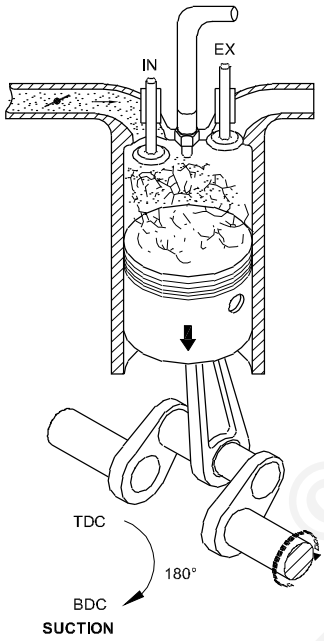
The inlet and exhaust valves are closed, The piston moves from BDC to TDC. The charge air is compressed in the cylinder & air pressure and temperature is increased.

Fig 2



II STROKE

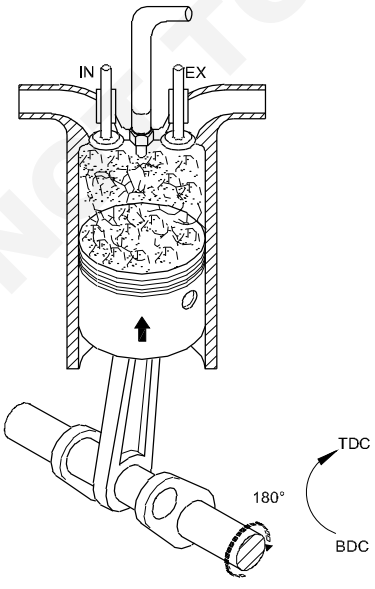
Fig 3



SUCTION

SUCTION STROKE

Fig 4

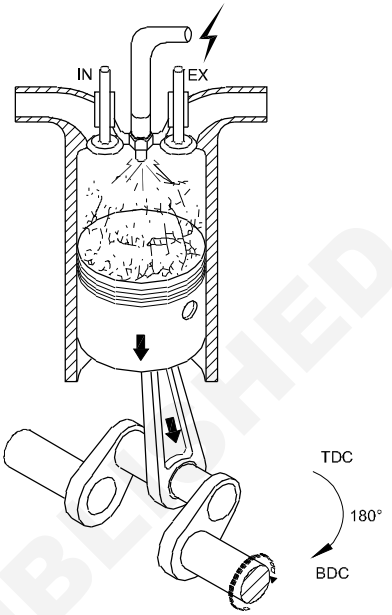


COMPRESSION STROKE

Power stroke

At the end of the compression stroke diesel fuel is injected into the hot compressed air in the combustion chamber; result burning of diesel with an explosion the gas expand and pressure develops inside the cylinder. The piston moves from TDC to BDC (Fig 5). Both the valves remain closed. Power is supplied to the fly wheel.

Fig 5



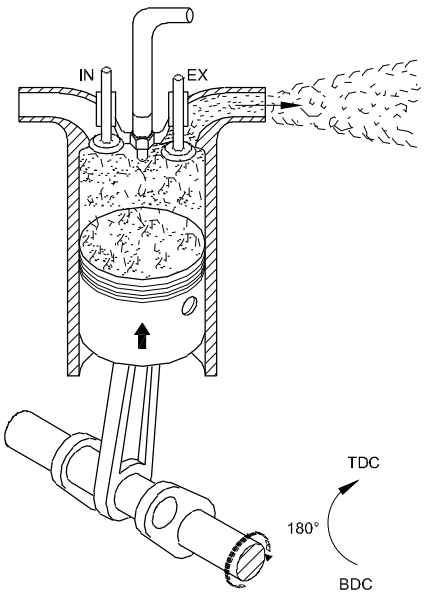
POWER STROKE

Exhaust stroke

The inlet valve remains in closed position. The exhaust valve opens, the piston moves from BDC to TDC (Fig 6) due to the energy stored in the flywheel. The burnt gases inside the cylinder go out through the exhaust valves.

The cycle of suction, compression, power and exhaust are repeated. In this type of engines one power stroke is obtained in two revolutions of the crankshaft.

Fig 6



EXHAUST STROKE

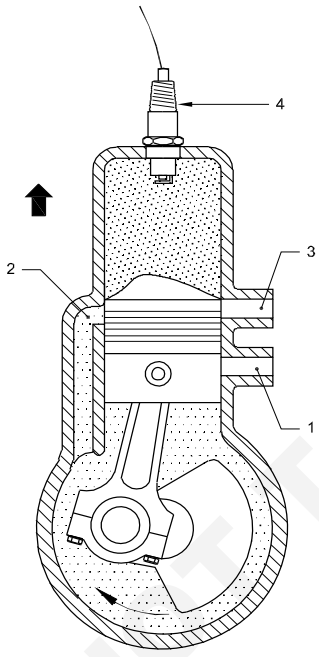
Working of spark ignition engine

Objectives : At the end of this lesson you shall be able to
- **describe the function of a two-stroke engine**
- **describe the function of a four-stroke engine**
- **differentiate between a four-stroke and a two-stroke engine**
- **explain an OTTO cycle**
- **explain a diesel cycle.**

Two-Stroke spark ignition engine: To produce power in two stroke engine the following operations take place in the sequence given below.

First stroke (Suction and compression): As the piston moves up from BDC, (Fig 1) it closes the inlet port (1), the exhaust port (3) and the transfer port (2). Further upward movement of the piston results in compressing the mixture in the cylinder and opening of the inlet port (1). The upward motion of the piston creates a partial vacuum inside the crank-case below the piston, and the air/fuel mixture is drawn into the crank-case through the inlet port (I). The exhaust and transfer ports remain closed during the operation of the upward stroke and the charge which reached above the piston during the previous stroke is compressed. At the end of this stroke the mixture is ignited by an electric spark (4). This causes the pressure to rise.

Fig 1



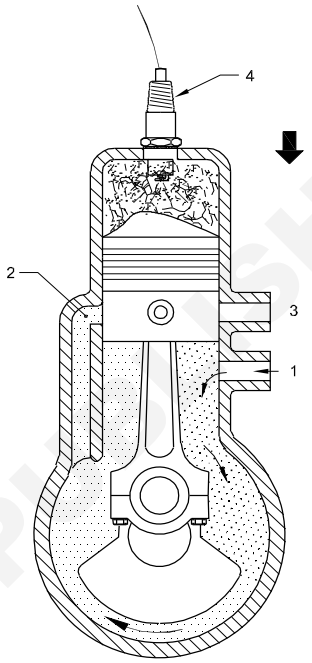
FIRST STROKE

MTN166031

Second stroke (power and exhaust): The piston is forced downward from the TDC (Fig 2). During this stroke the exhaust port opens and burnt gases escape into the atmosphere. Further downward movement of the piston opens the transfer port and allows the partially compressed mixture, received during the previous stroke, to reach the combustion chamber from the crankcase.

The piston head has a special shape. It deflects a fresh change of fuel mixture up into the cylinder. The mixture flows down and pushes the burnt gas out. Through the exhaust port. This process is called scavenging. Once the flywheel has completed one revolution, the cycle is repeated. In this engine one power stroke is obtained in each revolution of the crankshaft.

Fig 2



FIRST STROKE

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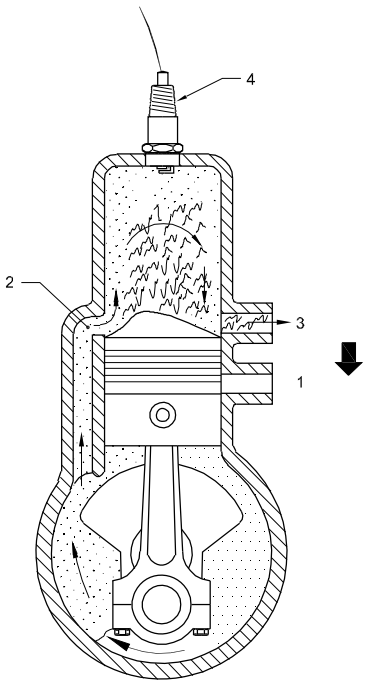
Spark ignition (Fig 3)

Fig 3



SECOND STROKE

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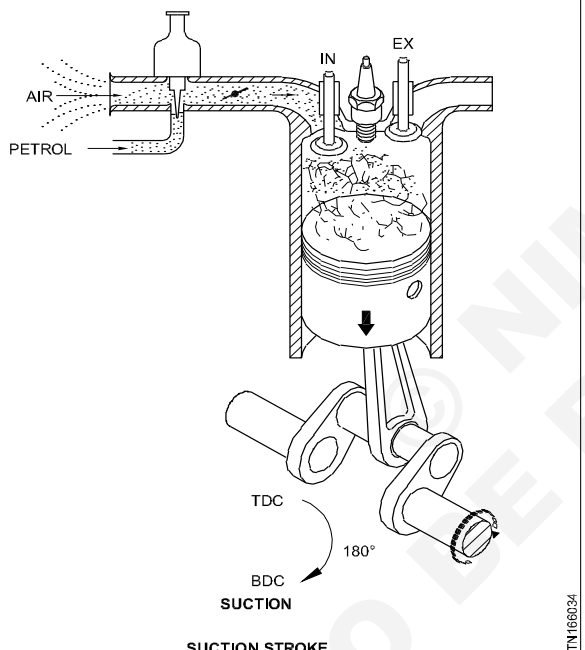
In a spark ignition (SI) engine, petrol is used as fuel. During the suction stroke the air and fuel mixture is sucked into the cylinder. The quantity of the mixture is metered by the carburettor according to the load and speed. The ratio of air/fuel mixture is also metered by the carburettor. During the compression stroke, this air/fuel mixture is ignited by the spark and the mixture is burnt. It raises the pressure of the gas above the piston. The piston is forced down and this power is supplied to the flywheel. During the exhaust stroke burnt gases escape through the exhaust port/valve.

In this type of engine the compression ratio is low.

Four-stroke spark ignition engine: To produce power in a four-stroke engine the following operations take place in the sequence given below.

Suction stroke: The piston moves from TDC to BDC (Fig 4). A vacuum is created inside the cylinder. The inlet valve opens while the exhaust valve remains closed. The charge (air/air-fuel mixture) enters the cylinder.

Fig 4



Compression stroke: The inlet valve closes. The exhaust valve remains closed. The piston moves from BDC to TDC (Fig 5). The charge air-fuel mixture is compressed. The pressure and temperature rise.

Power stroke: The compressed air fuel mixture is ignited and pressure develops inside the cylinder. The gas expands and the piston is forced down from TDC to BDC (Fig 6). Both the valves remain closed. Power is supplied to the flywheel.

Exhaust stroke: The inlet valve remains in the closed position. The exhaust valve opens, the piston moves from BDC to TDC (Fig 7) due to the energy stored in the flywheel. The burnt gases inside the cylinder go out through the exhaust valves. At the end of the stroke the exhaust valve closes.

The cycle of suction, compression power and exhaust are repeated. In this type of engines one power stroke is obtained in two revolutions of the crankshaft.

Fig 5

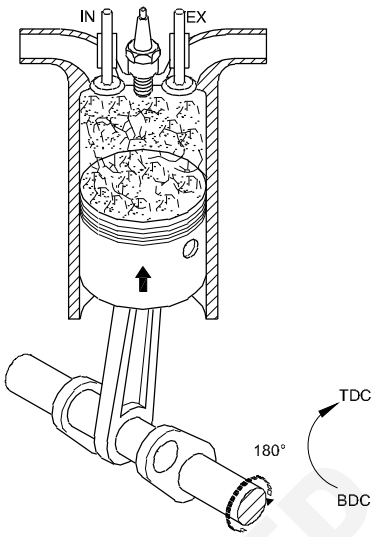


Fig 6

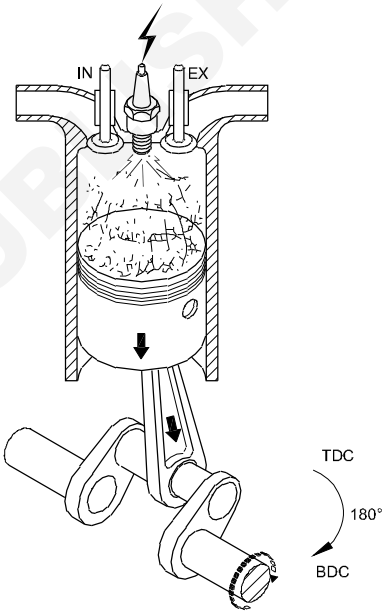
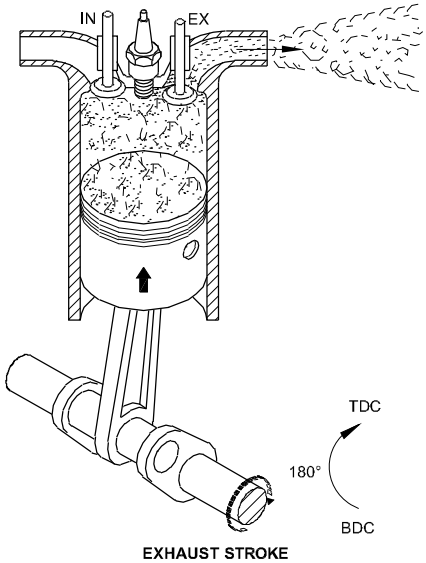


Fig 7



Comparison between four-stroke engine and two-stroke engine

Four-stroke engine	Two-stroke engine
Four operations (suction, compression, power and exhaust) take place in the four strokes of the piston.	The four operations take place in two strokes of the piston.
It gives one power stroke in the four strokes, i.e in two revolutions of the crankshaft. As such three strokes are idle strokes.	The power stroke takes place in every two strokes i.e. one power stroke for one revolution of the crankshaft.
Engine design is complicated and heavier flywheel is used	Engine design is simple
Engine require more space	The engine has more uniform load as every time the piston comes down it is the power stroke. As such a lighter flywheel is used.
The engine has more parts such as valves and its operating mechanism.	Engine require more space
More thermal efficiency.	The engine has no valves operating mechanism.
The engine efficiency is more.	The engine is less expensive.
Engine has heavy weight.	The engine efficiency is less.
Complicated lubricating system	Simple lubricating system

Comparison between S.I and C.I engine

SI engine	CI engine
Petrol is used as fuel.	Diesel is used as fuel.
During the suction stroke air and fuel mixture is sucked in.	During the suction stroke air alone is sucked in.
Compression ratio is low. (Max. 10:1)	Compression ratio is high. (Max. 24:1)
Compression pressure is low. (90 to 150 PSI)	Compression pressure is high. (400 to 550 PSI)
Compression temperature is low.	Compression temperature is high.
It operates under constant volume cycle (otto cycle).	It operates under constant pressure cycle (diesel cycle).
Fuel is ignited by means of an electric spark.	Fuel is ignited due to the heat of the highly compressed air. Combustion takes place at constant pressure.
A carburettor is used to atomize, vaporize and meter the correct amount of fuel according to the requirement.	Fuel injection pumps and atomizers are used to inject metered quantities of fuel at high pressure according to the requirement.
Less vibration, and hence, smooth running.	More vibration, and hence, rough running and more

Otto Cycle

1 - 2 - Suction

2 - 3 - Compression

3 - 4 - Heat addition

4 - 5 - Power

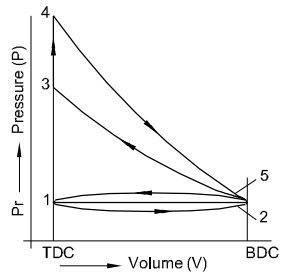
5 - 2 - 1 - Exhaust

In otto cycle engine, (Fig 8) combustion takes place at constant volume.

Suction takes place at a pressure below atmospheric pressure when piston moves from TDC to BDC. (1-2)

Compression takes place when piston moves from BDC to TDC. (2-3)

Fig 8



Fuel mixture is ignited by introducing a spark at constant volume. (3-4)

The gas expands during the power stroke (4-5), reducing both pressure and temperature.

Heat is rejected at constant volume. (5-2)

Burnt gases exhaust when piston moves from BDC to TDC. (2-1)

Diesel Cycle

1 - 2 - Suction

2 - 3 - Compression

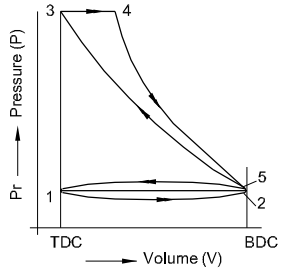
3 - 4 - Heat addition

4 - 5 - Power

Suction takes place at (Fig 9) pressure below atmospheric pressure when piston moves from TDC to BDC. (1-2)

Compression takes place when piston moves BDC to TDC. (2-3) (Both the valves closed).

Fig 9



Fuel is sprayed at high pressure and ignited by hot compressed air (3-4), and this process takes place at constant pressure.

Fuel ignites, pressure of burnt gas increases, gas expands and piston is forced from TDC to BDC. (4-5)

Heat is rejected at constant volume. (5-2)

Burnt gases exhaust when piston moves from BDC to TDC. (2-1)

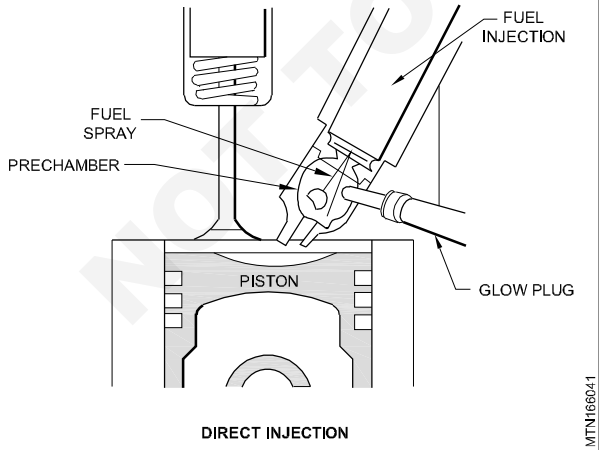
Direct and Indirect fuel injection system

Objectives : At the end of this lesson you shall be able to
- **state the function of direct fuel injection**
- **state the function of indirect fuel injection.**

Direct fuel injection works (Fig 1)

Gasoline engines work by sucking a mixture of gasoline and air into a cylinder, compressing it with a piston, and igniting it with a spark. The resulting explosion drives the piston downwards, producing power. Traditional indirect fuel injection systems pre-mix the gasoline and air in a chamber just outside the cylinder called the intake manifold. In a direct injection system, the air and gasoline are not pre-mixed. Rather, air comes in via the intake manifold, while the gasoline is injected directly into the cylinder.

Fig 1



DIRECT INJECTION

Advantages of direct fuel injection: Combined with ultra-precise computer management, direct injection allows more accurate control over fuel metering, which is the amount of fuel injected and injection timing, the exact point when the fuel is introduced into the cylinder. The location of the injector also allows for a more optimal spray pattern that breaks the gasoline up into smaller droplets. The result is a more complete combustion - in other words, more of the gasoline is burned, which translates to more power and less pollution from each drop of gasoline.

Disadvantages of direct fuel injection

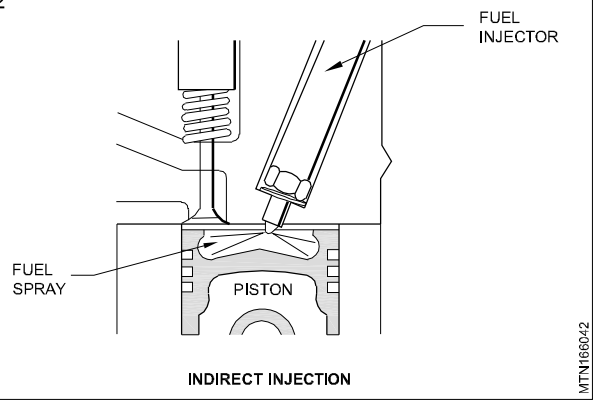
The primary disadvantages of direct injection engines are complexity and cost. Direct injection systems are more expensive to build because their components must be more rugged. They handle fuel at significantly higher pressures than indirect injection systems and the injectors themselves must be able to withstand the heat and pressure of combustion inside the cylinder.

Indirect injection (Fig 2)

Indirect injection in an internal combustion engine is fuel injection where fuel is not directly injected into the combustion chamber. In the last decade, gasoline engines equipped with indirect injection systems, wherein a fuel injector delivers the fuel at some point before the intake valve, have mostly fallen out of favor to direct injection. However, certain manufacturers such as Volkswagen and Toyota have developed a 'dual injection' system, combining direct injectors with port (indirect) injectors, combining the benefits of both types of fuel injection. Direct injection allows the fuel to be precisely metered into the combustion chamber under high pressure which can lead to greater power, fuel efficiency. The issue with direct injection is that it typically leads to greater amounts of particulate matter and with the fuel no longer contacting the intake valves, carbon can accumulate on the intake valves over time. Adding indirect injection keeps fuel spraying on the intake valves, reducing or eliminating the carbon accumulation on intake valves and in low load conditions, indirect

injection allows for better fuel-air mixing. This system is mainly used in higher cost models due to the added expense and complexity.

Fig 2



INDIRECT INJECTION

Port injection refers to the spraying of the fuel onto the back of the intake port, which speeds up its evaporation.

An indirect injection diesel engine delivers fuel into a chamber off the combustion chamber, called a prechamber, where combustion begins and then spreads into the main combustion chamber. The prechamber is carefully designed to ensure adequate mixing of the atomized fuel with the compression-heated air.

Classification of indirect combustion chambers

- 3.1 Swirl chamber
- 3.2 Precombustion chamber
- 3.3 Air cell chamber

Overview

The purpose of the divided combustion chamber is to speed up the combustion process, in order to increase the power output by increasing engine speed.[2] The addition of a prechamber, however, increases heat loss to the cooling system and thereby lowers engine efficiency. The engine requires glow plugs for starting. In an indirect injection system the air moves fast, mixing the fuel and air. This simplifies injector design and allows the use of smaller engines and less tightly toleranced designs which are simpler to manufacture and more reliable. Direct injection, by contrast, uses slow-moving air and fast-moving fuel; both the design and manufacture of the injectors is more difficult. The optimisation of the in-cylinder air flow is much more difficult than designing a prechamber. There is much more integration between the design of the injector and the engine.[3] It is for this reason that car diesel engines were almost all indirect injection until the ready availability of powerful CFD simulation systems made the adoption of direct injection practical.

Advantages of indirect injection combustion chambers

- Smaller diesels can be produced.
- The injection pressure required is low, so the injector is cheaper to produce.
- The injection direction is of less importance.
- Indirect injection is much simpler to design and manufacture; less injector development is required and the injection pressures are low (1500 psi/100 bar versus 5000 psi/345 bar and higher for direct injection)
- The lower stresses that indirect injection imposes on internal components mean that it is possible to produce petrol and indirect injection diesel versions of the same basic engine. At best such types differ only in the cylinder head and the need to fit a distributor and spark plugs in the petrol version whilst fitting an injection pump and injectors to the diesel. Examples include the BMC A-Series and B-Series engines and the Land Rover 2.25/2.5-litre 4-cylinder types. Such designs allow petrol and diesel versions of the same vehicle to be built with minimal design changes between them.
- Higher engine speeds can be reached, since burning continues in the prechamber.

Disadvantages

- Fuel efficiency is lower than with direct injection because of heat loss due to large exposed areas and pressure loss due to air motion through the throats. This is somewhat offset due to indirect injection having a much higher compression ratio and typically having no emissions equipment.
- Glow plugs are needed for a cold engine start on diesel engines.
- Because the heat and pressure of combustion is applied to one specific point on the piston as it exits the precombustion chamber or swirl chamber, such engines are less suited to high specific power outputs (such as turbocharging or tuning) than direct injection diesels. The increased temperature and pressure on one part of the piston crown causes uneven expansion which can lead to cracking, distortion or other damage due to improper use; use of " starting fluid" (ether) is not recommended in glow plug, indirect injection systems, because explosive knock can occur, causing engine damage.

Basic technical terms used in relation to engines

T.D.C (Top dead centre): It is the position of the piston at the top of a cylinder, where the piston changes its direction of motion from the top to the bottom.

B.D.C (Bottom dead centre): It is the position of the piston at the bottom of the cylinder where the piston changes its direction of motion from the bottom to the top.

Stroke: The distance travelled by the piston from TDC to BDC or BDC to TDC.

Cycle: A set of operations performed in sequence by the motion of the piston in an engine to produce power.

Swept volume (VS): Displacement volume of a piston.

Clearance volume (VC): Volume of the space above the piston when it is at TDC.

Compression ratio (CR)

Ratio of compression volumes before the stroke and after.

$$CR = \frac{VS + VC}{VC}$$

where VS = Swept volume

VC = Clearance volume

VS+VC = Total volume at BDC.

Power

Power is the rate at which work is done in a specific time.

$$Power = \frac{(Force \times Distance\ moved)}{Time}$$

Horsepower (HP)

It is the measurement of power in SAE. One hp is the power required to lift a load of 33000 lbs, through one foot in one minute or 4500 kg through one meter in one minute (in metric system)

Thermal efficiency

It is the ratio of work output to the fuel energy burnt in the engine. This relationship is expressed in percentage.

Brake horsepower (BHP)

It is the power output of an engine, available at the flywheel,

$$BHP = \frac{2\pi NT}{4500}$$

where N is r.p.m of the crankshaft, and T is the torque produced.

Indicated horsepower (IHP)

It is the power developed in the engine cylinder.

$$IHP = \frac{PLAN}{4500} X K$$

Where Pm is the mean effective pressure in kg./cm².

L is length of stroke in metres

A is the area of the piston in cm²

N is the No. of power strokes per minute

K is the No. of cylinders.

Frictional horsepower

It is the horsepower lost in the engine due to friction.

FHP = IHP - BHP

Mechanical efficiency

It is the ratio of power delivered (BHP) and the power available in the engine (IHP). It is expressed in percentage

$$\text{Mechanical efficiency} = = \frac{BHP}{IHP} \times 100$$

Volumetric efficiency

It is the ratio between the air drawn in the cylinder during the suction stroke and the volume of the cylinder.

Throw

It is the distance between the centre of the crank pin to the centre of the main journal. The piston stroke is double the throw.

Firing order

The firing order is the sequence in which the power stroke takes place in each cylinder in a multi-cylinder engine.

Technical Specification of an engine

Engines are specified as per the following.

Type

- Number of cylinders
- Bore diameter
- Stroke length
- Capacity in cu.cm/cu.inch
- Maximum engine output at specified r.p.m.
- Maximum torque
- Compression ratio
- Firing order
- Idling speed
- Air cleaner (Type)
- Oil filter (Type)
- Fuel filter
- Fuel injection pump
- Weight of engine
- Cooling system (type)
- Type of fuel

Engine Specification

Dimensions	
Overall Length	1995 mm
Overall Width	735 mm
Overall Height	1095 mm
Wheel Base	1265 mm
Ground Clearance	150 mm

Engine		
Type		Air cooled, Four Stroke, OHC
Displacement		124.7 cc
Cylinder Arrangement		10° inclined from horizontal
Maximum Power		6.72 Kw (9 BHP) @ 7000 rpm
Bore X stroke		52.4 mm x 57.8 mm
Compression Ratio		9.1 : 1
Cylinder Compression		13.0± 2.0 kg/cm^2
Carburetor		Side draft, variable - venturi, piston valve with throttle sensor
Fuel Tank Capacity		12.0 ltr (Min)
Valve Train		Over Head Camshaft (OHC), Poppet valve
Valve Clearance (cold)	Inlet	0.05 mm ± 0.02 When the engine is cold
	Exhaust	0.05 mm ± 0.02 When the engine is cold
Starting		Kick/Electric start
Idle speed		1400 ± 100 rpm
Ignition		Digital - CDI (AMI)
Ign. Timing	"F" mark	15° BTDC@ 2000 rpm
	Full Advance	28° ± 1° BTDC @ 4000 rpm

Lubrication	
Type	Forced pressure and wet sump
Oil pump type	Trochold
Oil Filter	Wire Mesh & Centrifugal filter
Air filter	Dry, Paper plated type
Engine oil capacity	0.9 ltr at disassembly, 0.70 ltr at oil change
Engien oil grade	SAE 10 W 30
Engine oil make	4T oil

Transmission		
Clutch		Multiplate wet type clutch
Primary Reduction		3.350 (67/20)
Final Reduction		3.000 (42/14)
Gear Box		4 Speed Constant Mesh
Gear Ratio	1st	2.769 (36/13)
	2nd	1.500 (30/12)
	3rd	1.095 (23/21)
	4th	0.913 (21/23)

Chasis	
Type	Tubular Double Cradle Type

Suspension	
Front	Telescopic hydraulic Fork
Rear	Swing arm shock absorber assisted
Caster Angle	26° degrees
Trail length	89 mm
Front Fork Oil Capacity	157 1 ± 1 cc

Brakes	
Front	Drum
Rear	Drum type
Brake fluid	DOT - 3 or DOT - 4

Wheels & tyres	
Tyre size (Front)	2.75 x 18 - 4 PR / 42 P
Tyre size (Rear)	2.75 x 18 - 6 PR / 48 P

Cold Tyre Pressure	
Front (Rider only/ Ridder & pillion)	1.75 kg/cm^2 or 25 psi / 1.75 kg/cm^2 or 25 psi
Rear (Rider only/ Ridder & pillion)	2.25 kg/cm^2 or 33 psi / 2.80 kg/cm^2 or 41 psi

Electricals	
Battery	12 V - 2.5 Ah (Kick start) / 5 Ah (Electric Start)
Alternator	125 W @ 5000 rpm
Spark Plug	NGK - CPR 6 EA 9, Champion - RG 9 Yc
Head Lamp	35W / 35W Halogen (Multi Reflector)
Tail Lamp / Stop Lamp	5W / 21W
Turn Signal Lamp	10W x 4
Fuse	15A, 10A (Kick start); 20A, 15A (Electric Start)

Gauges used in two and three wheeler

Objectives: At the end of this lesson you shall be able to
- **explain the location of various gauges in a vehicle**
- **explain the purpose of a fuel gauge**
- **explain the working of a fuel gauge.**

The gauges indicate to the driver the working of the particular system to which they are connected. These gauges are located on the dashboard of the vehicle.

Some of the electrically operated gauge are the following.

- Fuel gauge (Balancing coil type)

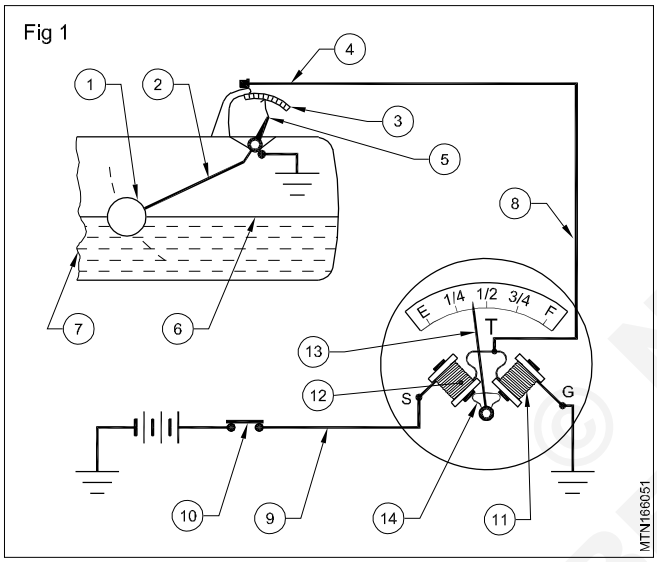
Fuel gauge

Purpose

It is used to know the quantity of fuel available in the fuel tank.

Tank unit (A) (Fig 1)

Fig 1



It consists of a tank unit and the indicator unit. The two units are connected in series by a single wire to the battery through the Ignition switch. When the ignition switch is turned on, current passes through both the units.

The tank unit is fitted on the fuel tank and the indicator unit on the dashboard. The tank unit consists of a hinged arm with a float fitted at one end and a sliding contact at the other end and also a variable resistance. The sliding contact moves along the resistance. The float arm moves up and down as the level of fuel in the tank changes. The movement of the float arm changes the electrical resistance in the circuit.

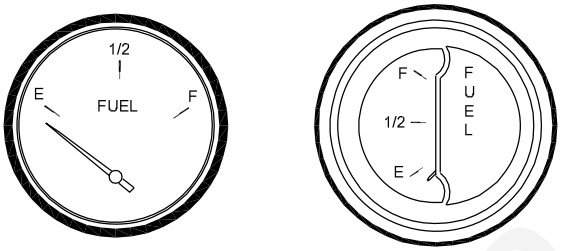
Gauge unit (Dash unit) (B) (Fig 2)

It is fitted on the panel board.

Two terminals (8) & (9) are connected to the tank unit's terminal (4) and ignition switch (10) respectively.

It consists of two coils (11) & (12) and a pointer (13) with the magnet (14) attached to it.

Fig 2



FUEL GAUGES

Working

When the ignition switch (10) is on, current from the battery flows to the coils and a magnetic field is produced. When the tank (7) is full, the float (1) raises above and moves the sliding contact (5) to the high resistance position on the resistance coil (3). The current flowing through the coil (12) also flows through the coil (11). The magnetism of the coil (12) becomes weaker.

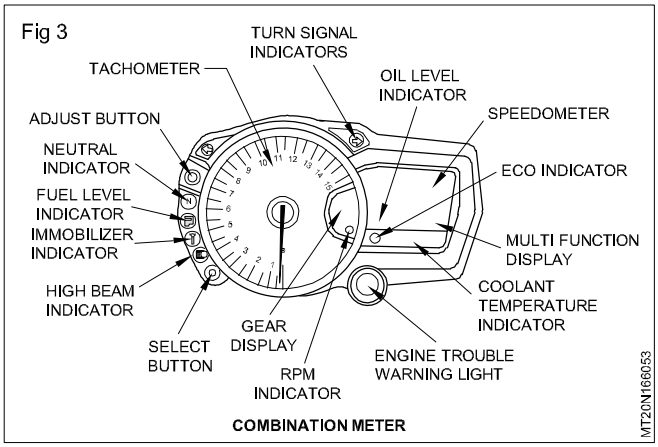
The magnetism of the coil (11) thus becomes stronger and pulls the armature (14) and the pointer (13) to the full side of the dial. When the fuel level (6) comes down the float in the tank falls down and resistance also becomes less, thereby strengthening the magnetic field around coil (12) and forcing the armature and pointer towards the empty side of the dial.

Instruments and indicators

A modern combination meter plays a role of a communication media between the rider and the vehicle. This combination meter consists various instruments and indicators. These instruments and indicators are used to intimate the rider about necessary and critical conditions. It comes with numerous designs to provide aesthetic and ergonomic appeal. Use of LCD screen for displaying the required information has become common nowadays. Depending upon the configuration, the meter can be recognized either as analog, partly digital or full digital meter. Proper illumination and warning buzzers are provided to make them noticeable as and when required.

Functions of instruments and indicators

Figure shows a combination meter of a high performance motorcycle. This meter includes a LCD screen which is used to display the information in digital form. Current sensor technologies and actuator technologies help to maintain constant feedback in the form of exact digits. The colour of illumination provided to particular indicator differs with its function and its importance with respect to safety. Proper illumination is accomplished with the help of LED lights. Functions of various instruments and indicators are explained below.



Functions of Instruments

Tachometer: The tachometer allows the rider to monitor the engine speed and keep it within the ideal power range. When the key is turned to "ON", the tachometer will sweep across the r/min range and then return to zero r/min in order to rest the electrical circuit.

Clock: The clock displays when the key is turned to "ON".

Fuel Meter: The fuel meter indicates the amount of fuel in the fuel tank. The display segments of the fuel meter disappear towards "E" (Empty) as the fuel level decreases. When the last segment and fuel level warning indicator start flashing, the fuel tank must be refilled as soon as possible.

Eco Indicator: This indicator comes on when the vehicle is being operated in an environmentally friendly, fuel-efficient manner. The indicator goes off when the vehicle is stopped.

Transmission Gear Display: This display shows the selected gear. The neutral position is indicated by N and by the neutral indicator light.

Multi-Function Display: The multi-function display provides necessary information as and when required. The rider can visualize the required information with one push of a button. The multi-function display is equipped with the following;

- An odometer
- Two trip meters (Which show the distance travelled since they were last set to zero)
- A fuel reserve trip meter (Which shows the distance travelled since the left segment of the fuel meter started flashing)
- A coolant temperature display
- An air intake temperature display
- An instantaneous fuel consumption display
- An average fuel consumption display

Function of Indicators

Turn Signal Indicator Light: This indicator light flashes when the turn signal switch is pushed to the left or right.

Neutral Indicator Light: This indicator light comes on when the transmission is in the neutral position.

High Beam Indicator Light: This indicator light comes on when the high beam of the headlight is switched on.

Oil Level warning Light: This warning light comes on if the engine oil level is low.

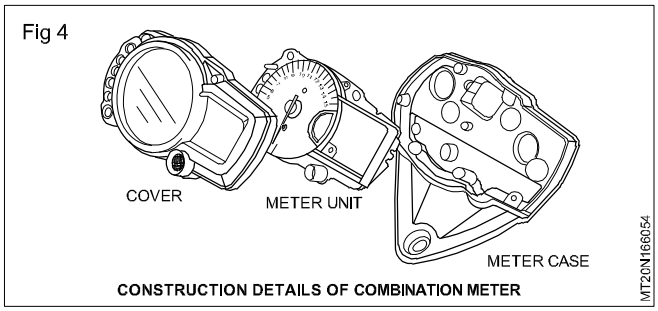
Coolant Temperature Warning Light: This warning light comes on if the engine overheats. If this occurs, stop the engine immediately and allow the engine to cool.

Engine Trouble Warning Light: This warning light comes on or flashes if a problem is detected in the electrical circuit monitoring the engine.

ABS Warning Light (For ABS Models): In normal operation, the ABS warning light comes on when the key is turned to "ON", and goes off after traveling at a speed of 10 km/h or higher.

Construction

Fundamentally, a combination meter is constructed with the help of three components: Cover, Meter Unit and Meter case. The cover gives aesthetic appeal to the meter console and protects the meter unit from environmental impact. The meter unit holds all electronic components necessarily required to operate the various instruments and indicators. The mother board, stepping motors, pointers, LED lights and LCD screen are the major components of the meter unit. The meter unit is mounted on the meter case which forms a rigid base for the whole unit. The meter unit is screwed to the case while the cover is press fitted with the case. The case is also used to mount the meter console on the frame. Fig 4 shows few designs for state-of-the-art combination meters.



Cylinder block, piston and piston rings

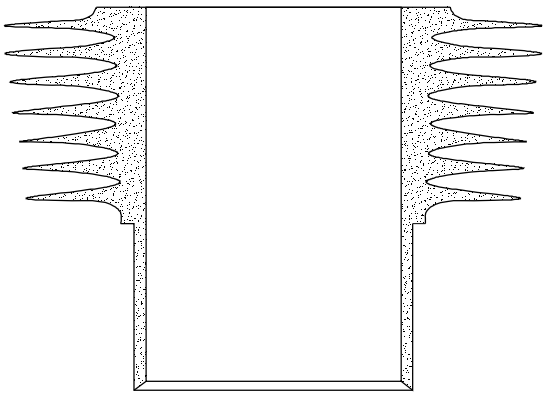
Objectives: At the end of this lesson you shall be able to
- **explain the function of cylinder**
- **explain the function of piston**
- **explain the function of piston ring.**

Cylinder

As the cylinder is exposed to extreme heat of the burning gas, it needs cooling. On air-cooled engines, the cylinder is provided with cooling fins.

A one-piece cast iron cylinder is used on small engines. (Fig 1)

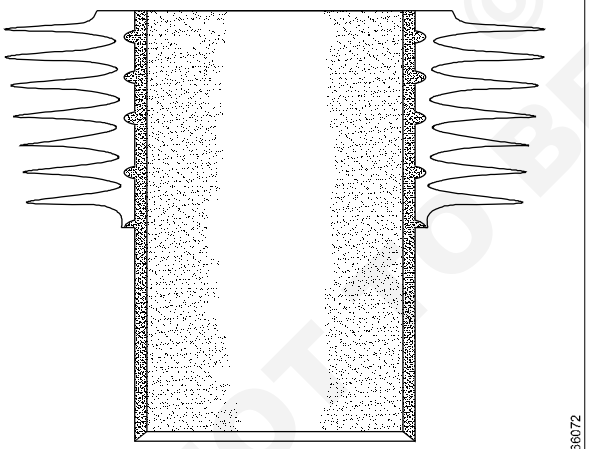
Fig 1



ONE PIECE CAST IRON CYLINDER

A cast aluminium cylinder fitted with an iron sleeve is often used on medium and large sized engines.

Fig 2



CAST ALUMINUM CYLINDER WITH IRON SLEEVE

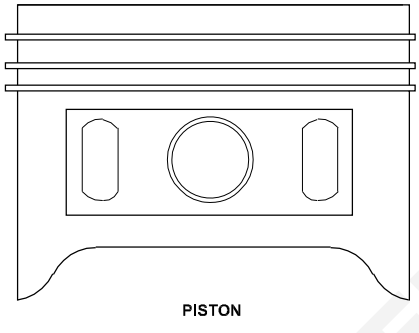
Aluminium cylinder

Aluminium cylinder is being used for better heat dissipation and to reduce weight.

Piston

The piston moves at very high speed in the cylinder and is exposed to the extreme temperature of the burning gas. Pistons are made of a specially forged aluminium alloy which is not only light in weight but also resistant to thermal expansion.

Fig 3



PISTON

The reciprocating motion of the piston is converted into the rotary motion of the crankshaft via the connecting rod. To smoothen this motion conversion, the piston pin's hole slightly offset against the center of the piston.

Most of the piston used on 'four-stroke engines are provided with valve recesses in the piston head to prevent contact between the valves and the piston.

Because of the "offset" and the "valve recess", the direction of the piston installation is specified.

Refer to the mark on the piston head.

"IN" or "NI" - intake side

Piston is Tin coated and grooves are provided to reduce friction. There are slots provided in the boss side to reduce weight and give room for piston expansion.

Off-set piston pin: Piston pin is offset to reduce the piston slap during reciprocation.

Piston rings: There is some clearance between the piston and the cylinder wall. Piston rings are fitted to prevent gas and oil to leak through this clearance.

The cylinder wall is coated with oil. If not sealed, the oil will leak into the cylinder and burn thus depleting the oil.

Three rings top, second and oil ring are installed on the piston.

Top ring: The top ring seals gas in the combustion chamber. It has a "barrel-face" section in order to maintain sealing even when the piston is inclined.

Most top rings are chrome-plated to maximize wear resistance.

Second ring: The second ring has a beveled edge.

The second ring functions to:

- Seals gas.
- Scrape off excess oil on the cylinder wall when moving downward.
- Coat the cylinder wall with oil when moving upward.

Oil ring

The oil ring scrapes off excess oil on the cylinder wall as it moves downward. The scraped off oil is drained through holes in the piston.

The oil ring is composed of two steel rails and an expander ring.

Fig 4

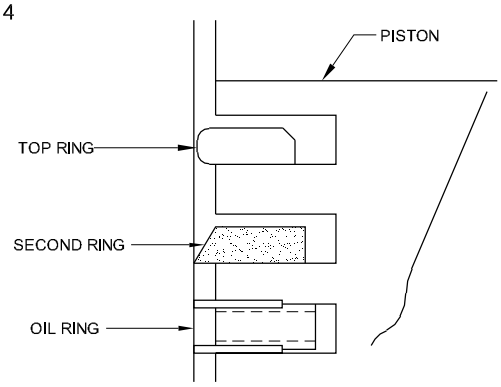


Fig 5

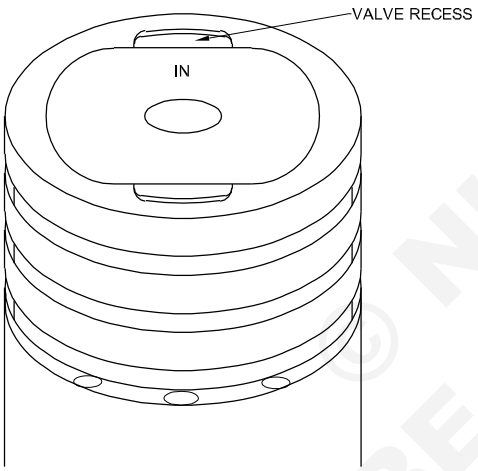


Fig 6

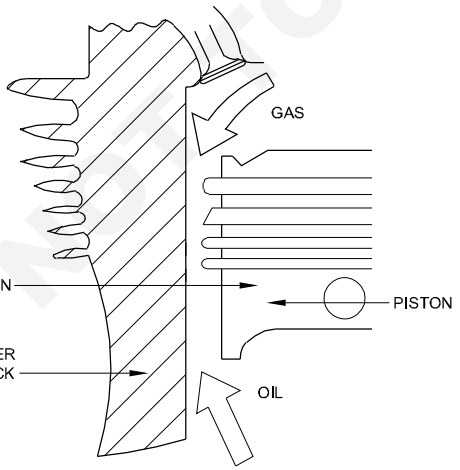


Fig 7

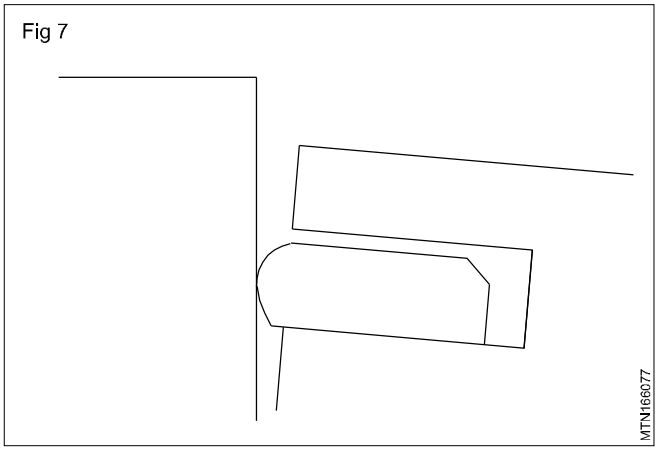


Fig 8

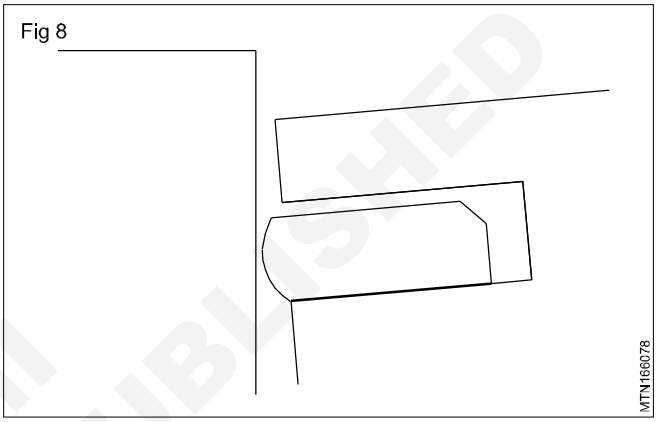


Fig 9

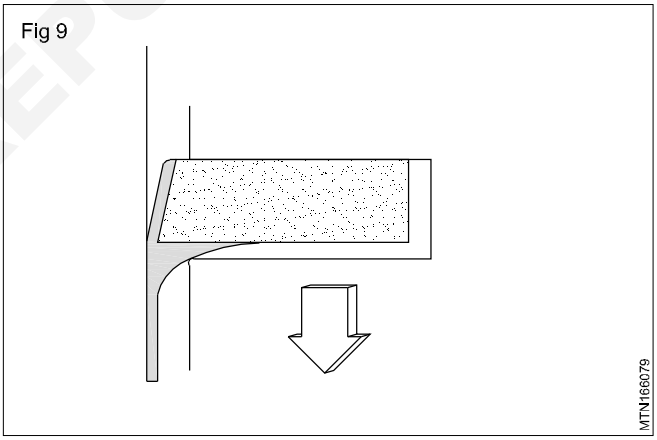


Fig 10

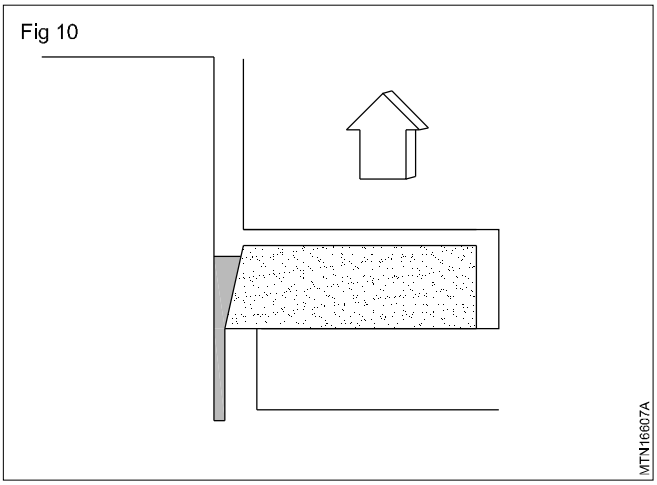


Fig 11

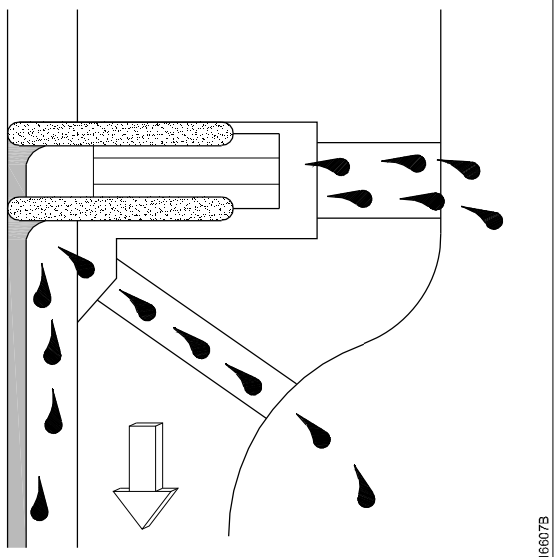
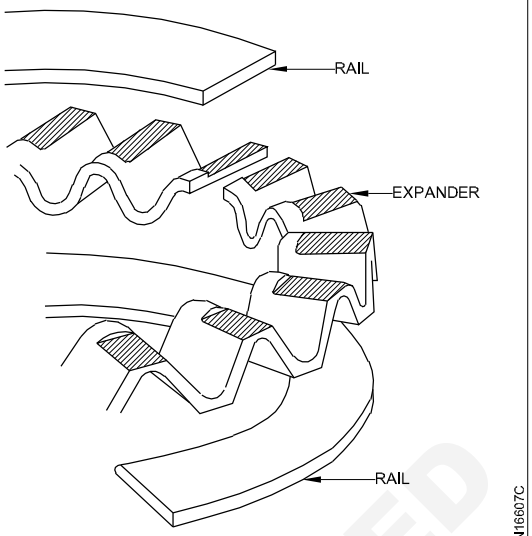


Fig 12



Cylinder block and its components

Objectives: At the end of this lesson you shall be able to
- **describe the function of the engine**
- **describe the construction and function of cylinder block.**

Engine

The main function of engine is to produce power to proper the vehicle. It is done in the engine by converting the heat energy of the air/fuel mixture in to mechanical energy

A good engine should fulfill the following requirements.

- It should be fuel efficient
- It should consume less mobile oil
- It should be high by wear-resistant
- It should have good thermal conductivity
- It should have capacity to with stand high temperature and pressure.

Following are the main components of an engine.

Cylinder block: It forms the base of the engine. Two types of cylinder blocks are used in vehicles

1 **Single piece casting:** In this type the cylinder block and crack case are cast as one piece. It gives better rigidity and it in easy to cast, which reduces the cost of manufacturing

2 **Two - piece casting:** In this type the cylinder block and crack case are cast separately. The crack case is bottled to the cylinder block. The cylinder block is made of cast iron in two wheelers. In two wheelers the crack case and gear box case form as a single unit which holds engine oil as engine lubricating

Piston and piston rings

Objectives: At the end of this lesson you shall be able to
- **state the function and the requirements of a piston**
- **state the constructional features of a piston**
- **list out the different types of pistons**
- **list out the different types of piston rings**
- **state the constructional features of piston rings.**

A piston is of a cylindrical shape which reciprocates inside the cylinder bore. The main functions of the pistons are:

- to transmit the power developed by fuel combustion to the crankshaft through the connecting rod.
- to transfer the heat generated due to combustion to the cylinder wall.

Requirements of a piston: A piston should be:

- able to withstand high temperature and pressure of combustion.
- a good conductor of heat
- light enough to minimise the inertia load.

Construction of a piston: It has a special shape at different portions according to the design. A piston is designed with five portions according to the purpose and functional features.

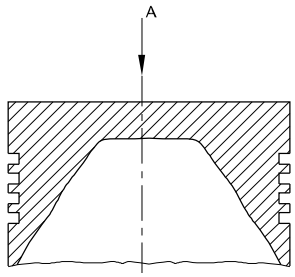
The crown or head: It is the top most portion of the piston. It is subjected to high pressure and temperature due to the combustion of the fuel.

Four types of heads are used.

Flat head (Fig 1)

It is simple in shape and is most commonly used. It is simple in construction. Decarbonising of this is very easy.

Fig 1



Domed head (Fig 2&3)

It has a projection shaped like a dome on the crown. The dome acts as a deflector and helps to make a homogeneous mixture of air and fuel.

It is used in two-stroke cycle engines. It is difficult to manufacture compared to flat heads.

Fig 2

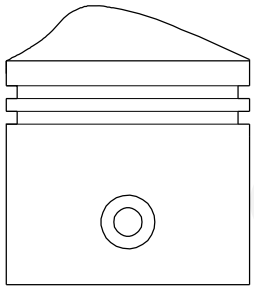
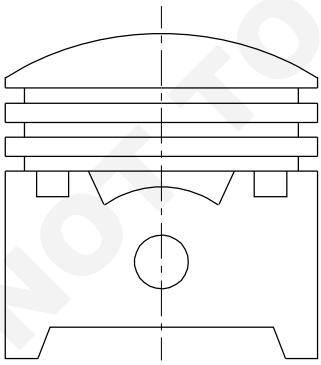


Fig 3



Concave head: It has a concave cavity on the top. It is used in high compression diesel engines to reduce the clearance space (Fig 4).

Irregular head (cavity piston): It has a cavity on the top, and a conical shaped projection is provided inside the cavity. This helps in swirling of air and thereby making for homogeneous burning, and it improves combustion. It is used in high compression diesel engines (Fig 5).

Fig 4

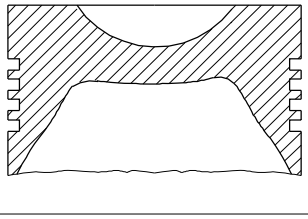
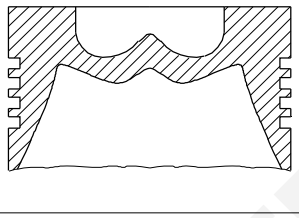
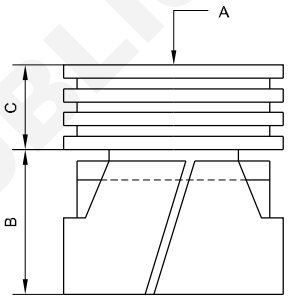


Fig 5



Skirt: Skirt is the lowest portion of the piston. It works as a guide to the piston in the bore and enables the piston to move in a straight line. The skirt has the least clearance with the liner. The piston to liner clearance is measured at the skirt. (Fig 6)

Fig 6

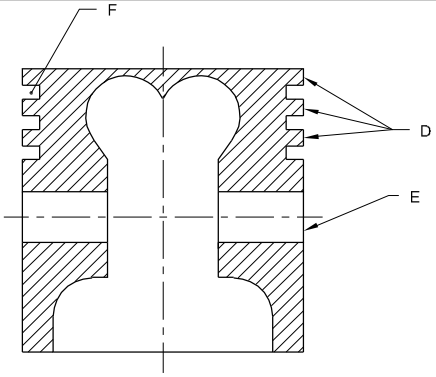


Ring section (Fig 7)

It is the portion between the top of the piston and the last ring groove. It has more clearance with the cylinder than with the skirt. There are two types of piston ring grooves.

- **Compression ring groove:** These grooves accommodate compression rings.
- **Oil ring groove:** These grooves accommodate the oil scraper rings.

Fig 7

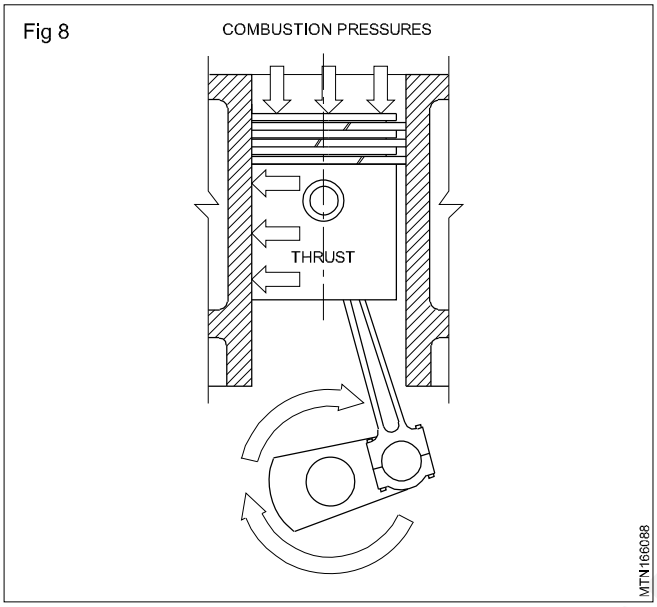


Land

This is the piston's circumference left above the top ring groove and between the ring grooves.

Gudgeon pin boss (Fig 8): At this portion of the piston a gudgeon pin is fitted to connect the piston and the connecting rod. In some cases it is reinforced with ribs to withstand the combustion pressure. When the engine is running in clockwise direction, seen from the front of the engine, the left side of the piston is the maximum thrust side and right side is the minimum thrust side.

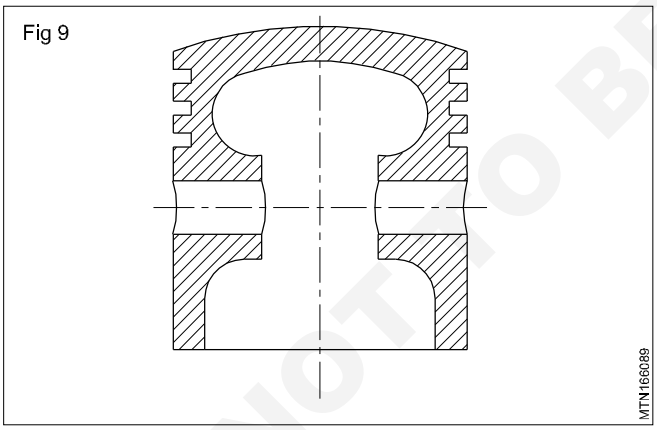
Fig 8



Designs/ types of pistons

Solid skirt piston (Fig 9): These pistons are used in compression, ignition engines or heavy petrol engines. This design can take up heavy loads and thrusts.

Fig 9



Slipper pistons (Fig 10): This type of pistons is used in modern engines to increase the area of contact at thrust faces. It is lighter in weight compared to the solid skirt piston.

Split skirt piston (Fig 11): It is widely used in two-stroke scooters and mopeds. It is lighter in weight and has less inertia load.

Piston rings

Types

- Compression ring
- Oil control ring

Fig 10

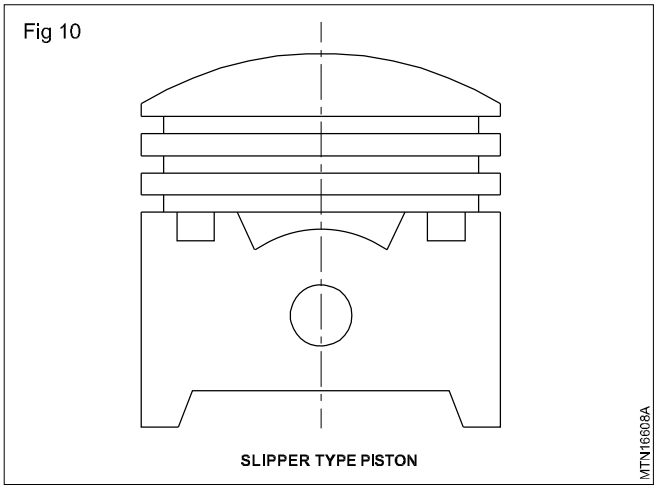
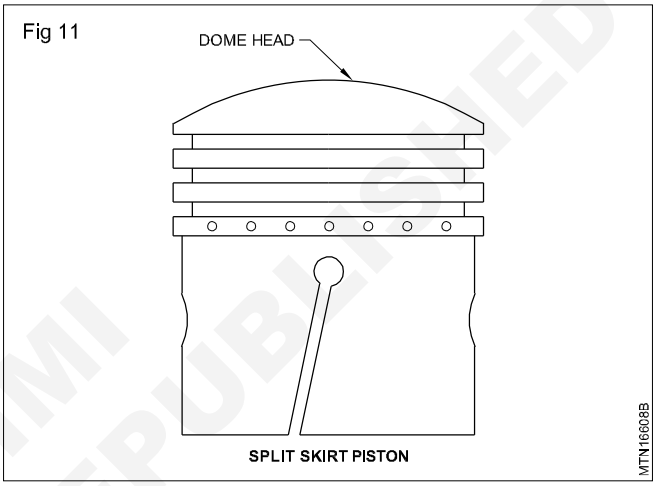


Fig 11



Compression rings

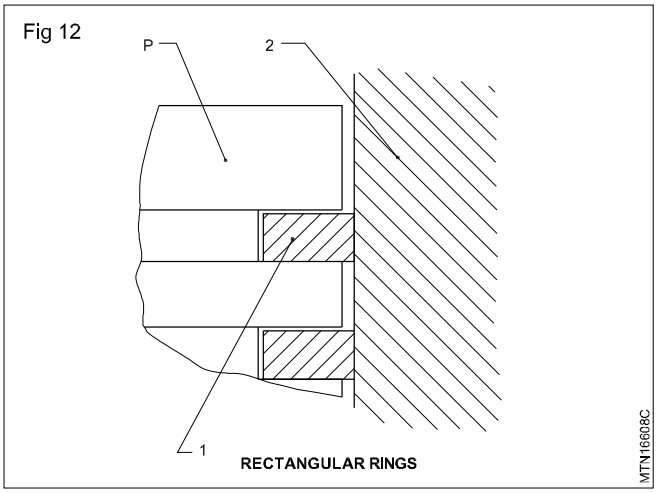
These rings effectively seal the compression pressure and the leakage of the combustion gases. These are fitted in the top grooves. They also transfer heat from the piston to the cylinder walls. These rings vary in their cross-section.

The following types of compression rings are used.

Rectangular rings (Fig 12)

These rings are very popular and easy to manufacture with less cost. The face of the rings (1) remains in full contact with the wall of the liner (2).

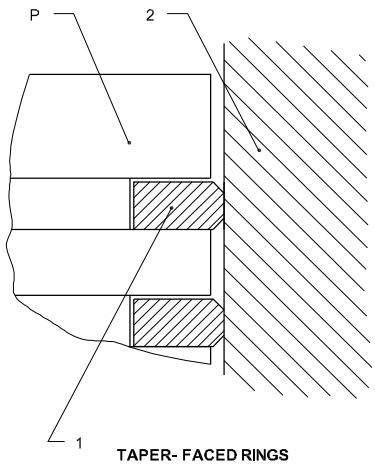
Fig 12



Taper-faced rings (Fig 13)

The face of the ring (1) is tapered. The lower edge of the ring is in touch with the liner (2). These rings are good for controlling oil consumption by scraping all the oil from the liner (2). These rings cannot effectively control blow-by.

Fig 13

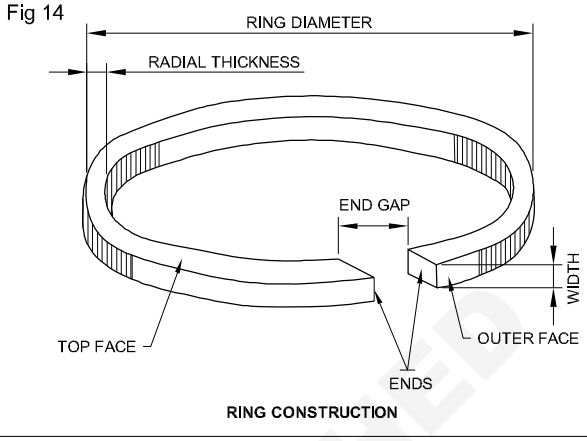


TAPER- FACED RINGS

Ring Construction (Fig 14)

The construction of a piston ring and the nomenclature of its various parts. The ring is generally cast individually and machined carefully so that when in position, it is able to erect uniform pressure against the cylinder walls.

Fig 14



RING CONSTRUCTION

Piston ring clearance

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

- **state the recommended clearances for rings**
- **state the piston rings fitting precautions**
- **state the causes and remedies of piston rings**
- **state the compression ratio.**

Piston ring clearance: While inserting ring into the piston, gets expand and ship into the ring groove;

- Ring clearance is put provision to take expansion
- The gap almost closed whom piston inside the cylinder
- Which is must for sealing purpose of gests.
- In practice the position ring and gap when installed should be kept recommendable by manufacture.
- Excess ring end gap will result in blew by gases.
- The ring gap in measure with the feeler gauge.

Piston clearance: The gap of film that is allowed between the piston and circumference of the cylinder bose is called piston clearance. This gap is provision to move the piston freely in the cylices that take expansion during working of engine. The piston clearance will vary according to the size of the engine and material. The position clearance can be obtained by measuring cylinder bose dia and piston dia with the help of micrometer and bose dial gauge.

Piston pin: It is also called grudge pin, connects the piston and the small end of the connecting sod. It is made of tubular form. It passes through the bases in the piston and the small end of the connecting rod this is made of low carbon case hardened steel. Piston pin connections are two types;

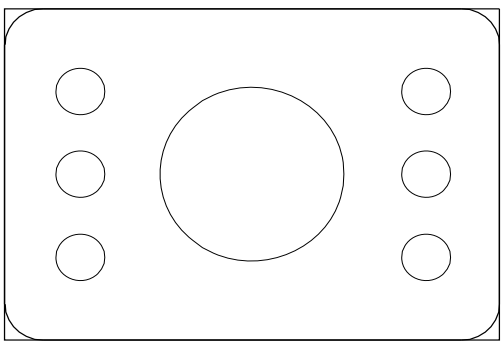
a Fully floating

b Semi-floating

Now a days only full-floating piston pins are available which are locked with circlips on both ends in the piston boss.

Gasket: Gaskets are used to provide a tight fitting joint between two surfaces. i.e., the joint between the cylinder head and cylinder block. Cylinder head gaskets are made of embossed steel which are shim type. (Fig 1)

Fig 1



Piston clearance (Fig 2&3)

Piston rings have gap so that they may be installed into the piston grooves and removed when worn out by expanding them. The gap ensures pressure against the cylinder wall thus having effective seal to prevent leakage of heavy combustion pressure. This gap must be checked because if it is too great due to cylinder bore water, the radial pressure will be reduced.

Fig 2

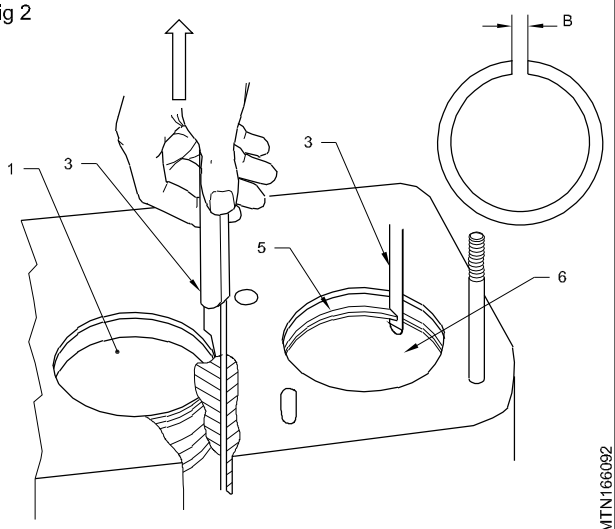
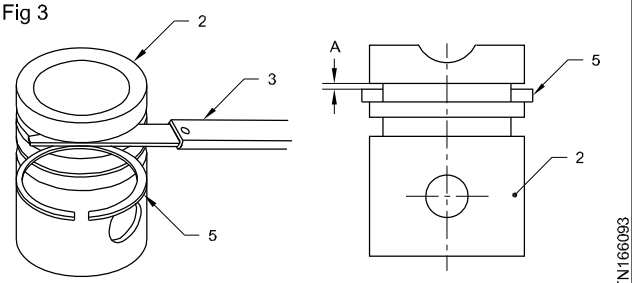


Fig 3



To check this gap clean the carbon from the ends of the ring and then check it with feeler gauges. This gap may be in the region 0.178 - 0.50 mm governed by the diameter of the bore but if it exceed 1mm per 100mm of bore diameter, new rings must be fitted.

The gap between the ring and the groove in the piston should also be checked by feeler gauges. This gap it usually 0.038-0.102 mm Fig 3 for compression rings and a little less for the oil control rings. The gap between piston and limer is measured by feeler gauge from the bottom of the limer (skirt) is 25.4mm Fig 2.

Precautions while fitting rings in the piston

There are two types of piston rings (compression ring and oil scraper ring) used in an i.c engines. While fitting the piston rings follow the precaution.

1 Remove the ridge in the linner.

2 Use proper ridge cutter.

3 Measure the end gap of new ring.

4 Use piston ring cutter to remove excerse material.

5 Use piston ring grooves cleaner to remove carbon from grooves.

6 Clean the piston groove, linner rings with specified cleaning liquid.

7 Excess piston ring expand lead broken, so limit the ring expansion as need.

8 Use the ring expander to fit the ring in the piston.

9 Check the end gap clearance of the ring.

10 Check ring side clearance in the piston's groove.

11 Ensure the piston rings and gap should not be inline.

Causes and remedy

1 Wear in the piston ring grooves causes the rings to rise and fall during movement of piston and its pumping action resulting in high oil consumption.

2 Exercise gas blow by, loss of compression take place if gap is too much (cylinder wall and piston ring).

3 During service the piston ring may have lost elastic properties due it which radial pressure reduced on the cylinder wall. This property was checked by press long together worn and a new observing whether the gap of the worn ring closen than the new ring.

Compression ratio (Fig 4): It is the ratio of the volume of the charge in the above in the cylinder above the piston at bottom dead centre and the vehicle the charge when the piston is at top dead centre that volume above the piston at bottom dead centre that displacement of the cylinder plus the clearance and the volume above the piston at top dead centre is the clearance volume, the compression ration can be

For example, if clearance volume is 90cm^3 and displaced volume is 540 cm^3, the compression ratio will be

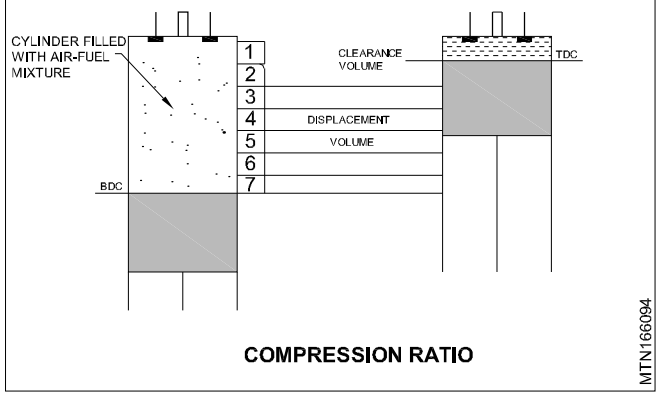
$$\frac{\text{Clearance volume + Displacement volume}}{\text{Clearance volume}}$$

The compression ration 7:1 is illustrated in Fig 4 automobile engines had low compression ratios. They are known as

$$r - \frac{90 + 540}{90} = \frac{630}{90} = 7:1$$

low compression engines the available at that time could not be subjected to pressure without detonation. The modern gasoline engine have compression ratios 7:1 to 10:1 Diesel engines from much higher compression ratios from 11: to 221

Fig 4



The compression ratio of an engine will be increased and condition that will decrease the size of the clearance volume such as the accumulation of carbon deposits high

compression ratio results in decreased operating effecting and grater power output for a given engine.

The pressure of the mixture at maximum compression determined by the compression ratio. Some other factors are also considered like engine speed, temperature, degree of vapourisation of the fuel and leakage past the pistonings

Piston pins and connecting rod

Objectives: At the end of this lesson you shall be able to
- **list out the various types of piston pins and material of the position pin.**

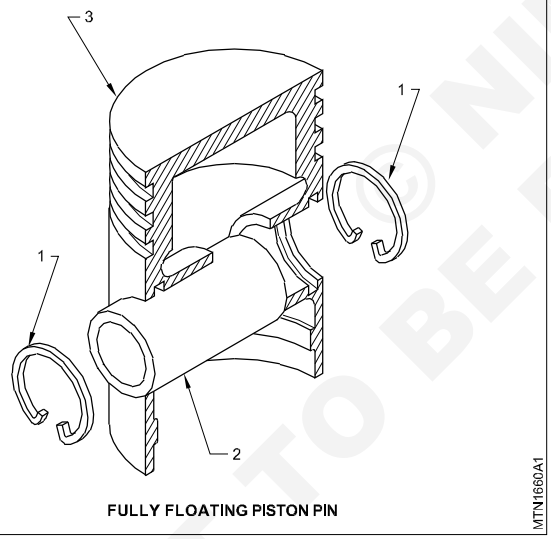
The piston pin or gudgeon pin connects the piston with the connecting rod. It should be strong enough to transmit power and withstand pressure of combustion. Piston pins are made hollow to reduce inertia load due to the reciprocating motion.

Types of piston pins

Fully floating piston pin (Fig 1)

In this type there are circlips (1) on either side of the piston pin (2). The pin (2) is free to rotate both in the piston (3) and the connecting rod. Circlips (1) are fitted into the grooves provided in the piston boss. This type of pins is used in engines which carry heavy loads. One gun metal or bronze bush is used between the small end of the connecting rod and the piston pin. Small two-stroke engines may have a needle bearing cage instead of a bush.

Fig 1



FULLY FLOATING PISTON PIN

Semi-floating piston pin (Fig 2)

The pin (1) is fastened to the connecting rod (2) with a clamp (3), screw (4) and nut. In this the piston boss forms the bearing.

Set screw type piston pin (Fig 3)

The pin (1) is fastened to the piston (2) by a set screw (3) through the piston boss and is provided with a bush in the small end of the connecting rod.

Material

The piston pins are made of nickel/chromium alloy steel. The outer surface is ground, chromium plated and the case is hardened.

Fig 2

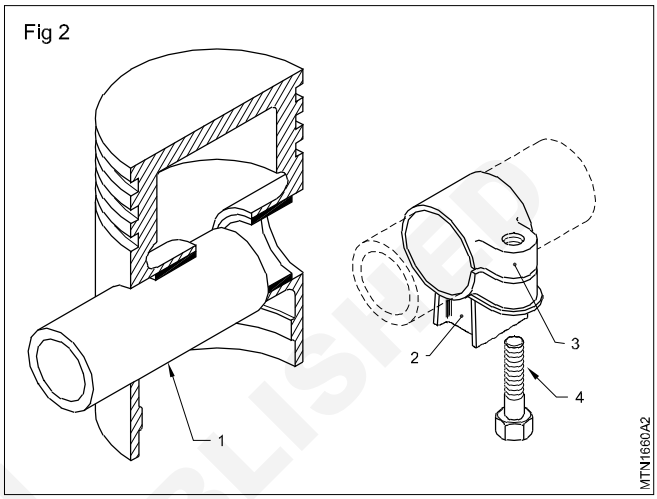
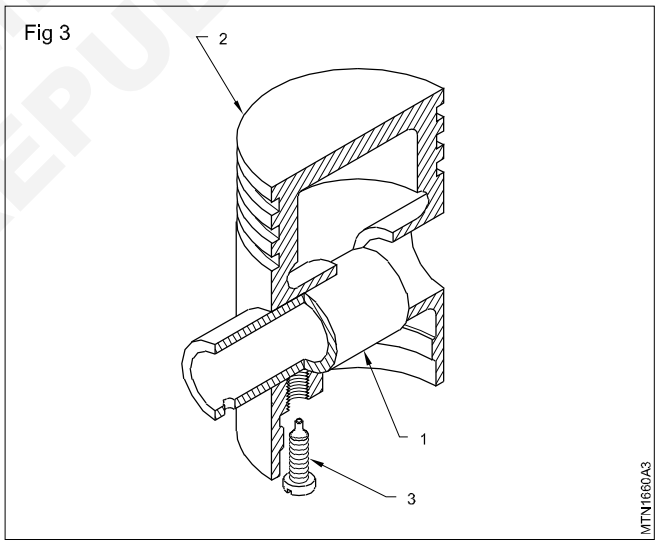


Fig 3



Pistons rings

Functions: The piston rings in I.C engine have to perform the following functions;

1 To form a seal for the high pressure gases from the combustion chamber against leak into the crank case.

2 To provide easy passage for heat flow from the piston crown to the cylinder walls.

3 To maintain sufficient lubricating oil on cylinder walls throughout the entire length of the piston travel, minimizing the ring and cylinder wear, and at the same time, control the thickness of the oil film so that satisfactory oil control is maintained. The oil is not to be allowed to go up into the combustion chamber where eventually it would burn to leave carbon deposits.

This radial play and axial play in the connecting rod big and leads abnormal noise in the engine.

Venality and taper: The cylinders bore get worn out with time and tend to become oval shaped further the wear is not uniform even on the same side from top to bottom.

The maximum wear occurs at the upper limit of the ring travel the cylinder Bose should be measured to determine orality and taper.

This can be done by using either an inside micrometer as a dial gauge the diameters is measured both at the bottom of cylinders in two directions in each case. i.e. in the longitudinal direction of the two direction of the cylinders black and in the perpendicular to it.

In each case the measurement is made by slightly probing the position so as to give maximum reading the difference in reading at the top and at bottom gives the ovality (Fig 4)

The difference in the top and bottom reading in the same direction gives tapes in that direction (Fig 5)

After determining the ovality and the taper, shop manual is consulted to find ant whether reboring the cylinder is necessary or honing only will be sufficient.

Fig 4

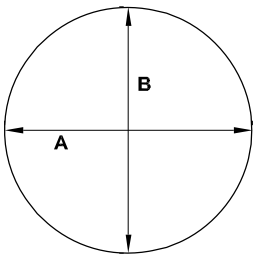
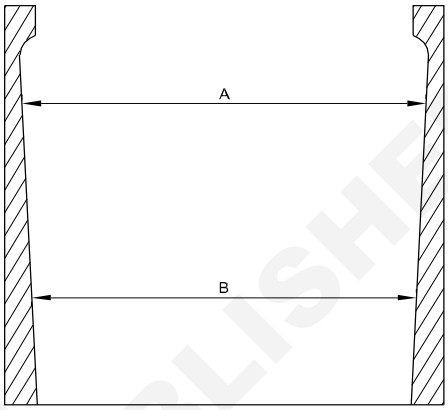


Fig 5



Crankshaft / connecting rod

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

- **state the functions of the crankshaft**
- **state the constructional features of crankshafts**
- **state the material of crankshafts**
- **state the necessity for heat treatment, and the balancing of the crankshaft**
- **state the functions and constructional features of the flywheel**
- **state the significance of the timing marks on the flywheel.**

Functions of a crankshaft

The crankshaft converts the reciprocating motion of the piston into rotary motion, and transmits the torque to the flywheel.

Construction (Fig 1)

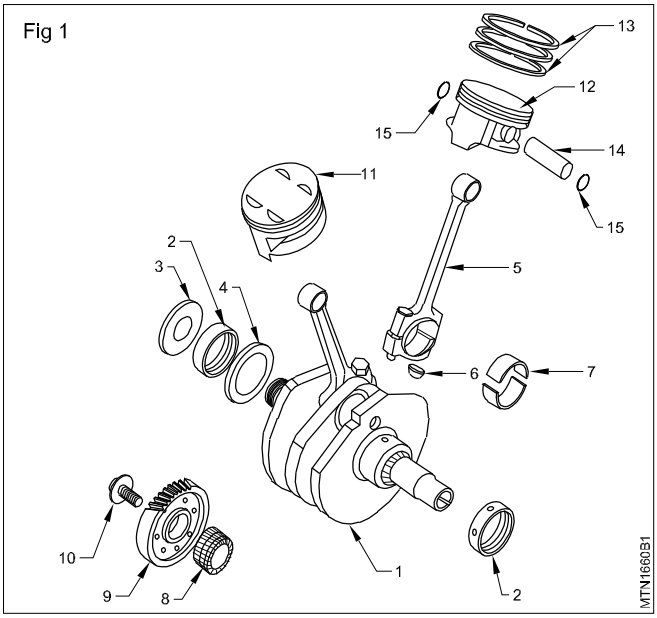
A crankshaft consists of a crank pin (1), webs or crank arm (2) and balancing weights (3) which are provided on the opposite side of the crank arms for balancing the main journals (4).

Crankshafts have drilled oil passages (5) through which oil flows from the main bearings to the connecting rod bearings.

The front end of the crankshaft carries the gear or sprocket (6) to drive the cam shaft.

At the rear end of the crankshaft, a flywheel (9) is fitted. The inertia of the flywheel (9) tends to keep the crankshaft to rotate at a constant speed. Next to the rear end main journal an oil seal (10) is fitted. In some engines, oil return threads are provided which return the lubricating oil to the sump.

Fig 1



Materials

A crankshaft has to withstand the centrifugal force, the impact force by the piston and the connecting rod. It should be light in weight. It is made of the following material.

- Nickel steel
- Chrome, vanadium steel
- Nickel chrome steel
- Nickel chrome molybdenum steel

Balancing of crankshaft

The crankshaft is subjected to torsional vibration and engine vibration. Engine vibration is due to the uneven weight distribution on the crankshaft and the unbalanced reciprocating forces of pistons and connecting rods. Balancing is achieved by removing materials (by drilling) in the crank web or by adding weight to the shaft between centres in a special balancing machine.

Types

1 Single piece crank shaft

2 Assembled crank shaft

Two wheeler crank shaft: assembled crank shaft is used;

Crank shaft: The crank shaft in two wheels are supported by ball bearing on its two ends. It is built up type and is balanced with two weights on crack web. The material for crank shaft is nickel chrome steel made by forging.

The radial play as bend occurs in the crack shaft is called run-out. This run-out is checked and measured by the dial gauge by putting on v- blocks.

Connecting rod: The function of connecting rod is to convert the reciprocating molar of the piston into rotary motion of the crank shaft.

The smaller end of the connecting rod is connected to the piston with the gudgeon pin with bush bearing.

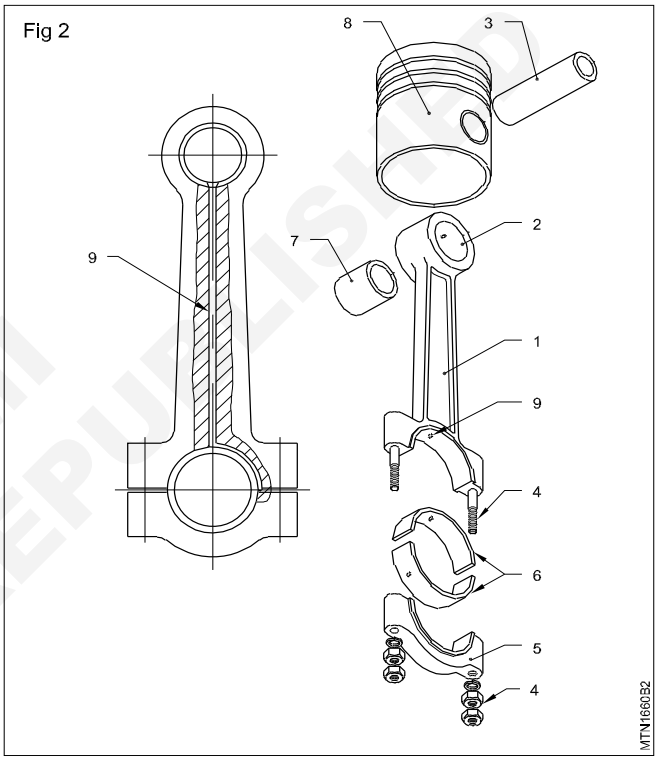
The big end of the connecting rod is connected to the crank shaft crank pins with the help of needle bearing of shell bearing this is made of forged steels in I- section.

The worn out of the bearing and crank pin at the big end and which leads the radial play. This can be repaired by replacing the big end bearing and crank pin.

The axial play is caused by wear of crank pin ends which can be arrested by adding shims at the crank pin in heavy vehicles. Where as, only replacement in two wheelers.

This radial play and axial play in the connecting rod big end results in abnormal noise in engine.

Fig 2



Bearings

Objectives: At the end of this lesson you shall be able to
- **understand the need of bearings**
- **state the different types of bearings used in vehicle**
- **state the uses of the different types of bearings**
- **explain the function and application of different types of bearings.**

Bearings: Bearings are used to support rotating components and to reduce friction between the static and rolling components. The following types of bearings are used in automobiles.

- Bush bearing
- Ball bearing
- Roller bearing
- Needle roller bearing
- Taper roller bearing

Bush bearings are made of copper-lead, tin-aluminium, tin-copper and used in the small end of the connecting rod, camshaft, oil pump drive shaft etc.

Ball bearings (A) (Fig 1) reduce friction between rotating parts to a minimum, and can take radial as well as axial load.

Ball bearings consist of an inner race (2), outer race (3) and balls (4). These bearings are used in the gearbox.

Roller bearings (B) also consist of an inner race (5), outer race (6) and rollers (7) (Fig 2). These bearings can take heavy radial load but no axial load and are used in the final drive, flywheel, water pump etc.

Needle roller bearings (C) (Fig 3) are similar to roller bearings except that the ratio between the length of the needle roller (8) and the diameter of the roller is much more than that of a roller bearing.

Fig 1

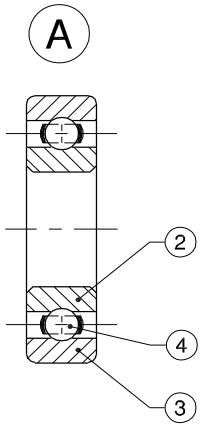


Fig 2

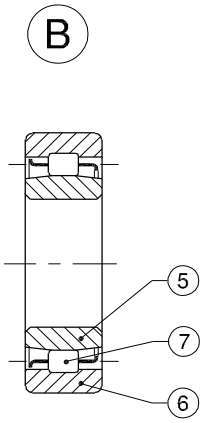
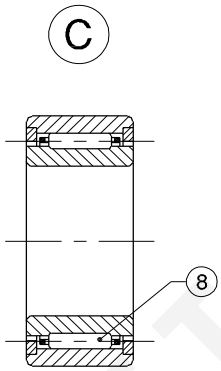


Fig 3

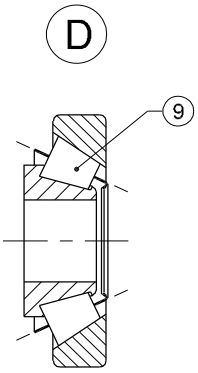


Taper roller bearings (D) (Fig 4) have taper rollers (9) instead of plain rollers. In automobiles, these bearings are generally used in pairs and these can take axial and radial loads. These bearings are used in the differential assembly, wheel hubs etc.

Crankshaft bearings: These bearings are made into two halves. These bearings operate at critical loads and high rotational speeds. These bearing run quieter and are easy to replace. These bearings are also called thin wall bearings. These are made of a thin steel shell base with a thin lining on it.

The lining materials are copper-lead or lead-bronze or tin lead or soft aluminium alloy. Cadmium alloy with copper or cadmium alloy with silver withstands high pressure. Iridium with copper and lead has excellent wear and corrosion resistance. The lining is plated to a thickness of about five thousandth of an inch.

Fig 4



Half shells are provided with an oil groove (1) (Fig 5 to 7) and oil feed holes (2). The bearing shell also has a locking lip (3) on it to fix it on the lip slot (4) of the bore and cap. In some cases dowel pins (5) are provided the parent bore which aligns with the hole on the bearing shell and avoids rotation of the shell.

Fig 5

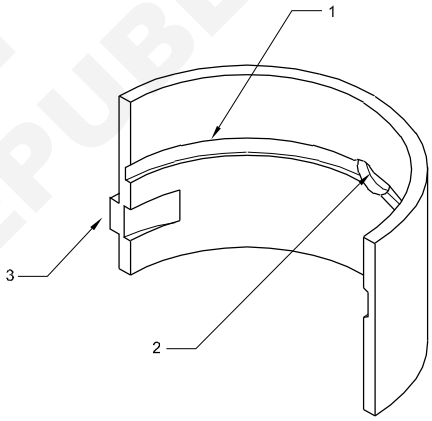


Fig 6

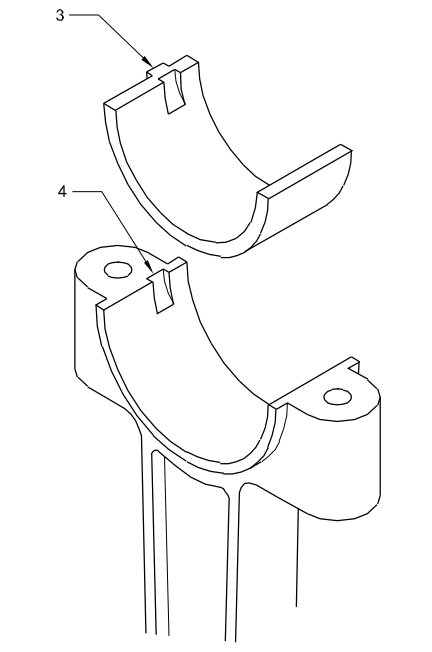
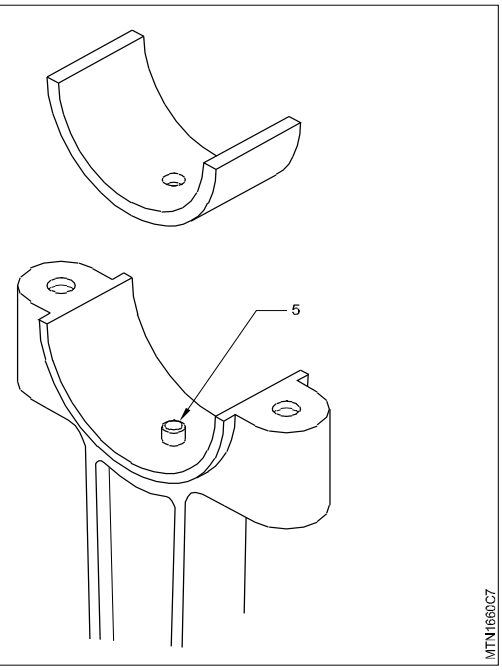


Fig 7



Details of engine bearings

Engine bearings: These are also called "Shell bearings or sliding function bearings or precision insert bearings. These are largely used for free rotation of crankshaft, connecting rods and camshaft. They provide low frictional areas for these shafts to rotate smoothly under different speeds and loads.

Shell bearings: These have been dealt in I Year Trade Theory. In this lesson, some more useful points are discussed on the shell bearings. They are stated as below:

- Qualities of engine bearings
- Bearing materials
- Bearing spread and crush
- Bearing failures and remedies
- Connecting rod and camshaft bearings
- Load on precision insert bearings
- Advantages of using insert bearings.

Qualities of engine bearings: The bearing should have

- Excellent fatigue strength
- Good conformability
- Fine embeddability
- Superior surface action
- High temperature strength
- Adequate corrosion resistance
- Quick thermal conductivity

Fatigue strength: The capacity of the bearing to withstand high loading and impact loads, without being crushed for a reasonable period of life is known as fatigue strength.

Conformability: The capacity of the bearing to adjust to the conditions of crankcase distortion and crankshaft warpage and conform to the journal at all times is termed as conformability.

Embeddability: The bearing should be able to absorb dirt and metal particles and keep them below their working surface to avoid abrasive wear on the journals. This aspect is called embeddability.

Surface action: The bearing should have enough self lubricating properties to withstand metal to metal contact between journals and bearings. This property is termed as surface action.

Temperature strength: Bearings are subjected to higher temperature condition during operation and as the temperature raises, they become softer. The bearing should not become too soft and loose its load carrying strength, at operating temperature.

Thermal conductivity: The bearing should quickly conduct the heat through the shell and parent bore to the block and keep its temperature low. Bearing materials are selected in such a way to suit each engine design requirements in these areas.

Bearing materials used: Different varieties of materials now in use are;

- Tin base babbitt
- Lead base babbitt
- Cadmium nickel or silver alloy
- Copper lead alloy (with tin overlay)
- Aluminium alloy
- Silver lead

Tin base babbitt: Low fatigue strength but has good conformability, embeddability, surface action and corrosive resistance. This is popularly used on heat engines. (Petrol engines)

Lead base babbitt: Improved fatigue strength compare to tin base babbitt and similar to them in other respect. This is popularly used in petrol engines.

Cadmium nickel or silver alloy

Fatigue strength is further improved but not very good in conformability, embeddability and surface action popularly used in high speed high pressure engines.

Copper lead alloy

Superior fatigue strength even at higher temperature. These are improved by overlay tin coating or tin base micro babbitt surface and popularly used in high speed diesel engines.

Aluminium alloy: Aluminium alloy excels with respect to fatigue strength, load carrying capacity, corrosion resistance and freedom from scoring tendencies. In case of seizures, only bearing get affected and journals are saved from scoring when aluminium bearings are used. The sticking bearings material can be easily removed from the journals. Due to poor embeddability, improved hardening of the journals is necessary.

Trouble shooting procedure

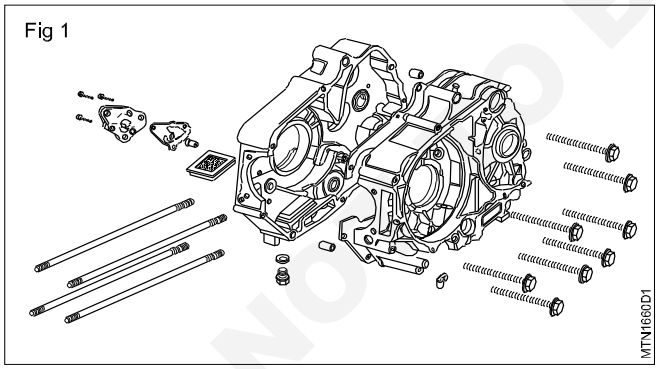
Fault	Causes	Remedies
Low compression	Spark plug loose Cylinder bore wornout Piston ring wornout Valve seal wornout Cylinder head gas ket damaged	Tight it Tight / replace Replace Replace / replace Replace
High compression	Excessive air fuel mixture enter into cylinder Improperly exhaust the burnt gases	Correct the valve clearance Adjust the tappet clearance
Excessive noise	Improper power supply to spark plug Carbon deposited in combustion chamber Incorrect fuel quality Piston ring broken Valve spring broken Tappet bend	Correct the ignition circuit Remove the carbon deposit Use correct fuel Replace Replace Replace
Poor idling	Incorrect idling adjustment Defective carburettor Dirty fuel filter Weak compression	Adjust property Overhaul or replace Clean or replace check and replace defect parts

Crank case assembly

Objectives : At the end of this lesson you shall be able to
- **explain about crank case**
- **state various components of crank case**
- **construction of crank case.**

Crank case (Fig 1) & (Fig 3): It is an assembly mainly that holds the crankshaft. It forms as housing to the crankshaft assembly. Which is supported with the help of ball bearings on its both ends.

Fig 1



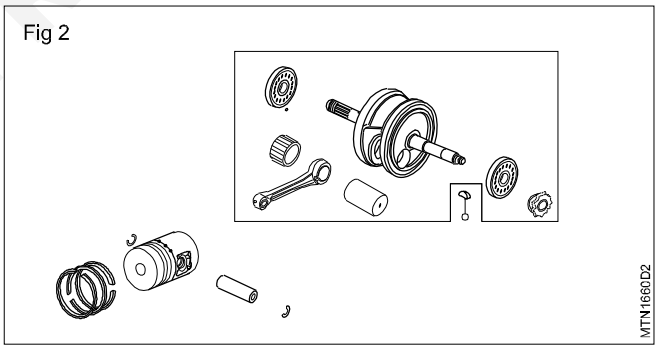
Main components of crankcase: The main components are;

1 Right side case
2 Left side case
3 Oil pump with oil gallery
4 Right side case cover
5 Left side case cover

One is right side case which holds the clutch on its side and also output shaft of transmission at drive sprocket.

The oil pump, strainer and oil gallery is made to hold on this case.

Fig 2



The front end of case is fixed to the engine cylinder with cylinder studs and the lower side is for engine oil drain bolt and washer which is also cranking side.

The other is left side case which holds the A/C generator assembly and fly wheel. The both crank case chucks are aligned with the dowel pins and fixed with bolt flange tightened at recommended torque (Fig 4).

The right side crank case cover holds the clutch linkage lever and also oil filler gauge (14) or depth gauge (Fig 3).

The left side crank case cover (15) protects the A/c generator assembly (10). The left and right side crankcase covers are fixed with bolt flange (16) to the crankcase.

Crankshaft (Fig 2) & (Fig 5): The crankshaft changes the reciprocating motion of the piston into rotary motion

via the connecting rod. The crankshaft web functions as a counter weight to balance the reciprocating mass of the piston and connecting rod.

Crankshafts used on single cylinder engines are so called assembly type, with the right and left crank halves connected via a press-fitted crank pin. A needle roller bearing is installed a the big end of the connecting rod.

Fig 3

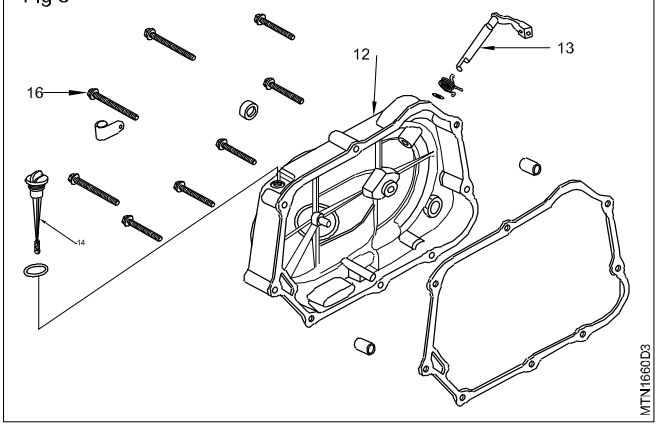


Fig 4

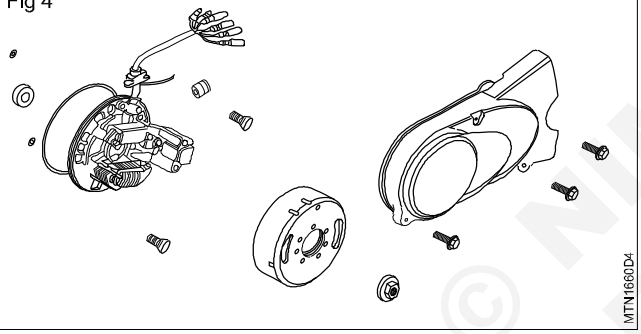
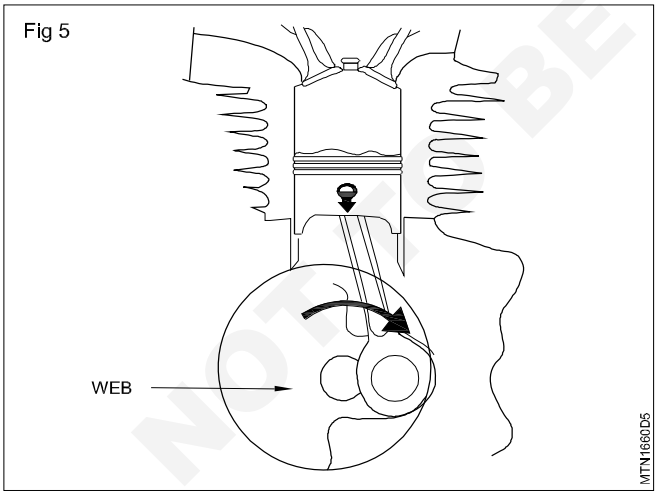


Fig 5



The crankshaft is supported by radial ball bearing on left side and roller bearing on right side to withstand heavy thrust and radial load.

Off-set crankshaft

In a conventional crankshaft arrangement, the thrust of piston on cylinder wall leads to friction. To reduce this friction loss the crankshaft is off-set from the center line of the cylinder. In the power stroke during the gas expansion, the piston and connecting rod are in one straight line, ensuring maximum utilisation of the energy developed during power stroke.

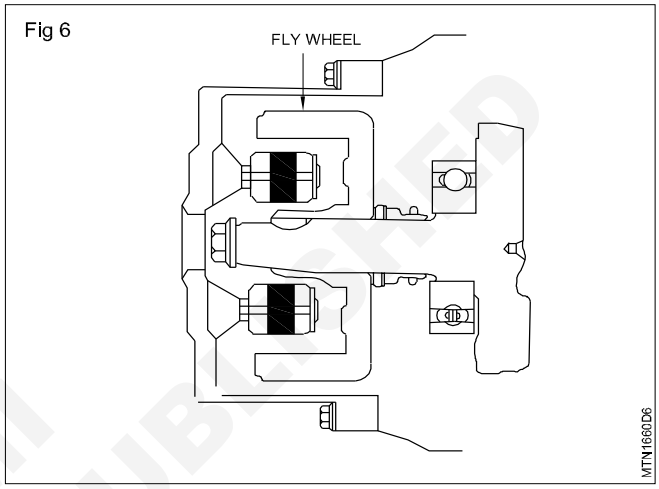
Flywheel: To smooth crankshaft rotation, a flywheel is installed. This also functions as part of the alternator.

Crankshaft bearing set plate

LHS crankshaft bearing is clamped using three set plates to reduce vibration (Fig 4).

Push plunger mechanism: A spring loaded push plunger is provided on left hand side crankshaft bearing. It gives cushioning effect on crankshaft axial movement in power stroke thereby reduces vibration and noise (Fig 6).

Fig 6



RHS crankshaft bearing (Fig 7&8): Split type of roller bearing is used in order to reduce friction and engine vibration.

Fig 7

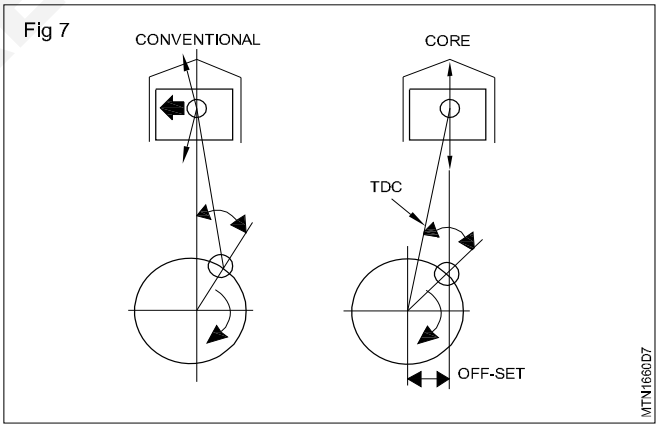
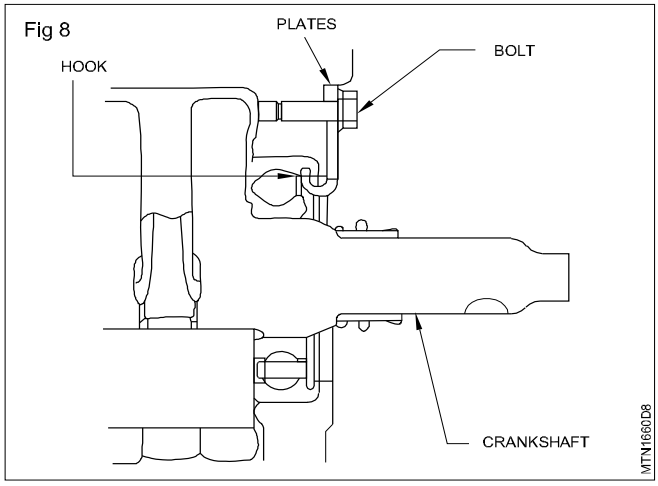


Fig 8



Valves

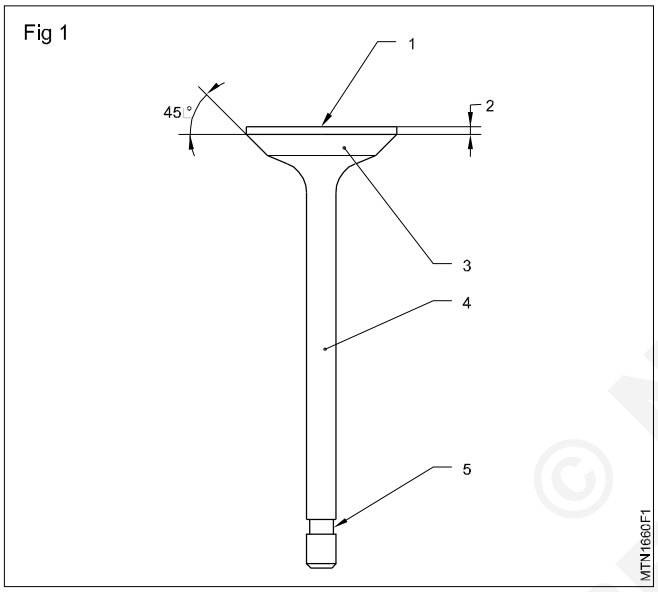
Objectives : At the end of this lesson you shall be able to
- **state the functions of valves**
- **explain the constructional features of valves**
- **list out the different types of valves and their material**
- **state the types of valve operating mechanism**
- **list out the parts of the valve mechanism**
- **state the functions of each part in the valve mechanism.**
- **explain valve timing.**

Functions of valves

- To open and close the inlet and exhaust passages of the cylinder.
- To dissipate heat, through its seat to the cylinder head.

Construction of a valve (Fig 1): The head (1) of the valve is ground with a margin (2) to provide strength.

Fig 1



The valve face (3) is ground to 30° or 45° angle which matches with the seat angle to avoid leakage. The valve stem (4) is of a round shape. The length of the stem varies from engine to engine. At the end of the stem a groove (5) is provided to hold the spring lock.

In some heavy duty engines the valves are hollow, and sodium is filled inside, which helps in the quick cooling of the valve.

Types of valves

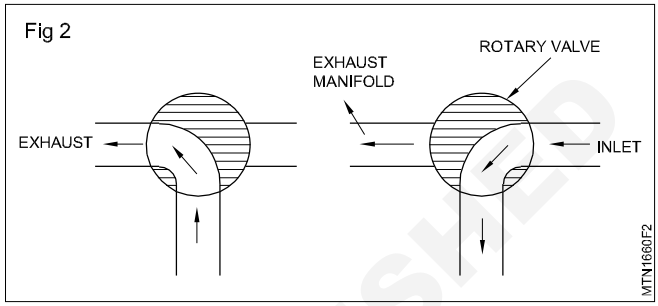
- Poppet-valves
- Reed valves
- Rotary valves
- Sleeves valves

Poppet-valves: As the name indicates these valves pop on their seat. Three types of poppet-valves are in use.

- Standard valve
- Flat top valve
- Tulip valve

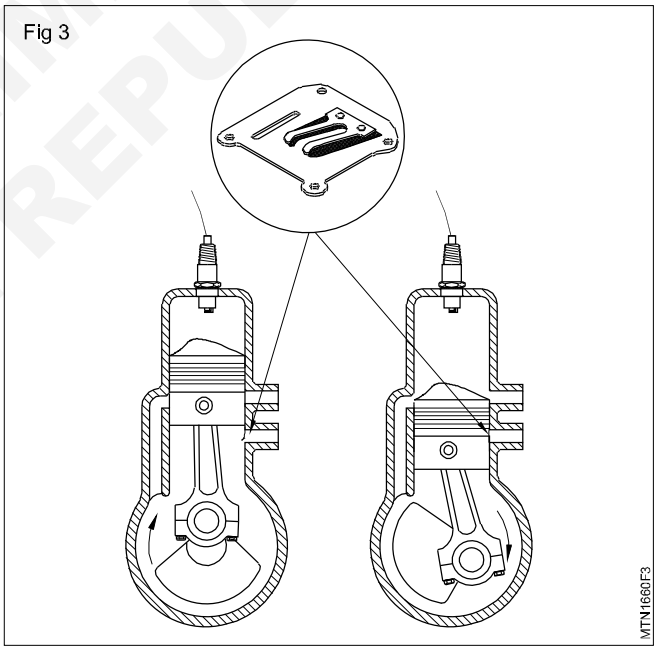
Rotary valve (Fig 2): In this type a hollow shaft runs in the housing which is attached to the cylinder head. This hollow shaft has two ports cut in it, and it aligns the opening in the cylinder head with the inlet manifold, and at the time of the exhaust stroke its opening in the cylinder head with the inlet manifold, and at the time of the exhaust stroke its opening aligns with the exhaust manifold.

Fig 2



Reed valve (Fig 3): It is a metallic strip hinged at one end. It covers the passages and allows air or charge to flow in one direction only. It is normally used in two-stroke engine and air compressors.

Fig 3

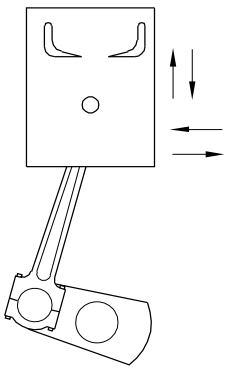


Sleeve valve (Fig 4): In this type, ports are cut in the cylinder liner. It runs will a slight up and down motion. It is also having rotary motion in another sleeve. This aligns with the inlet and exhaust ports at a set time when the inlet and exhaust manifoke open.

Valve materials

- Inlet valve
- Nickel steel alloy, stellite facing
- Exhaust valve
- Silicon-chrome alloy steel, sodium filled valves.

Fig 4



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Arrangement of cylinders: Many two wheelers use multi cylinder engines to produce high power. According to their arrangement, multi cylinder engines mainly classified as below.

a V twin engines
b Horizontally opposed twin cylinder engines
c Side-by-side twin cylinder engines
d V four engines
e Horizontally opposed four cylinder engines
f Three cylinder in-line engines
g Four cylinder in-line engines
h V five engines
i Six cylinder in-line engines
j Horizontally opposed six cylinder engines
k V eight engines

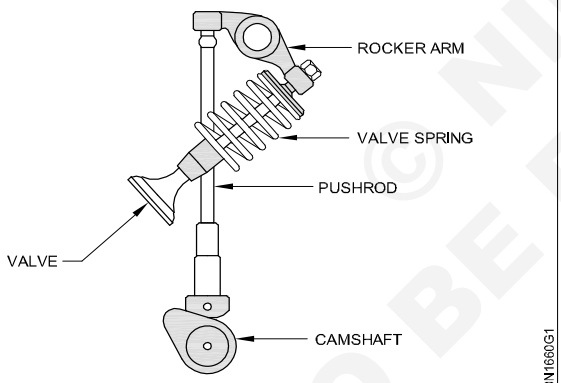
Valve operating mechanism

Objective : At the end of this lesson you shall be able to
• explain valve operating mechanism.

Engines may be classified with respect to the mechanism used to operate the valves. Now a days, following three types of configurations are used to operate valves.

a Pushrod overhead valve (Fig 1&2)

Fig 1



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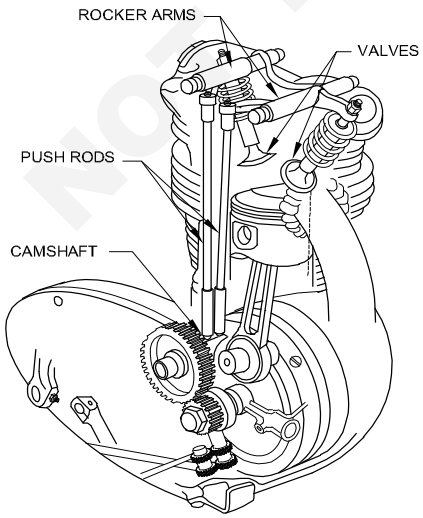
PUSH ROD VALVE OPERATING MECHANISM

Fig 2



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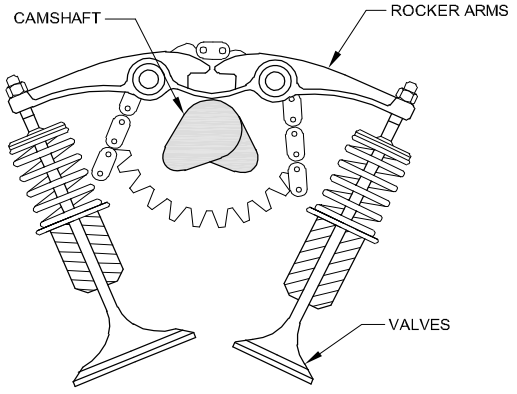
PUSHROD OVERHEAD VALVE ENGINE

As figure shown a single camshaft located in crankcase in drive by crankshaft through gear drive. This camshaft contains two different cams generated on its periphery. These cams push the pushrods of inlet as well as exhaust valves when required. Rocker arm pivoted in cylinder head and operated by pushrods. Rocker arms then push the valves for appropriate action.

Opening and closing time of valves are totally controlled by cam shaft adjustment. This type of engine is used on cruiser bikes because of their better balancing characteristics in longitudinal direction.

b Single overhead camshaft (Fig 3&4): The pushrods are eliminated in this system and a single camshaft is mounted above the valves in cylinder head. Cams are generated on a single cam shaft to operate inlet and exhaust valves. This camshaft is run by crankshaft through a chain drive shown in Fig 3&4 rocker arms are operated by respective cams and consequently it operates valves. Balancing of single overhead cam engine is better because of elimination of pushrods.

Fig 3



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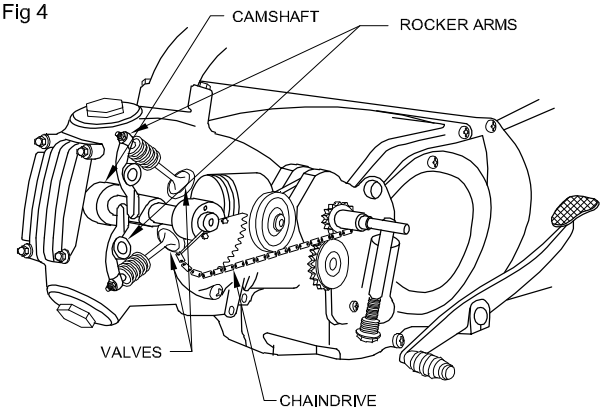
SINGLE OVERHEAD CAMSHAFT MECHANISM

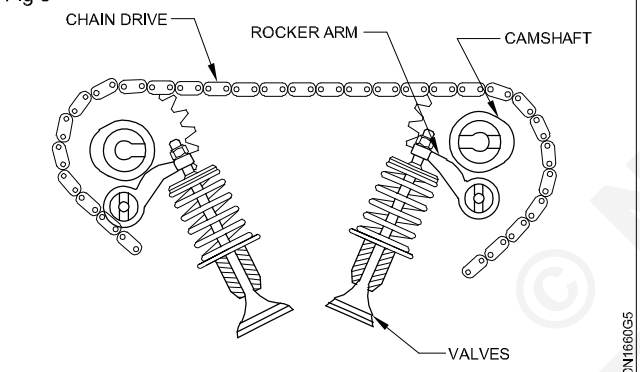
Fig 4



SINGLE OVERHEAD CAMSHAFT ENGINE

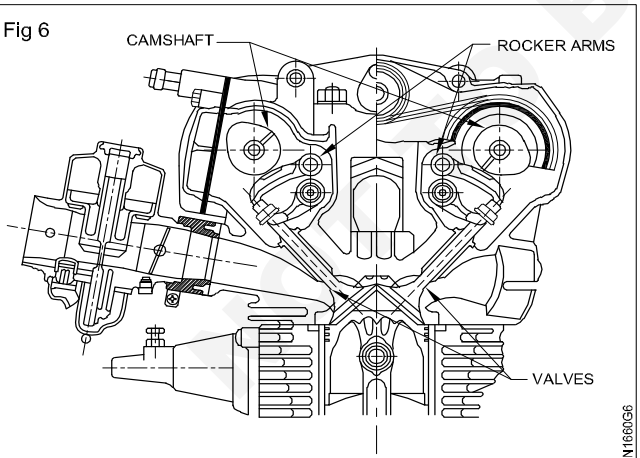
c Double overhead camshaft (Fig 5&6): Few two wheelers make use of double overhead camshaft engines because of the extra cost and weight. The cylinder head contains two exclusive camshafts, one for inlet valve and second is for exhaust valve. Both the camshafts are run by chain drive. Performance of this engine is little higher than single overhead camshaft engine.

Fig 5



DOUBLE OVERHEAD CAMSHAFT MECHANISM

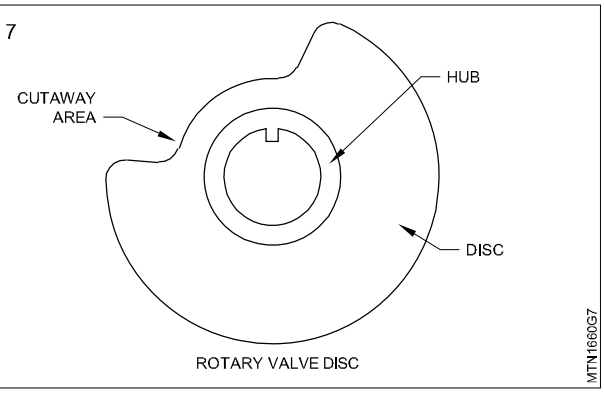
Fig 6



CYLINDER HEAD OF DOUBLE OVERHEAD CAMSHAFT

Rotary valve (Fig 7): A rotary valve controls the opening and closing of inlet port by using a partially cutaway rotating disc. This disc is directly mounted on the crankshaft and rotates with it. Opening and closing of the inlet port takes place at definite times.

Fig 7

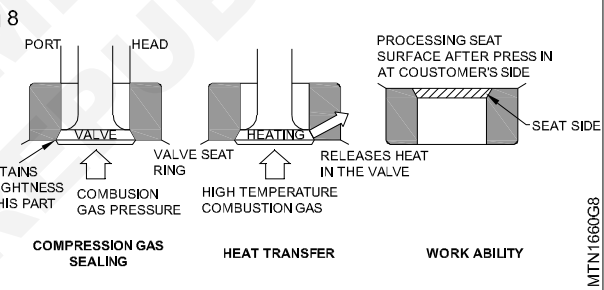


ROTARY VALVE DISC

The carburettor is conventionally mounted on the side of the engine. Rotary valve slot allows the air-fuel-oil mixture to enter into the vacuumed chamber of crankcase. The total duration of supplying fresh charge is either for entire upward stroke of the piston. The length of slot on rotary valve is accordingly designed. The disc is used in rotary valve engine.

Importance of valve seats (Fig 8): Valve and valve seats are ground to correct size and shape so that valve may seat properly on the seat for effective valve seating and sealing. The valve face angle must be match the valve seat angle. Valve seating and sealing is closely related to the engine performance.

Fig 8



Function of valve seats (Fig 9)

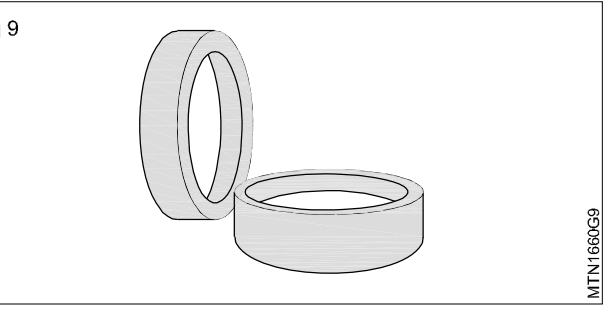
1 Compression gas sealing prevents compressed gaseous bodies and combustion gas from leaking into the manifold.

2 Heat transfer releases heat in the valve to the cylinder head.

3 Strength holds tight when the valve is mounted.

4 Wear-resistance hard to wear down under high heat and high load.

Fig 9



Valve timing diagrams

Objective : At the end of this lesson you shall be able to
- **explain valve timing diagrams.**

Four - stroke petrol engine: Now a days, most two wheelers' engines use the four-stroke cycle for engine. The process begins by the starter motor or kick start gear rotating the engine until combustion takes place. The piston is assembled with a crankshaft through a connecting rod.

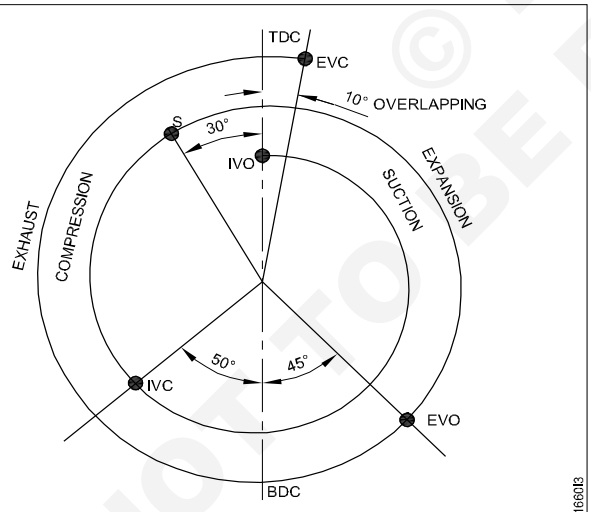
This arrangement allows the piston to reciprocate in the cylinder as the crankshaft rotates. A piston stroke is a movement of piston either from TDC to BDC or BDC to TDC of the cylinder. The number of piston strokes required to complete the cycle help to decide the engine cycles.

The intake stroke, inlet valve opens and the piston inside the cylinder moves downward. This movement generates suction inside the cylinder and a mixture of air and fuel comes into the cylinder. The crankshaft rotates through 180 degrees from top dead centre (TDC) to bottom dead centre (BDC).

As the engine continues to rotate, the intake valve closes and the piston starts moving upward in the cylinder. This as a result, compresses the air-fuel mixture. The crankshaft rotates through 180 degrees from bottom dead centre (BDC) to top dead centre (TDC) as shown in Figure.

Fig 1 shows valve timing diagram for high speed engine. The valve timing diagram shows the opening and closing time of valve with respect to crank position.

Fig 1



VALVE TIMING DIAGRAM FOR FOUR-STROKE ENGINE

Since the valve require definite period of time to open and close, a slight lead time is necessary for proper operation of engine.

The inlet valve opens as the piston reaches to TDC. The valve will be fully opened and fresh charge starts filling into the cylinder as soon as the piston starts downward movement. If the inlet valve is allowed to close at BDC, the cylinder would receive less amount of charge than its capacity.

The pressure of the charge at the end of suction stroke will be below atmospheric pressure. To evade this, the inlet valve is retained open for 40 to 50 degrees rotation of crank after the BDC. The kinetic energy of the fresh charge produces a ram effect which packs more charge into the cylinder during this additional valve opening.

Complete removal of the burnt gases from the cylinder is necessary to take in more charge. Earlier opening of the exhaust valve before reaching to BDC allows the removal of the exhaust gases by advantage of the pressure difference. The kinetic energy of incoming fresh charge also helps in removing the burnt gases.

To achieve this, the inlet and exhaust valves overlap for 10 degrees of crank rotation as shown in Figure. This overlap must not be excessive enough through the exhaust manifold.

Theoretically, it would be appropriate to produce spark just at the end of compression stroke. However, there is always a time lag between the spark and start of ignition. The compressed charge requires chemical and physical reactions for complete combustion.

The ignition starts some times after introducing spark, therefore it becomes necessary to introduce the spark before piston reaches to TDC. Spark is introduced 20 degrees before TDC. This allows proper burning of fresh charge and helps to improve power output.

Valve timing: Each manufacturer specifies the timings of the opening and closing of the valves as per the design of the engine to give the maximum output under all loads and speeds.

The opening and closing of the valves in an IC engine in relation to the movement of the piston and flywheel is called valve timing.

The opening and closing of the valves exactly at TDC & BDC do not improve the volumetric efficiency of an engine. Burnt gases also are not driven out fully.

Practically, the valves are arranged to open early and close late to fill the cylinder fully and to allow all burnt gases to escape from the cylinder.

Inlet valve

LEAD: Inlet valves are made to open certain degrees earlier than T.D.C. This enables air/air fuel mixture to fill the cylinder to its capacity. It also helps in scavenging burnt gases by using the momentum of intake air/air fuel mixture.

LAG: Inlet valves are made to close certain degrees after B.D.C to increase the volumetric efficiency by allowing more charge.

Exhaust valve

LEAD: Exhaust valves are made to open certain degrees earlier than B.D.C.

LAG: Exhaust valves are made to close certain degrees after T.D.C. to develop a suction effect by the outgoing gases. It also helps in the scavenging of the exhaust gases by using the intake charge's momentum.

Overlap period: At the end of the exhaust stroke and the beginning of the suction stroke, both the valves remain open for certain degrees. This period during which both the valves remain open is called the valve overlap.

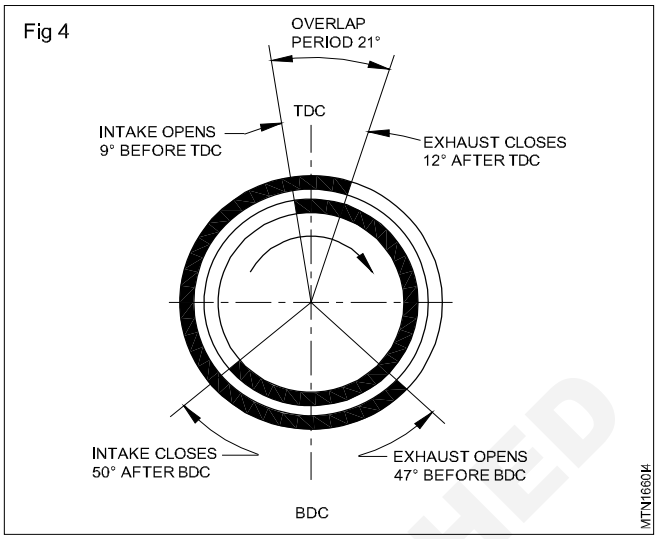
Graphical representation of valve timing: The valve timing is represented by a diagram drawn on the face of the flywheel in degrees of the crankshaft rotation.

Valve timing (Jeep) (Fig 4)

- Inlet valve opens 9 degrees before T.D.C.
- Inlet valve closes 50 degrees after B.D.C.
- Exhaust valve opens 47 degrees before B.D.C.
- Exhaust valve closes 12 degrees after T.D.C.
- Overlap period 21 degrees.

Valve timing varies from one make of engine to another.

Fig 4



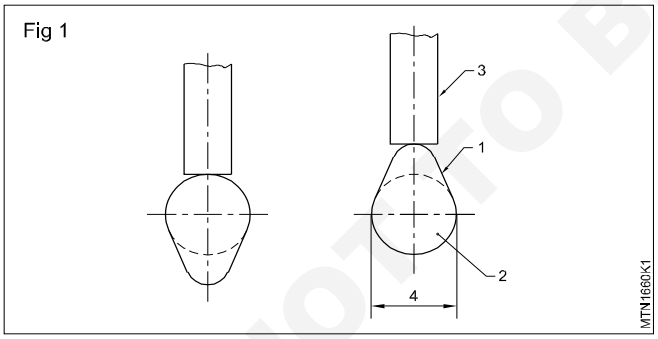
Camshaft

Objectives: At the end of this lesson you shall be able to
- **state the function of the camshaft**
- **state the constructional features and material of the camshaft.**

Functions of the camshaft (Fig 1): The camshaft is used to convert the rotary motion into reciprocating motion with the help of the cam lobe. This reciprocating motion is transmitted to the valve through the tappet, push-rod and rocker levers. The camshaft also drives the oil pump shaft. In petrol engines the fuel pump and the distributor get their drive from the camshaft.

Construction of the camshaft: The camshaft (Fig 1) is either forged or cast with the cam lobes one of each valve.

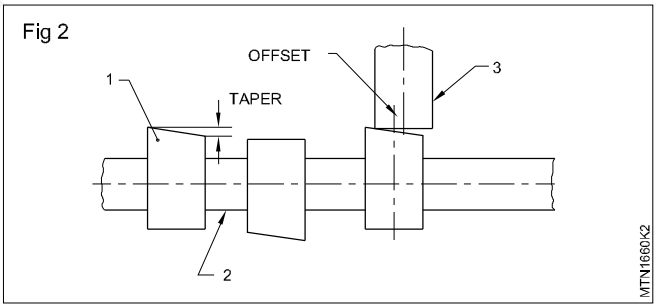
Fig 1



The camshaft has a series of support bearings along it is length.

The cam surface (Fig 2) is hardened for longer life. In some engines the axis of the tappet/lifter is slightly offset from the axis of the cam lobe. This off set gives a little rotation to tappet/lifter wears out uniformly. The lifter/tappet rests on the cam lobe. The lifter remains in its position on the base circle. When the cam rotates the lobe lifts the lifter.

Fig 2



Valve operating mechanism

Objectives: At the end of this lesson you shall be able to
- **state roller rocker arm**
- **state roller camshaft**
- **state types of cam chain tensioner**
- **explain spring type cam chair tensioners**
- **explain hydraulic type chain tensioner.**

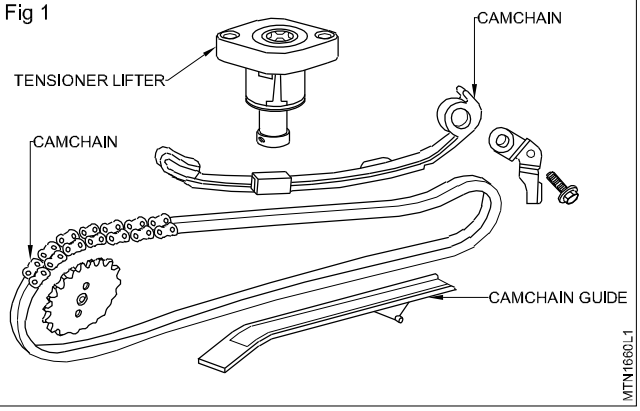
Roller Rocker arm: Rocker arm is provided with a roller, which rolls over the cam lobe instead of sliding. This reduces the friction loss and wear. A needle bearing is provided between the rocker arm pin and the rocker arm. This also reduces the friction. It is used to open the valve when rotating the cam shaft.

Roller camshaft: Camshaft has been provided with roller

cam. This is to reduce the friction losses and noise level during valve operation.

Cam chain tensioner: The cam chain tensioner takes up slack in the cam chain, most cam chain tensioners used today adjust cam chain slack automatically (Fig 1).

Fig 1



Types of cam chain tensioner

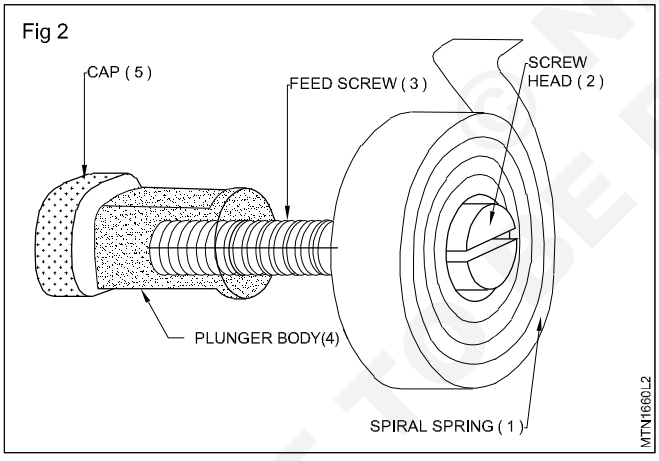
1 Spiral spring type tensioner

2 Hydraulic type tensioner

Parts name (Fig 2)

1 Spiral spring
2 Screw head
3 Feed screw
4 Plunger body
5 Cap

Fig 2



Spiral spring type tensioner: This is commonly used in small and medium sized engines according to the location and working stroke of the tensioner.

Operation

A spiral spring is attached to the feed screw, along with ta spacer and washer. One end of the feed screw is attached to the plunger body having an internal threads. The other end is with screw head.

Rotating the screw head in clockwise direction moves the plunger body towards right side against spring tension thereby releases the tension on cam chain.

Releasing the screw head, automatically turns anticlockwise moving the plunger body towards left side due to spring tension.

Check the lifter operation

- The tensioner shaft should not go into the body when it is pushed gently by thumb.
- When it is turned clockwise with a stopper tool, the tensioner shaft should be pulled into the body. The shaft spring out of the body as soon as screw driver is released.

Never assemble the tensioner lifter to the engine with the tension condition, as it may cause cam chain noise / wear.

Cam chain tensioner (Fig 3&4): The cam chain tensioner takes up slack in the cam chain, most cam chain tensioners used today adjust cam chain slack automatically.

Fig 3

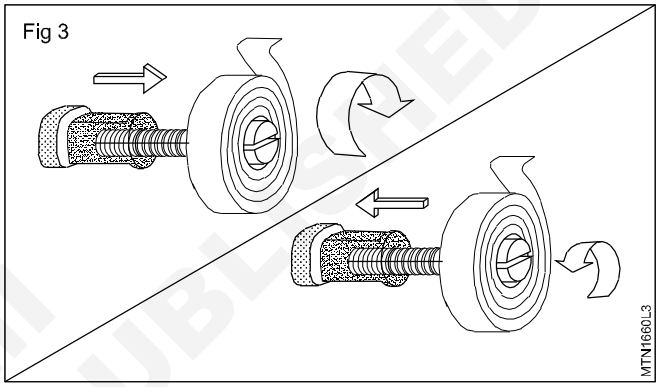
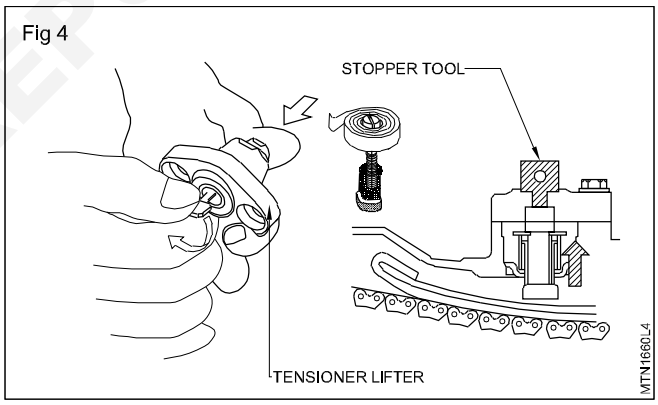


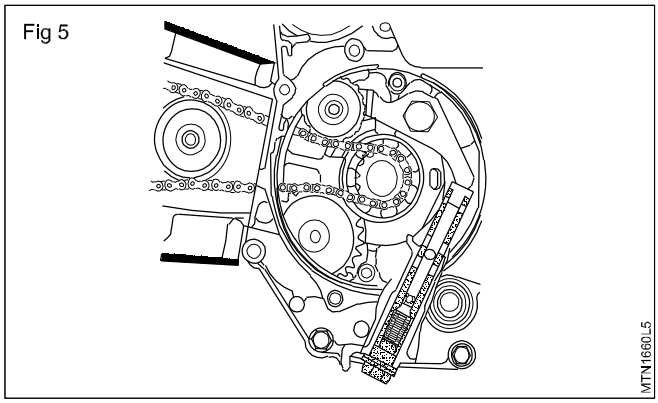
Fig 4



Hydraulic type tensioner (Fig 5 to 7)

The plunger is forced upward by the spring. The hydraulic chamber is filled with engine oil. In the plunger, on top of the hydraulic chamber there is a one-way valve provided, which is composed with a steel ball and its seat.

Fig 5

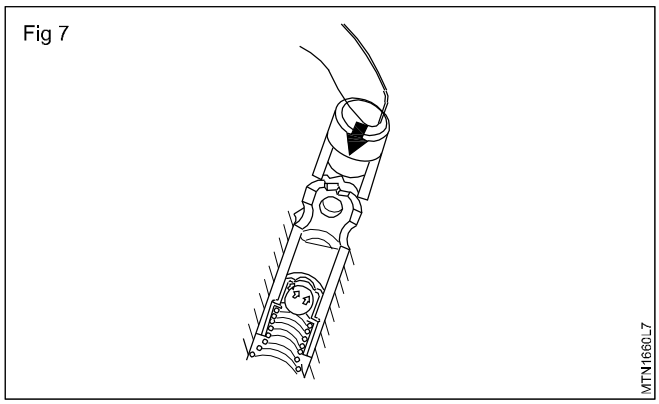


Operation

When there is a slack in the cam chain, the plunger strokes upward to push the tensioner arm to take up the slack.

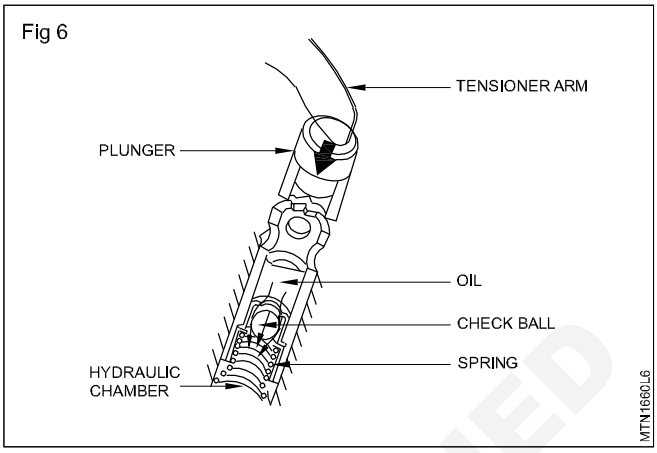
At this moment oil enters the hydraulic chamber through a clearance opened between the steel ball and its seat.

Fig 7



When the plunger is pushed down, the steel ball seats to close the clearance (= oil passage). Oil in the hydraulic chamber is then almost like solid, having no way to go out, and does not allow the plunger to be pushed down any further. Thus the cam chain tension is maintained.

Fig 6



Trouble shooting in valves

Trouble	Causes	Remedies
Excessive smoke	Piston oil ring wornout	Replace
	Cylinder bore wornout	Replace the limer
	Valve oil seal damaged	Replace
	Valve guide wornout	Replace
Over heating	Firing incorrect	Set timing
	Dirty spark plug	Clean or replace
	Incorrect spark plug	Replace
	Improper power supply	Check HT lead
Abnormal noise	Cam chain loose	Adjust
	Excessive tappet clearance	Adjust
	Piston ring broken	Replace
	Valve spring broken	Replace
	Big end bearing worn out.	Replace
Cam chain noise	Cam chain wornout	Replace
	Cam chain tensioner damaged	Replace
	Cam sprocket wornout	Replace
Cam chain slack excessively	Cam chain tensioner wornout	Replace
	Improper chain tension adjustment.	Adjust

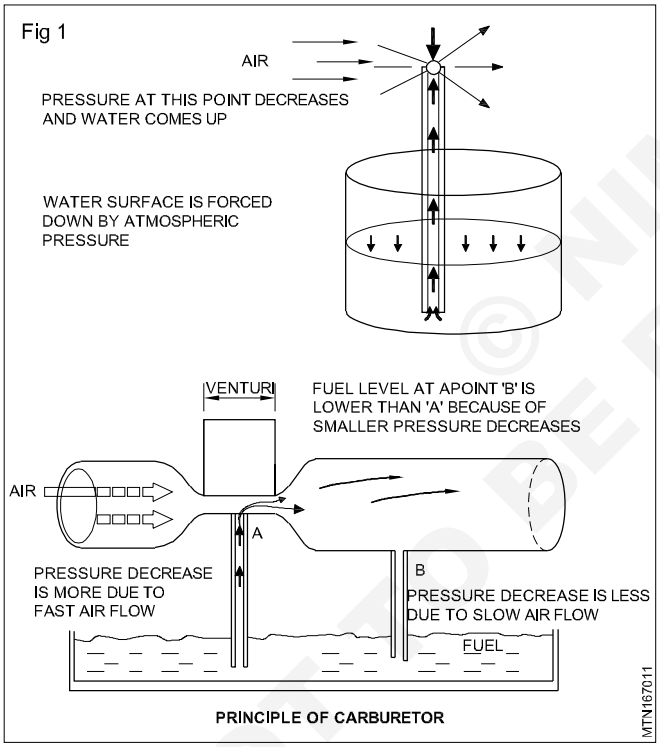
Carburettor

Objectives: At the end of this lesson you shall be able to
- **state the principle of carburettor**
- **state the types of carburettor**
- **state the functions of a carburettor**
- **state the various circuits in a carburettor**
- **state the functions of the various circuits in a motor cycle carburettor.**

Working Principle

The carburettor works on Bernoulli's principle: the faster air moves, the lower its static pressure, and the higher its dynamic pressure. The throttle (accelerator) linkage does not directly control the flow of liquid fuel. Instead, it actuates carburettor mechanisms which meter the flow of air being pulled into the engine. The speed of this flow, and therefore its pressure, determines the amount of fuel drawn into the air stream (Fig 1).

Fig 1



PRINCIPLE OF CARBURETOR

The carburettor is a device for atomising and vapourising fuel and mixing air in varying propotions to changing operation conditions such as varying speed, load and operating temperature.

Types of carburettors: Carburettors are divided into two types;

- Constant choke
- Constant vacuum

Again they are classified as stated below.

As per draft

- Up draft
- Down draft
- Horizontal draft

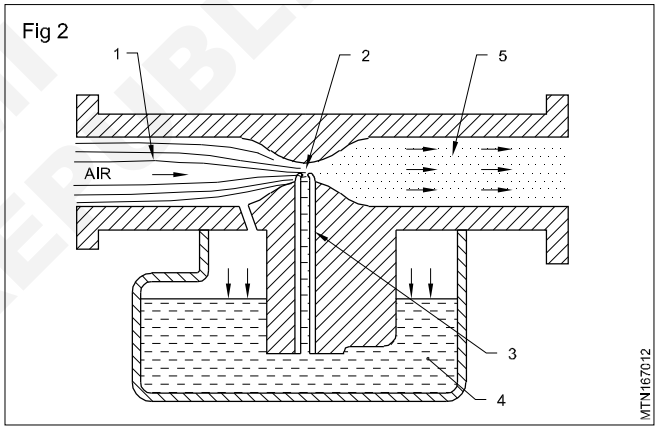
As per venturi arrangement

- Single venturi
- Double venturi
- Triple venturi
- Multi-venturi

Horizontal/natural draft (Fig 2)

In this type the carburettor is fitted in line with the manifold. Due to suction, air flows from the chamber (1) to the chamber (5) through the venturi (2), and sucks fuel from the float chamber (4) through the nozzle (3). This air/fuel mixture is then sucked into the cylinder.

Fig 2



Venturi arrangements

Different types of venturies and more than one venturi are also provided in a carburettor. Each type is designed to provide decreased pressure, to draw fuel from the discharge jet and to create a vacuum to help vapourisation. Multiple venturies also help to keep the fuel away from the carburettor walls to reduce condensation.

Functions of a carburettor: The functions of a carburettor are to;

- atomise fuel into small drop lets
- vaporize the small droplets of fuel and mix it with air to make a homogeneous air/ fuel mixture
- supply fuel to the engine continuously in the required quantity according to load, r.p.m. etc.

To carry out the above functions, the carburettors are made up of jets and different circuits to supply correct air/ fuel mixture according to the needs of the engine at different loads and speeds.

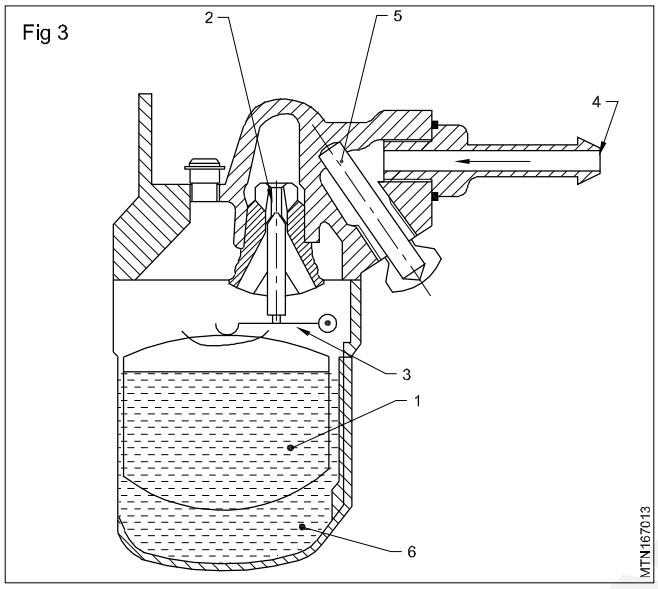
The following are the different circuits in carburettors.

- Float circuit
- Starting circuit
- Idling and low speed circuit
- High speed main circuit

Float circuit (Fig 3)

The float system regulates the fuel supply in the carburetor. It controls the static head above the main jet and the level of petrol in the spraying well.

Fig 3



The correct setting of the fuel level is determined by three main factors.

The weight of the float (1)

The size of the needle valve (2)

The thickness of the fibre washer

The needle valve (2) is offset and the float movement is transmitted via the float toggle (3).

Petrol is fed through the inlet (4) and is filtered by the fine filter (5) before passing through the needle valve assembly (2) to the float chamber (6).

When the fuel level rises in the float chamber ,the float (1) is lifted and it presses the needle valve (2) against the float valve seat and cuts off the flow of fuel to the chamber. When the fuel is consumed, the level in the float chamber drops; the needle valve (2) leaves its seat and fuel flows again into the float chamber.

The valve regulates the flow of petrol into the float chamber. It is maintained at a constant level.

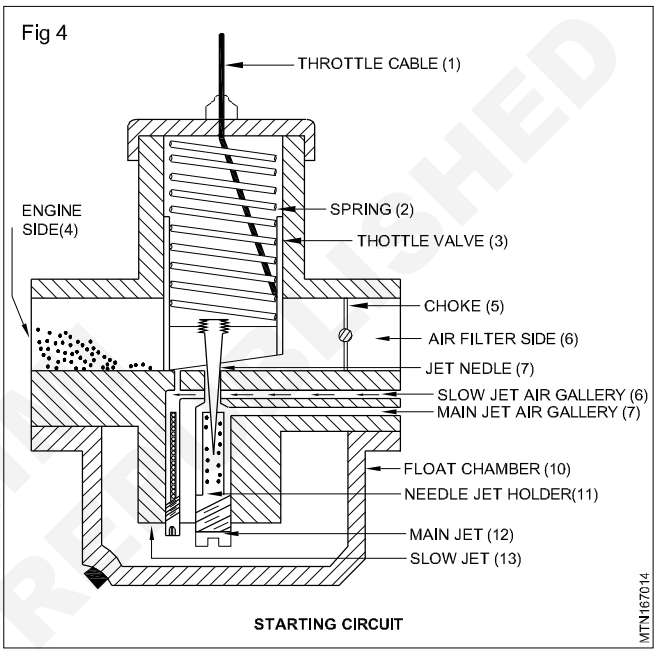
Starting circuit

1 Throttle cable
2 Spring
3 Throttle valve
4 Engine side
5 Choke
6 Air filter side
7 Jet needle
8 Slow jet air gallery
9 Rain jet air gallery
10 Float chamber
11 Needle jet holder
12 Main jet
13 Slow jet

Starting circuit (Fig 4)

The choke (5) is used to supply a little extra fuel for cold start. This is done by pressing a choke lever, which choke and restrict the air passage of carburettor's horn side - slow jet (8) due to restriction of air passage by throttle side (b) is through the slow jet air gallery (8) and slow jet (13) respectively. While starting the engine a rich mixture is required. The starting circuit provides the necessary rich mixture to the engine enable to easily starting at cold condition. After started the engine, immediately release the choke.

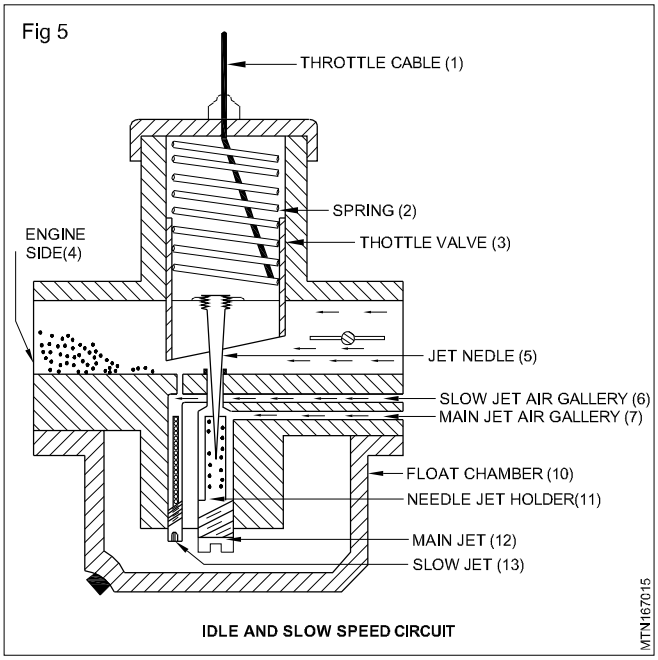
Fig 4



STARTING CIRCUIT

Idle and slow speed circuit (Fig 5)

Fig 5



IDLE AND SLOW SPEED CIRCUIT

After started, the engine require less rich mixture than at starting. The vaccum created under --- the throttle (3) when the engine is idling causes petrol to flow from the float

chamber (8) to the slow jet (11) and mix with air coming from slow jet air gallery (6). The mixed air fuel mixture discharged through the slow jet part or artifice to the engine cylinder.

Further to increase the engine speed, slightly lift the throttle valve (3) by accelerating. In this stage out side air sucked through the underneath the throttle valve. Throttle jet nedle valve (5) also open the main jet (10). Thus of addition increasing the supply of air-fuel mixture through the main jet. More supply of air fuel mixture increasing the engine speed. This allows the engine to accelerate smoothly from the idle position.

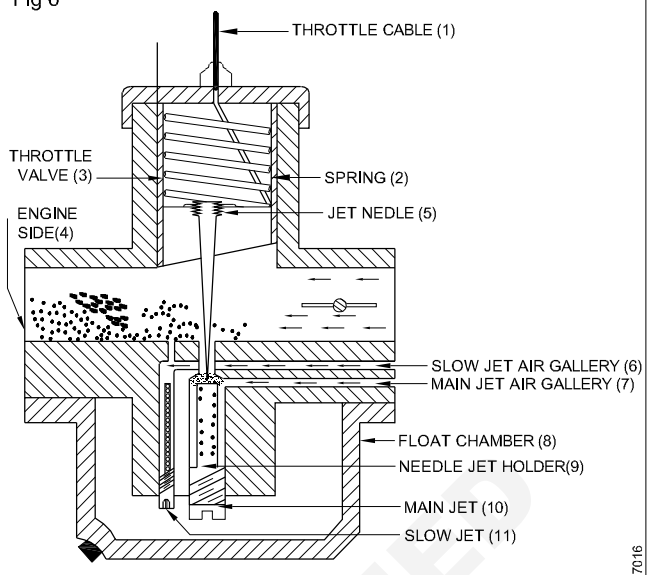
Normal and high speed circuit (Fig 6)

For accelerating engine speed from idling to nor running further lift the throttle valve upward by twist the throttle grip at required. Whole engine suction cross the main jet (10) and air velocity acrossing the main jet area will be more. Due to which more quantify of air fuel mixture discharged through the main jet towards the engine side (4). In this position fuel is feed through the main jet and the air by main air jet.

For acceleration up to the maximum speed and full power performance throttle valve lift to maximum position. The air velocity in the air horn and main jet artifice will be more.

It creates a pressure drop around the main jet artifice. Further, more air fuel mixture discharged through the main jet towards the engine. Thus increasing the engine speed to maximum.

Fig 6



Air fuel mixture ratio (AFM)

1 Starting AFM ratio = 9 : 1

2 Idling and slow speed AFM ration = 12 :1

3 Normal running AFM ratio = 15:1

4 Learn / Economical AFM ratio = 18 : 1

Functions of carburettor and adjustments

Objective: At the end of this lesson you shall be able to
- **state the need for a carburettor**
- **state the working method of a carburettor**
- **list out the different adjustments in a carburettor**
- **state the procedure for different adjustments in a carburettor.**

Need of a carburettor: The carburettor is a device for atomising and vapourising fuel and mixing air in varying proportions to changing operation conditions such as varying speed, load and operating temperature of the engine. In addition, modern carburettors are required to do this while maintaining low rates of exhaust emissions.

To function correctly under all these conditions, most carburetors contain a complex set of mechanisms to support several different operating modes, called circuits like idling circuit, acceleration circuit and economy circuit.

Working method of carburettor: During the suction stroke air is drawn through the air filter and it passes through the air horn (1).A discharge tube (2) is connected between the air horn (1) and fuel bowl (3). When air passes through air horn (1) it creates vacuum at the tip of the discharge tube(2) which sucks fuel from the fuel bowl (3).

An air bleed (4) is provided on the jet tube (2) which aids in breaking the fuel particles into very fine particles known as atomising.The fuel and air mixture is then sucked into the cylinder.

Carburettor adjustment: Too much fuel in the fuel-air mixture is referred to as too rich, and not enough fuel is too lean. The mixture is normally adjusted by one or more needle valves on an automotive carburettor, or a pilot-operated lever on piston-engined aircraft (since mixture is air density (altitude) dependent). The air to petrol ratio is 14.7:1, meaning that for each part of petrol, 14.7 units of air will be consumed. Stoichiometric (chemically correct)mixture are different for various fuels other than petrol.

Check the carburettor mixture adjustment include: measuring the carbon monoxide, hydrocarbon, and oxygen content of the exhaust using a gas analyzer, or directly viewing the colour of the flame in the combustion chamber through a special glass-bodied spark plug sold under the name "Colortune"[5] for this purpose.

The flame colour of stoichiometric burning is described as a "bunsen blue", turning to yellow if the mixture is rich and whitish-blue if too lean.

The mixture can also be judged after engine running by the state and colour of the spark plugs: black, dry sooty plugs indicate a too rich mixture, white to light gray deposits on the plugs indicate a lean mixture. The correct colour should be a brownish grey.

Fig 1

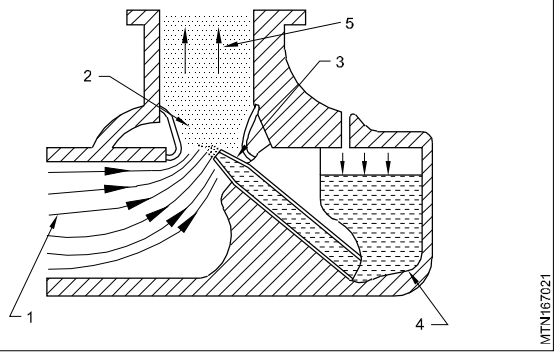
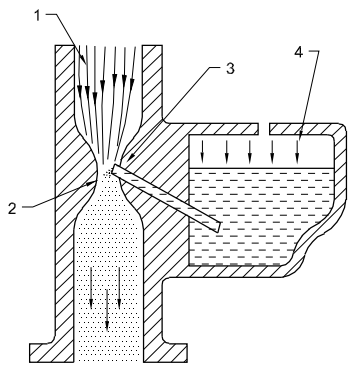


Fig 2



If the engine is having higher revolutions rpm (it can be found by hearing the engine noise or using a tachometer) then engine speed is more than 1500 rpm.Reduce the idling condition by reducing the fuel set screw.

If the engine is dying (running not smooth/intermittent) adjust the air bleeding screw. Sometimes it may contain small dirt particle which may obstruct the air flow. Clean the dirt.

Two basic adjustment mode of carburettor

a By removing a plug near the bottom of the float bowl and attaching a clear plastic sight tube.

b With the tube connected up, the reading is taken by loading the tube against the carburetor body and turning on the fuel tap.

c The more common method is to determine the float height.

d It is normally measured from the carburetor body gasket face.

e Remove the carburetor from the machine and to release the float bowl.

f Check is made with the carburetor an its side the value is closed of with the instrument fully inverted.

g To adjust the carburetor first carefully bend the small metal tang which operated the float value.

h The smallest movement here results in much greater change in float height.

Construction and operation of constant velocity carburettor

Objective: At the end of this lesson you shall be able to
- **state the construction of carburettor**
- **state the operation of carburettor.**

Construction (Fig 1): The vacuum-controlled valve incorporates a small shuttle valve in the air passage. Inside the suction chamber is an arm operated by the throttle cable. When the end of this arm bears upon the top of the shuttle valve is held down by the arm.

If the twist grip is now turned, the valve is allowed to open, and the vacuum will act on the diaphragm, lifting the piston. It will be seen that the upward travel of the valve is thus controlled by the arm, as is the closing of the throttle. The speed at which the valve open is, however, dependent on engine load and speed.

Operation velocity: carburetors have a similar jetting arrangement to the side types. A float chamber is mounted beneath the mixing chamber. Concentric to the valve/piston arrangement. A needle is attached to the underside of the valve, operating in conjunction with a needle valve to control the fuel delivery at low speed and intermediate speed settings.

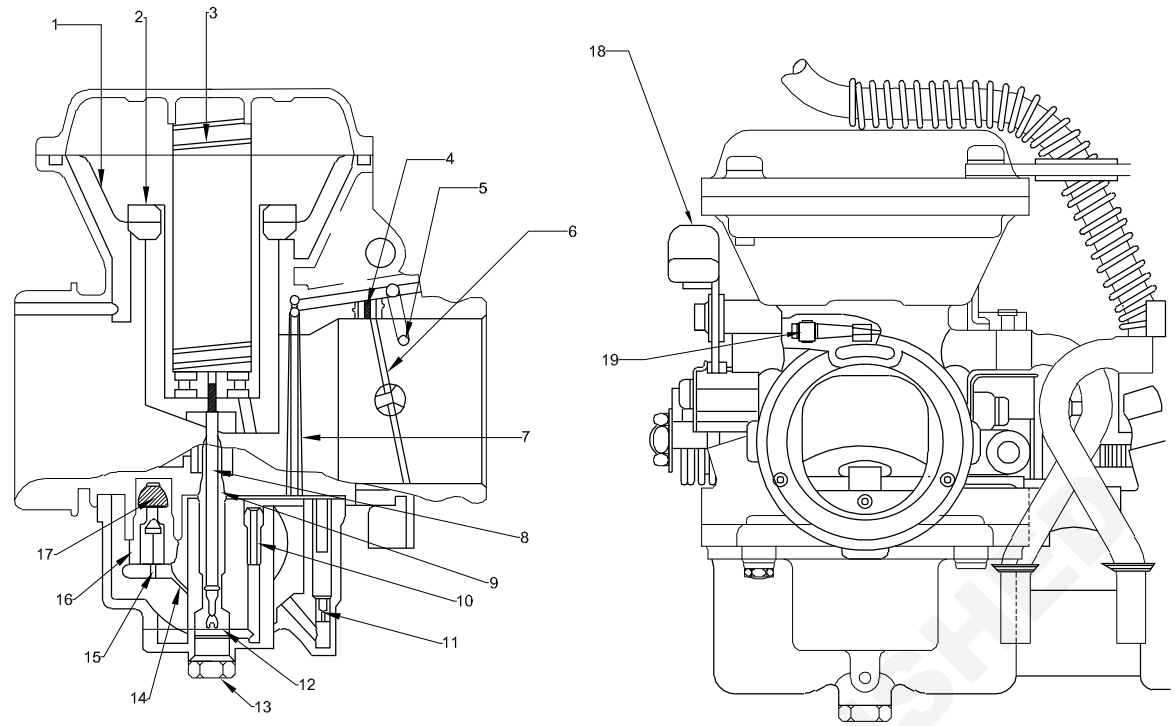
Below the needle jet arrangement is the main jet, occasionally supplemented by a primary main jet mounted nearer the engine side of the instruments.

An air passage, normally controlled by air jet, passes air into the carburettor via a pilot air screw. Fuel drawn trough a pilot jet is mixed with this air stream, and the resulting mixture is admitted via an outlet on the engine side of the throttle and butterfly valves. Cold starting is provided by a richening circuit in the majority of cases.

Working principle: The carburetor works on Bernoulli's principle the faster air moves, the lower its static pressure, and the highest its dynamic pressure. The throttle (accelerator) linkage does not directly control the flow of liquid fuel. Instead, it actuates carburettor mechanisms which meter the flow, and therefore its pressure, determines the amount of fuel drawn into the air stream

The carburetor is a is a device for atomizing and vapourising fuel and mixing it with air in varying proportions to suit the changing operation conditions such as varying engine speed, load and operating temperature.

Fig 1



1. DIAPHRAM	2. PISTON VALVE	3. RETURN SPRING	4. BYPASS OUTLET	5. PILOT OUTLET
6. THROTTLE BUTTERFLY	7. PILOT FEED PIPE	8. JET NEEDLE	9. NEEDLE JET	10. PILOT JET
11. STARTER JET	12. MAIN JET	13. DRAIN PLUG	14. FLOAT ASSEMBLY	15. NEEDLE VALVE
16. VALVE SEAT	17. FUEL FILTER	18. COLD START - LEVER	19. PILOT MIXTURE	

TYPICAL STROMBERG - TYPE CONSTANT VELOCITY CARBURETTOR

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Air filter

Objective: At the end of this lesson you shall be able to
- **state the function of air filter**
- **state the types of different types of filter.**

Air filter

For an engine to get an ample supply of air, it is necessary to clean the filter element regularly. If the air filter is clogged with dust, intake air resistance will increase and so will the fuel consumption. Dust will also enter the engine and will hasten the wear and tear of cylinder and piston. The carburettor's throttle valve and needle will also wear away quickly. Check and clean the air filter every 3000 km., but if you travel on dusty roads, cleaning should be done every 2000 km.

Types of air filters

The different tpes of air filters are used - paper filters, polyurethane foam filters and wire mesh filter. It is possible to clean and re-use foam filter and wire mesh filter, but paper filters are normally replaced. The foam and wire mesh filters are cleaned by washing it well in a bowl of kerosene oil, after which the kerosene oil is squeezed out of the foam filter. Compressed air is further used to clean the wire mesh filter.

The foam and wire mesh filters are then immersed in a pool of SAE 30 engine oil and the excess oil is then squeezed out but a little is retained, to enable it to trap dust as the air passes through the filter. Wire mesh filters can be re-oiled but this is not necessary for a two-stroke engine as the petrol mixture will automatically carry out this task.

Paper filters if not very dirty can be re-conditioned by gently tapping them to dislodge heavy surface dust and carefully blowing from the inside with compressed air. A paper filter can be cleaned once or twice, after which the paper will become so impregnated with fine particles that it loads up after a very short time.

The wire mesh filter is very inefficient and for better and longer life of engine, why not convert to foam or paper filter. when comparing the paper filter with foam, we find that the paper filter can be fan-folded to increase it's surface area in a limited space and is able to filter the air more efficiently with the lease pressure drop.

Fuel feed system

Objective: At the end of this lesson you shall be able to
- **describe the fuel supply system in 2 wheeler**
- **state fuel properties.**

Functions of Fuel system

Fuel feed systems: The function of the fuel system in an engine is to deliver a specified air/fuel mixture to the engine. In a petrol engine, the air and the petrol mixture is drawn to the cylinder, due to the vacuum created during the suction stroke.

The ratio of air/fuel mixture is 15:1 (by weight) for complete combustion. This ratio varies according to me speed, load and temperature of engine.

The basic fuel supply system in an automobile with petrol engine consists of a fuel tank, fuel lines, fuel pump, fuel filter, air cleaner, carburetor, inlet manifold and supply & return pipelines.

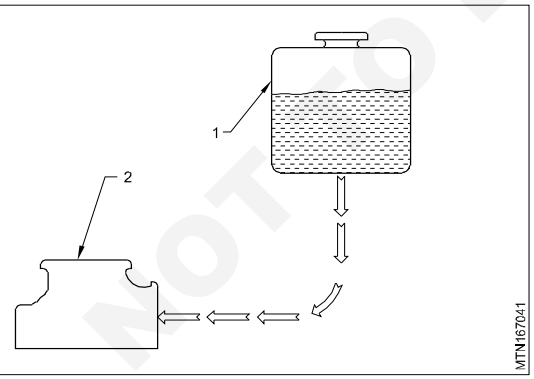
Following are the types of system which have been used for the supply of fuel from the fuel tank to the engine cylinder:

- Gravity system
- Pressure system
- Vacuum system
- Pump system

Fuel injection system: Out of these the first four systems make use of the carburettor while in the fuel injection system the carburettor has been dispensed with altogether. The gravity system is confined to two wheelers while the pressure and the vacuum system are obsolete now and the pump systems is being used widely on automobiles.

Gravity system: In this fuel tank is mounted at the highest position from where the fuel drops into the carburettor float chamber by gravity. The system is very simple and cheap but the rigidity of placing the fuel tank necessarily over the carburettor is a disadvantage

Fig 1



Fuel tank: It is a reservior to store fuel, which is made of steel or aluminium alloy sheet. The steel tank is usually coated on the inside with a lead-tin alloy to protect against corrosion. Recently synthetic rubber compounds and flame resistant fibre reinforced plastics are also been employed to make fuel tanks by moulding.

The fuel tank is divided into inter connected compartments by means of baffle plates or bridges. This arrangement reduces surging of fuel on account of sudden braking or cornerning. (1)

Holes are made on the side of fuel tank for fixing the fuel gauge (2)

Fuel filter cap (3) at top of tank with provision small air vent to avoid vaccum. The capacity of fuel tanks in two wheelers ranges from 3 litres to 12 litres.

Fuel cock: Fuel cock determiner the flow of fuel from the fuel tank to the engine via the carburettor. The fuel cock avoid the flooding of the carburettor

It is three position on ,off ,reserve. The reserve position access the bottom position of the fuel tank. Now many motor cycle vacuum, automatic operated

Fuel filters: The most commonly used filter for cleaning petrol is the fine mesh gauge. It has worked very well, where large dust particles are involved, but has not proved much effective in preventing the fine particles and the water from going inside the cylinder.

A very simple and effective device used is the ordinary chamois leather, which if first moistened with petrol will allow only the petrol to pass through it, and the water will be intercepted. Fine grit, of course, cannot pass through it.

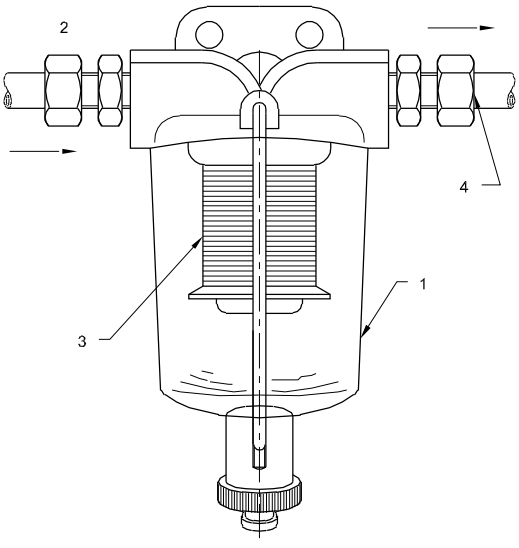
Fuel gauge: It is a device which contains float mechanism that floats on the fuel to measure the revel in the tank.

Fuel Supply system in two wheelers: The fuel feed system in two-wheeler is of gravity feed type. The fuel from fuel tank (1) is regulated through the fuel cock (2). Which is fitted at the bottom side of the fuel tank.

This regulated fuel (petrol) is carried through a special grade rubber pipe (4) to the carburettor float chamber (5).

Thus the fuel is subjected to vapourize to form atomization and supplied to the engine combustion chamber (6) along with air.

Fig 2



Fuel injection system

Objective: At the end of this lesson you shall be able to
- **state the petrol fuel injection system**
- **state the types of petrol injections system**
- **state construction of fuel injection system**
- **state working of electronic fuel injection system**
- **state the advantages of petrol injection system.**

Fuel Injection system: All modern motor cycles are fitted with fuel injection system to boost performance, increase fuel economy and reduce toxic unburned gases.

The fuel injection system is controlled by and ECU able to judge fuel feed and spark timing by gathering data from sensors which measures engine temperature, air intake and cam position. The fuel injection engine develops more power to give a higher speed, accelerate at a greater rate and be a more economical on fuel. Ifs the system brake down, it is not possible for a mechanic to repair, because special equipments are required to diagnose the faults.

Types of petrol injection system

According to location of the injector is classified into;

1 Cylinder (or) direct injection system

2 Port injection system

3 Manifold injection system

Advantages of petrol injection

1 Higher power and high speed

2 Low specific fuel consumption

3 No necessity to maintain, storage air fuel mixture in the manifold.

4 No necessity of induction heating.

5 Fuel from idling trouble.

6 Quick starting and warm up

7 Reduce toxic unburned gases

8 Accelerate at greater rate.

Sensors

S. No	Name of sensor	Location	function	working principle
1	Throttle position (T.P) Sensor	Throttle body with manifold	Detects degree of throttle opening and sending signal to ECM installed on throttle	Contains a idle pint idle switch and a potentiometer body
2	Manifold absolute Pressure (MAP) sensor	On intake manifold	Converts pressure change in intake manifold to voltage changes	Consist of semi conductor type pressure converting elements
3	Intake Air Temperature (IAT) sensor	Air cleaner	Measures temperature	Thermister
4	Engine Temperature (ECT) sensor	On engine cylinder block	Measures temperature and converts change in temperature into resistance changes in thermostat	Consist of thermistor which decreased the resistance with increse in coolant temperature
5	Crankshaft position (CKP) sensor	Mounted on engine	Generates AC voltage pulse air rotation of the crankshaft	Build-in hall's element which generate voltage from changes in the magnetic flux and wave form circuit.
6	Heated oxygen sensor (O_2)	On exhaust manifold	Detects concentration of oxygen in exhaust gas, and changes the mixture ratio accordingly.	Zirconium Dioxide coating in the Oxygen sensor generates the signal (in milli voltage)

Fuel Injection System: In this system the following sensors are used;

1 Intake air presser sensor (IAP)

2 Intake air temperature sensor (IAT)

3 Throttle position sensor (TPS)

4 Engine temperature sensor (ETS)

5 Crankshaft position sensor (CRP)

6 Oxygen sensor (O_2 Sensor)

All the sensors are connected with the engine or electronic control module (ECM) by electrical wires. Carburettor placed by the throttle body assembly and supply the fuel by fuel injector. One injector is mounted in the intake manifold.

The fule supply and return lines are connected to the injector and spring pressure. Voltage is supplied to the injector and the ECM grounds this injector. when the ECM grounds the Injector Winding (3), the oil magnetism lifts the injector (4) plunger and the (5) valve as the lower end of the plunger.

Lifting this valve supply fuel pressure to the nozzle simultaneously. When the fuel pressure reaches the determined (270 Kpa or 39 ASI) p, lifts the nozzle seats and fuel is discharged in to the intake parts. The ECM supplies the proper Injector pulse width to provide correct AFR.

Fuel Injection system

Electronic Fuel Injection (FI)

An Electronic Fuel Injection system (Fi) is a self contained custom built computer system which controls the operation of an engine by monitoring the engine speed, load and temperature, provides the spark at the right time for the prevailing conditions and metering the fuel to the engine requirement accurately.

In simplest terms, the purpose of electronic fuel injection is to delver the following advantages:

Advantage of Electronic Fuel Injection (FI)

1 **Better control on air - fuel mixing ratio:** A powerful on board computer (ECU - Electronic Control Unit) gives the signal to the Injector at an appropriate time before TDC thus ensuring delivery of the required fuel. Besides, the ECU monitors the atmospheric temperature through an Intake air temperature sensor (IAT Sensor) and the engines conditions through an Engine temperature sensor (ETs) and Manifold absolute pressure sensor (MAP Sensor), and provides better control on air-fuel ratio resulting in

- Improved cold startability and also improves hot fuel handling
- Improved pick up, faster throttle response and better altitude compensation thus ensuring good and comfortable driveability in various altitude conditions.
- Lower emissions and improves mileage.

2 **Lower mechanical complexity:** Unlike vehicles with carburettor, the Fi bike does not have a choke or any other mechanical levers. This reduces mechanical complexity and is easy to service.

3 **Easy to Diagnosis:** The serviceability of the Fi becomes easy. By using its powerful diagnostic tool system, mal-functioning of its system if any, can be easily detected.

Fuel Injection pump module: The Fuel pump module supplies fuel to the engine at system pressure. This pump module is located at the bottom surface of the fuel tank and connected to the Injector assembly through a separate online filter. This fuel pump module will be serviced as a set only. Individual parts of this module is not serviceable except the Seal fuel SDR (Rubber gasket)

In case of fuel leakage through the rubber gasket replace the gasket alone by following the procedure given below.

The fuel pump self primes, once the control key is switched ON. this can be felt by a mild humming sound from the tank or by a mild vibration a the fuel tank area. Once the priming is done, the pump once again starts working when the engine is cranked.

The fuel pump module requires atleast 3 litres of fuel in the tank. Ensure availability of minimum 3 liters of fuel in the fuel tank assembly before priming of the pump.

Fuel Injector

The fuel Injector is located at the Intake port of cylinder head assembly. The other end of Injector is connected to the fuel pump through a separate filter. The Injector injects fuel as required by the engine by getting input voltage from the ECU. As the fuel passes through the injector, an atomized spray is developed. the injector closes when the voltage supply the withdrawn by ECU, cutting off the fuel flow.

Properties of engine fuels

Objective: At the end of this lesson you shall be able to
- **state the properties of engine fuels.**

Fuel Properties

The fuel should have the following properties

1 **Knock rating:** The fuel should have high anti-knock value to make use of the higher compression ratio.

2 **Volatility:** It is the tendency of a full to change from liquid to vapour form.

3 **Calorific value:** The fuel should have high calorific value, calorific value of gasoline (petrol) 38-48 MJ/KG.

4 **Gum contact:** A good fuel should have the minimum gum contact.

5 **Sulphur content:** High sulphur content in undesirable.

6 **Aromatic content:** The aromatics are high knock-rating hydra-carbon. I has corrosive action on the rubber of the fuel system

7 **Boiling point:** It should have low boiling point for cold starting.

8 **Self ignition temperature:** It should have high self ignition temperature for knock resistance.

9 **Lead contents:** It should have less lead contents to reduce harmful exhaust gases.

10 **Octane number:** It should have high octane number for effective combustion.

Cooling system in motor cycle

Objectives: At the end of this lesson you shall be able to
- **state the necessity of the cooling system**
- **list out the different types of cooling systems**
- **explain air cooling system**
- **explain water cooling system in motor cycle (twin cylinder).**

Necessity of engine cooling system: Combustion of fuel inside a cylinder develops a very high temperature (appx. 2200°C). At this temperature the engine parts will expand and seize. Similarly the lubricating oil will lose its property. Therefore it is necessary to keep the engine temperature to operating limits.

This is done by the cooling system. Heat is removed from the engine by cooling media (water or air) and is dissipated to the atmosphere.

Types of cooling systems: There are two types of cooling systems used in engines.

- Direct cooling - air cooling.
- Indirect cooling - water cooling.

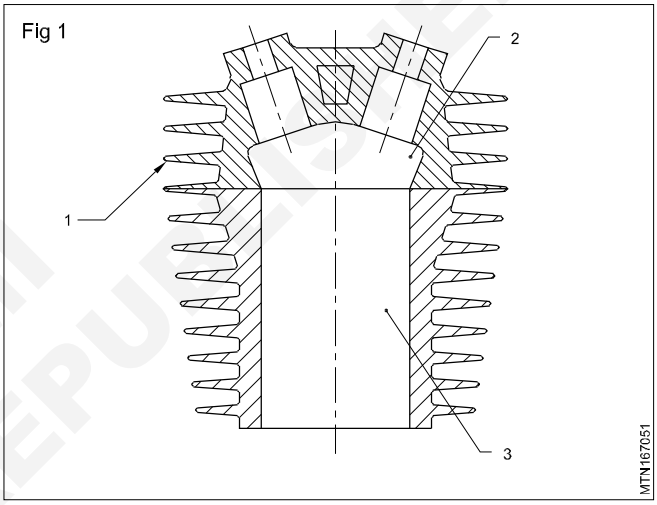
Air cooled engines (Fig 1): In air cooled engines, cylinders are semi-independent. They are not grouped in a block. Metal fins (1) are provided on the head (2) and cylinder (3), to help dissipate heat from the engine.

In some engines fans are also used to improve air circulation around the cylinders and heads. This type of cooling system is employed int two-wheelers and small stationary engines. These are used in both S.I and C.I engines.

Water cooling in motor cycle

Water cooling of a motorbike engine is not a present day technology but has been used in the past. The 250cc Villiers of 1936 used water-cooled engines very successfully.

Fig 1



Water-cooling has proved to be very advantageous for two stroke engine, which have a very high specific output. In an engine, we find that the power generated is maximum when the engine temperature is maintained at 90 degrees centigrade. This condition is not possible in an air-cooled engine, but in a water-cooled engine we are able to maintain this temperature by using a thermostat.

Other problems associated with air cooled engines due to overheating are detonation, pinking, pre-ignition, running on, etc., are all eliminated in water cooled engines.

Engine lubricating system

Objectives: At the end of this lesson you shall be able to
- **state the functions of lubrication in engine**
- **list out the different types of engine lubricating systems**
- **trouble shooting in lubricating system**
- **SAE oil grade**
- **list out the properties of lubricating oil**
- **state the functions of various types of oil pumps.**

Functions of lubricant: The main function of a lubricant is to minimise the friction between moving parts of engine.

Function of engine oil

- Absorb heat from the moving parts
- Minimise wear and tear of the components
- Provide cushioning effect between the moving parts.
- Clean the parts by carrying away dust any
- Proteus parts from corrosion
- Prevent blow by gases by providing an oil film between the rings and the liner.

Properties of lubricant (Fig 1)

1 It should have viscosity to suit the operating conditions.

2 The viscosity should remain the same in both hot and cold conditions.

3 The boiling temperature should be high.

4 It should be corrosion resistant.

5 It should with stand critical operating temperature.

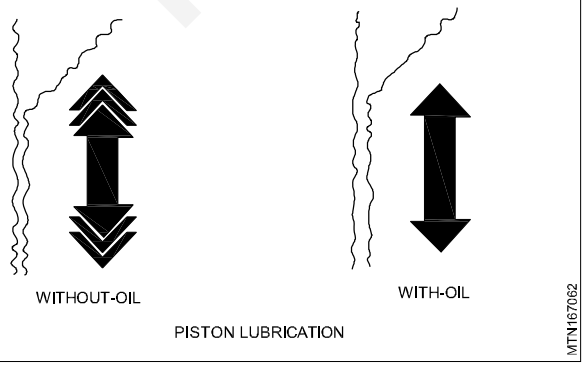
Types of lubricating system: The following types of lubricating systems are used in engines.

- Petrol - oil lubrication
- Splash lubrication
- Combined lubrication
- Dry sump lubrication
- Pressurised lubrication

Function of Engine Oil

Reducing Friction (Fig 2): Without oil, moving metal parts in contact rub against each other. The resulting friction causes the metal parts to wear and heat builds up.

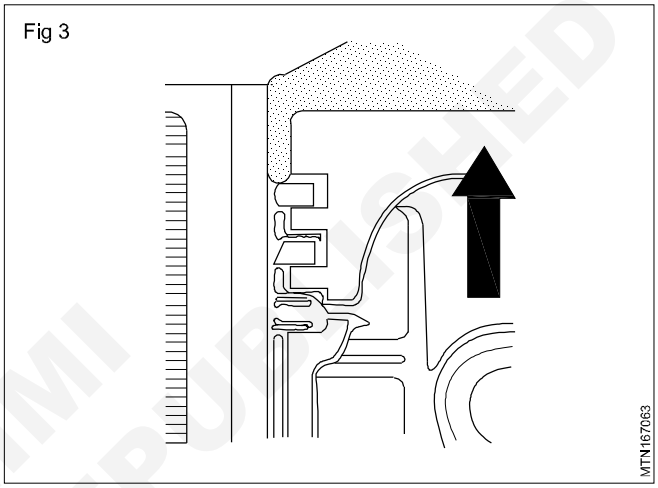
Fig 2



A film of oil between the metal parts prevents friction and wear.

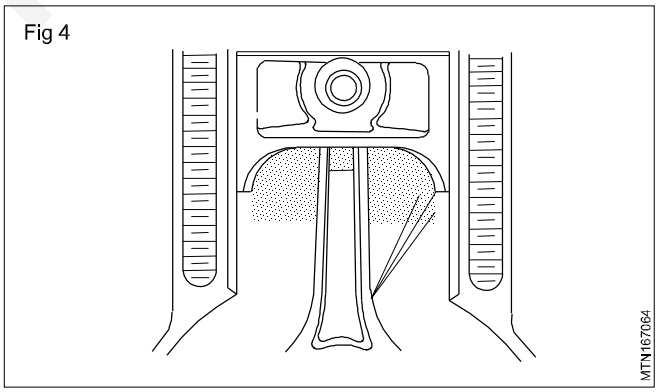
Sealing (Fig 3): Oil helps to seal in the gas. The slight clearance around the piston ring is filled with oil to ensure sealing.

Fig 3



Cooling (Fig 4): Oil cools the piston and the bearings. Oil removes heat from these parts and carries it to the sump.

Fig 4



Cleaning (Fig 5): Oil removes sludge, gum and some carbon to help keep the engine clean.

Rust prevention (Fig 6): Oil coats the surface of metal parts and prevents rusting.

Oil pumps

1 The oil pumps used to pump oil from the oil sump to the oil galleries at a certain pressure.

2 It is located in the crank case and is driven by the crank shaft. Two types of oil pumps are there.

3 Rotor type oil pump (2) gear type oil pump. Both are positive displacement type pumps

Fig 1

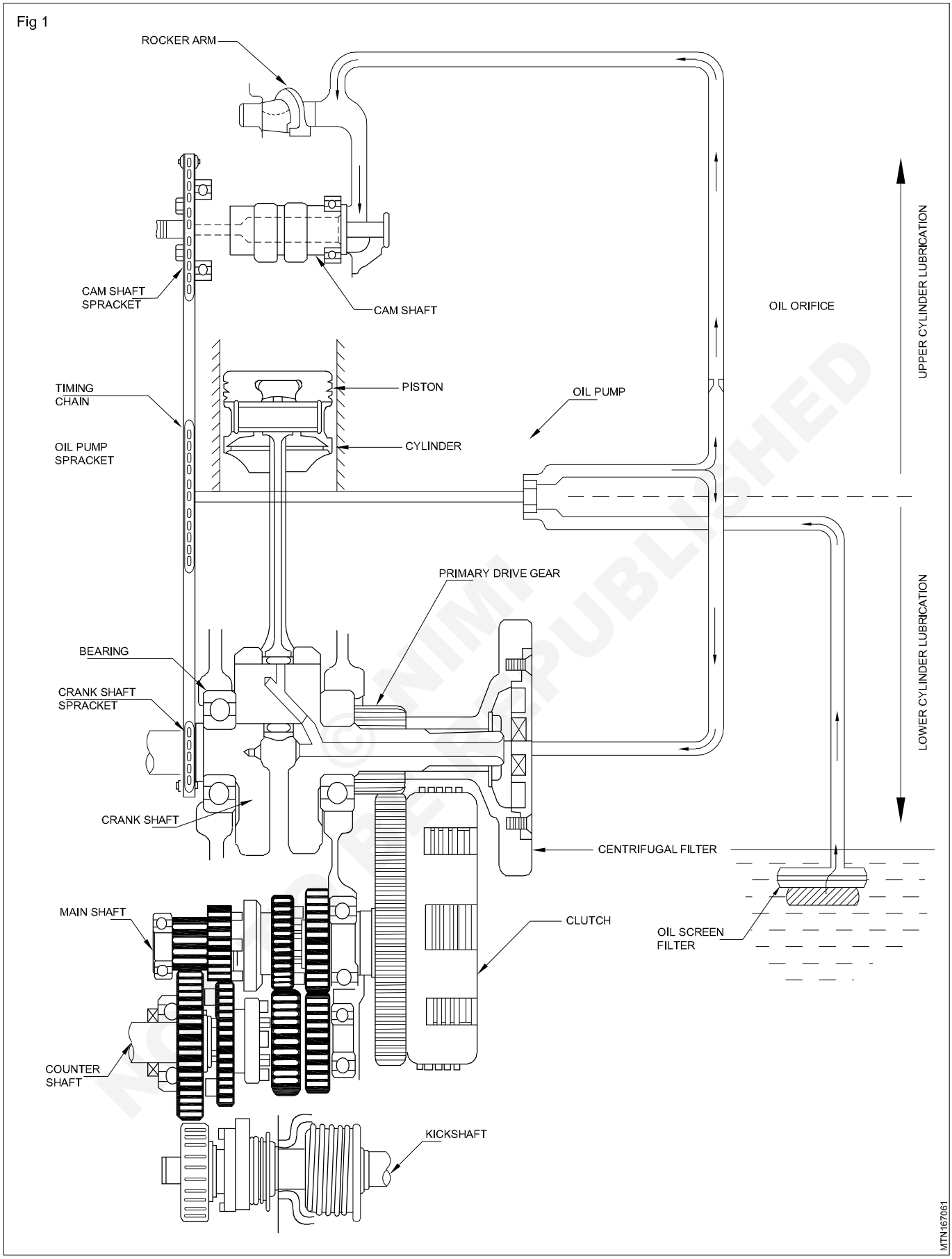


Fig 5

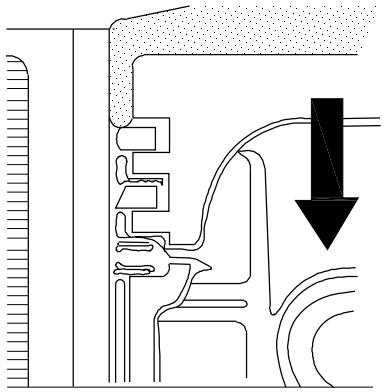


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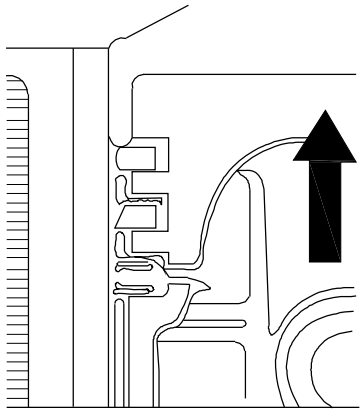
Fig 6



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Rotor type oil pump (Fig 7)

1 The rotary pump generally has a four lobe inner rotor with a five lobe outer rotor.

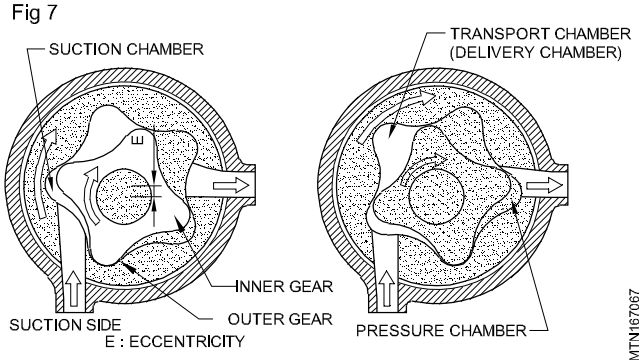
2 The outer rotor is driven by the inner rotor.

3 As the lober come out of mesh vacuum is created.

4 The oil is trapped between the lober and directed to the outlet.

5 At the lobes came back into mesh, the oil pressurized and expelled from the pump

Fig 7



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Gear Pump (Fig 8)

1 Gear pumps can use two gears riding in mesh with each other.

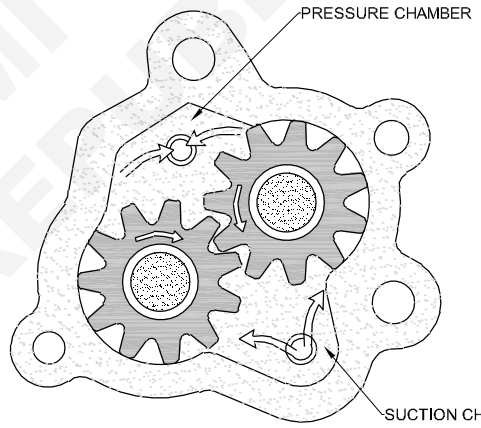
2 It also operate in the same manner as the rotor type pump.

3 The output pressure must be regulated to prevent excessive pressure.

4 A pressure relief valve opens to return oil to the sump.

5 Most of oil pumps are driven by the camshaft.

Fig 8



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Trouble shooting in lubrication system

Trouble	Causes	Remedies
Oil level too low	Oil ring wornout	Replace
	Valve seal damaged	Replace
	Oil leakage from engine	Rectify
Oil contamination	Oil & Compression ring worn out	Replace
	Incorrect oil quality	Replace

SAE Oil grade

Expected atmospheric temperature	Single viscosity graded oil	Multi viscosity graded oil
Below minus 10°F	SAE5W	SAEFW-20
Above minus 10°F	SAE10W	SAE 10W-20 or SAE10W-30
Above plus 10°F	SAE20W	SAE 20W-30 or SAE10W-30
Above 32°F	SAE20 or 20W SAE 30 Some manufacturers	SAE 20W-30 or SAE10W-30
Above 90°F	SAE30 SAE30 Some manufacturers	SAE 20W-30 or SAE 10W-30

Petrol engine basics

Objectives: At the end of this lesson you shall be able to
- **explain the characteristics of gasoline fuel**
- **state that engine power transfer**
- **state the engine components.**

Gasoline fuel system

The fuel system is made of the fuel tank, pump, filter and injectors or carburettor and is responsible for delivering fuel to the engine as needed. Each fuel system components perform easy flow to achieve expected engine performance and reliability.

Fuel system injectors/carburettor

The fuel injector is a last stop for fuel inside the engine combustion chamber it is basically an electrically operated and injected fuel is enough to run the engine.

Carburettors are used for mixing vaporized fuel with air to produce explosive mixture for internal combustion engines.

Cam and camshaft

Most of inline engine camshaft is mounted on lower part of cylinder block and modern engines camshaft is mounted on the cylinder head. Camshaft gets drive from crankshaft and it is operate the valves through operating mechanism.

Engine power transfer

Engine power is transferred through piston, connection rod, crankshaft, fly wheel and then clutch, gearbox, universal joint, propeller shaft, final drive, differential to wheels. The vehicle wheels move the vehicle.

Counter weights

Counterweights are used for balancing the crank shaft of the engine. It helps to run the engine smoothly at higher RPM. The weight of the piston and connecting rod combination affects the size and placement of the counter weight.

Piston components

Piston is one of the most important parts in a reciprocating engine. Piston helps to convert the heat energy obtained by the combustion of fuel into mechanical energy piston is incorporated with piston rings piston pin, connecting rod and other components to achieve the high compression pressure inside of the cylinder.

EFI air cleaner

Air cleaner contains an air filter in a device composed of fibrous or porous materials which removes solid particulates such as dust, pollens and bacteria from air. Filters containing an absorbent (or) catalyst such a charcoal also remove odors and gaseous pollutants (Ex.volatile organic) Air filters are used in application where air quality is important, notability in building ventilation in engines. Air compressors tend to use either paper foam or cotton filters, oil bath filters have fallen out of favour. The technology of air intake filters of gas turbine has improvements in the I.C engines air filters). Air enters the engine through the air intake or air induction system. The gift and dust particles in this air must be removed before it enters the engines

Gasoline fuel

Gasoline is the highest and most volatile liquid by refining the petroleum. The major characteristics of gasoline is as follows.

Velocity

Easy starting, quick warning good economy smooth acceleration, freedom from vapour lock, freedom from crankcase dilution, volatility bend, indication of volatility. The more volatile of gasoline give more uniform its distribution to the various cylinders and the smoother operation of the engine.

Purity: The gasoline must be free from dirt, grease and trees of chemical and water.

Sulphur content: Too much sulphur is likely to corrode cylinder bores and bearing surface.

Gum content

Fuel gun content creates a number of operating difficulties such as carbon deposits, sticking valves and piston rings, clogged carburettor jet. Gasoline should have a minimum amount of gum.

Antiknock quality

The antiknock compound is able to slow down the combustion of fuel and so preventing the knocking.

Calorific value: Fuel must have a high calorific value.

Viscosity: This is a physical property. This indicates the quality of fuel flow.

Carburettor air cleaner: The atmospheric air enters the air cleaner through the side passage and clean the dust particles. Fine particles are collected by the filter element and then cleaned air is passes via carburettor unit into the inlet manifold. Then air fuel mixture enter into the cylinder during suction stroke.

Inlet manifold: The inlet manifold is used to supply the air fuel mixture in carburettor system and fresh compressed air in EFI system to the intake ports in the cylinder head.

Note: Instructor should explain about diesel fuel.

Difference between gasoline and diesel fuel

Gasoline fuel	Diesel fuel
Spark ignition	Compression ignition
Gasoline used in petrol engine	Diesel used in diesel engine
Octane number in determine the burning quality of gasoline	Cetane number is determine the burning quality of diesel
Low density	Higher density
Quick evaporation	Late evaporation
Single filter system is used	Double filter is used in fuel system
Port injection system used	Direct injection system used
Produce more carbon monoxide	Produce less carbon monoxide

Pressure and vacuum: When an engine is idling there is a vacuum in the intake manifold. This vaccum pulls fuel and increases the effective pressure.

Intake air heating: Heating charge air an important measure to ensure reliable cold starting and to reduce white smoke and unburned hydrocarbon emissions. In take air heating can be provided in cylinder with glow plugs. In some engine glow plugs are provided in air intake system.

Stoichiometric ratio: The stoichiometric ratio is the exaction ratio between air and flammable gas or vapor at which complete combustion takes place. The stoichiometric ration of combustion verify from different types of fuels and oxidizers.

Air density: The density of air is mass per unit volume of earth's atmosphere. Air density like air pressure, decreases with increasing high attitude. It also changes with variation in atmospheric pressure, temperature and humidity.

Electronic fuel injection

Engine is the heart of a car, then its brain must be the Engine Control Unit (ECU). Also known as a Power train Control Module (PCM), the ECU optimizes engine performance by using sensors to decide how to control certain actuators in an engine. A car's ECU is primarily responsible for four tasks. Firstly, the ECU controls the fuel mixture. Secondly, the ECU controls idle speed. Thirdly, the ECU is responsible for ignition timing. Lastly, in some applications, the ECU controls valve timing.

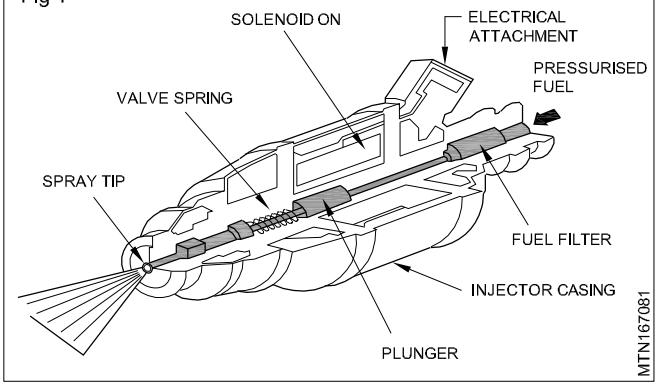
The electric fuel pump usually comes in an in-tank module that consists of a pump, a filter, and a sending unit. The sending how much fuel you have left in your tank. The pump sends the gasoline through a fuel filter, through fuel lines, and into a fuel rail.

A vacuum-powered fuel pressure regulator at the end of the fuel rail ensures that the fuel pressure in the rail remains constant relative to the intake pressure. For a gasoline engine, fuel pressure is usually on the order of 35-50 psi. Fuel injectors connect to the rail, but their valves remain closed until the ECU decides to send fuel into the cylinders.

Usually, the injectors have two pins. One pin is connected to the battery through the ignition relay and the other pin goes to the ECU. The ECU sends a pulsing ground to the injector, which closes the circuit, providing the injector's solenoid with current. The magnet on top of the plunger is attracted to the solenoid's magnetic field, opening the valve. Since there is high pressure in the rail, opening the valve sends fuel at a high velocity through the injector's spray tip. The duration that the valve is open-and consequently the amount of fuel sent into the cylinder-depends on the pulse width (i.e. how long the ECU sends the ground signal to the injector).

When the plunger rises, it opens a valve and the injector (Fig 1) sends fuel through the spray tip and into either the intake manifold, just upstream of the intake valve, or directly into the cylinder. The former system is called multiport fuel injection and the latter is direct injection.

Fig 1



When a driver pushes his or her gas pedal, an accelerator pedal position sensor (APP) sends a signal to the ECU, which then commands the throttle to open. The ECU takes information from the throttle position sensor and APP until the throttle has reached the desired position set by the driver.

Either a mass air flow sensor (MAF) or a Manifold Absolute Pressure Sensor (MAP) determines how much air is entering the throttle body and sends the information to the ECU. The ECU uses the information to decide how much fuel to inject into the cylinders to keep the mixture stoichiometric. The computer continually uses the TPS to check the throttle's position and the MAF or MAP sensor to check how much air is flowing through the intake in order to adjust the pulse sent to the injectors, ensuring that the appropriate amount of fuel gets injected into the incoming air. In addition, the ECU uses the o2 sensors to figure out how much oxygen is in the exhaust. The oxygen content in the exhaust provides an indication of how well the fuel is burining. Between the MAF sensors and the o2 sensor, the computer fine-tunes the pulse that it sends to the injectors.

Controlling idle

Let's talk about idling. Most early fuel injected vehicles utilized a solenoid-based idle air control valve (IAC) to vary air flow into the engine during idle (see the white plug in the above image). Controlled by the ECU, the IAC by passes the throttle valve and allows the computer to ensure smooth idle when the driver does not activate the accelerator pedal. The IAC is similar to a fuel injector in that they both alter fluid flow via a solenoid actuated pin.

Most new cars don't have IAC valves. With older cable controlled throttles, the air entering the engine during idle had to go around the throttle plate. Today, that's not that case, as Electronic Throttle Control systems allow the ECU to open and close the butterfly valve via a stepper motor.

The ECU monitors the rotational speed of the engine via a crankshaft position sensor, which is commonly a Hall Effect sensor or optical sensor that reads the rotational speed of the crank pulley, engine flywheel, or the crankshaft itself. The ECU sends fuel to the engine based upon how fast the crankshaft rotates, which is directly related to the load on the engine. Let's say you turn on your air conditioning or shift your vehicle into drive.

The speed of your crankshaft will decrease below the threshold speed set by the ECU due to the added load. The crankshaft position sensor will communicate this decreased engine speed to the ECU, which will then open the throttle more and send longer pulses to the injectors, adding more fuel to compensate for the increased engine load. This is the feedback control.

When you initially turn on the vehicle, the ECU checks the engine temperature via a coolant temperature sensor. If it notices that the engine is cold, it sets a higher idle threshold to warm the engine up.

The ECU's tasks of maintaining engine idle speed, as well as maintaining a proper air/fuel mixture, let's talk about ignition timing. To achieve optimum operation, the spark plug must be provided with current at very precise moments, usually about 10 to 40 crankshaft degrees prior to top dead center depending on engine speed. The extract moment that the spark plug fires relative to the piston's position is optimized to facilitate the development of peak pressure. This allows the engine to recover a maximum amount of work from the expanding gas.

Modern vehicles don't use a centrally located ignition coil. Instead, these distributaries ignition systems (DIS) have a coil located on each individual spark plug. Based on input from the crankshaft position sensor, knock sensor, coolant temperature sensor, mass airflow sensor, throttle position sensor and others, the ECU determines when to trigger a drived transistor, which then energizes the appropriate coil.

The ECU is able to monitor the piston's position via the crankshaft position sensor. The ECU continually receives information from the crankshaft position sensor and uses it to optimize spark timing. If the ECU receives information from the knock sensor (which is nothing more than a small microphone) that the engine has developed a knock (which is often caused by premature spark ignition), the ECU can retard ignition timing so as to alleviate the knock.

Controlling Valve Timing

The fourth major function of the ECU is to adjust valve timing. This applies to vehicles that utilize variable valve timing, which allows engines to achieve optimal efficiency at a multitude of engine speeds.

Fuel Tank and Fuel Pipes

Objectives: At the end of this lesson you shall be able to
- **explain the function of the fuel tank**
- **explain the function of each part of fuel tank**
- **explain the function of pipes.**

Fuel Tank: The Fuel tank is provided for storing diesel required for running the engine. It is constructed of either pressed sheet metal with welded seams and special coating to prevent corrosion or fiber glass reinforced plastic materials.

It may be round or rectangular in shape. It is mounted above the engine assembly.

Parts of the fuel tank

- Filler neck and cap
- Fuel gauge sensing unit (Float)
- Sediment bowl and drain plug
- Baffle
- Filter

Filler neck is provided for pumping diesel into the fuel tank. A cap is provided for closing the tank tightly. A vent hole is provided either in filler neck or in cap to maintain atmospheric pressure in the tank above the fuel.

Baffles are provided in the fuel tank to minimize the slushing of fuel due to movement inside the tank.

Fuel gauge sensing units provided to know the level of fuel available in tank. It consists of a float resting on the surface of the diesel in the tank. The float with the help of the electrical sensing system indicates the level of the fuel available in the tank, on the dash board fuel-gauge.

Filter is provided at the fuel tank a drain plug is provided to collect sediments and drain is out of the tank.

Fuel pipe

Fuel pipe between the fuel tank and the feed pump is called suction pipe, the pipes between F.I.P. and the injectors are called high pressure pipes. An over flow pipe is provided on fuel filter bowl and injectors to supply excess fuel back to fuel tank.

Fuel Filter

Objectives: At the end of this lesson you shall be able to
- **state the need of a fuel filter**
- **explain the types of fuel filter systems**
- **explain the need for bleeding the fuel system**
- **state the function of water separator.**

Need of fuel filter: Effective filtering of fuel, oil is most important for long trouble free functioning of the engine. Diesel fuel while transporting and handling has chances of getting contaminated by water, dirt, bacteria and wax crystals. Dirt is the worst enemy of the fuel injection equipment. Dirt contamination can be the result of careless filling of the fuel tank. When fuel tank is not filled, moist air condenses inside the metal wall of the fuel tank resulting in water contamination of the fuel.

For these reasons a very efficient filtering system is required to remove these impurities.

Types of fuel filter system: There are two types of fuel filtering system.

1 Single filter system

2 Two stage filter system

In a single filtering system one single filter assembly is used in between feed pump and fuel pump. The single filter in the system is capable of separating dirt from fuel. It should be replaced periodically as per the recommendations of the manufacturers.

In a two stage filter system, primary filter is used for filtering large solid contaminants and most of the water in the fuel is also removed by this filter. The secondary filter is made of a paper element. This filter controls the size of the particles allowed to pass into the fuel injectors. It also separates any water that might have passed through the primary filter. An overflow valve assembly is used to send back excess fuel to fuel tank. A bleeding screw is provided to bleed the air from fuel system.

Fuel filter element

A paper element is most suitable because important properties which determine filter quality such as pore size and pore distribution can be effectively maintained. Generally paper filter elements are used at the secondary stage filtration process.

Trouble shooting in engine

Trouble	Causes	Remedies
Cranks but does not start	• Spark plug defective • Valves are in open position • No fuel • Ignition coil defective • Compression leak • Pick up coil defective • No power to spark plug • H.T lead internal short • Magnet not work	Replace Adjust or replace Refill fuel Replace Rectify Replace Rectify Replace Rectify
Lean mixture supply	• Pilot screw improper adjustment • Carburettor jet holes are dirty • Air jet closed • Fuel line clogged • Fuel tank vent hole closed	Adjust properly Clean Rectify Rectify Open the holes
Engine idles roughly	• Incorrect firing order • Dirty air cleaner • Dirty carburettor or injectors	Sets zuining Clean Clean
Engine stalls	• Incorrect fuel supply • Incorrect valve adjustment • Incorrect firing order • Improper idle adjustment • Foreign matters in fuel	Rectify Adjust Set proper ignition zuining Adjust Clean or replace
Rich mixture supply	• Chock valve closed • Carburettor over flow • Needle valve w/o • Float puncture • Dirty air cleaner	Adjust Rectify Replace Replace Clean

Steering arm and its mechanism

Objectives: At the end of this lesson you shall be able to
- **define steering system in two wheelers**
- **explain the steering mechanism in two wheelers**
- **describe the steering arm with ball races**
- **describe steering handle.**

Scan the QR code to view the video for this exercise

Principles of steering

The steering system along with the suspension system, allow the driver to safely and easily control the vehicle's direction while driving.

The other functions of steering system is as follows;

- To turn the vehicle whenever required.
- To provide stability to the vehicle on road.
- To provide true rolling motion of the wheels at all times.
- To minimize tyre wear
- To multiply the driver's effort to turn the vehicle for easy operation.
- To prevent road shocks reaching the driver.

Steering

It is the system for controlling and dissecting the path of a running vehicle. In two wheelers the steering system also used for balancing of vehicle during driving.

Steering Mechanism (Fig 1)

The steering mechanism is simple in two wheelers, which consists of a steering arm or steering stem inserted into steering head of the frame. The steering arm is supported with the set of ball races and cones at steering head.

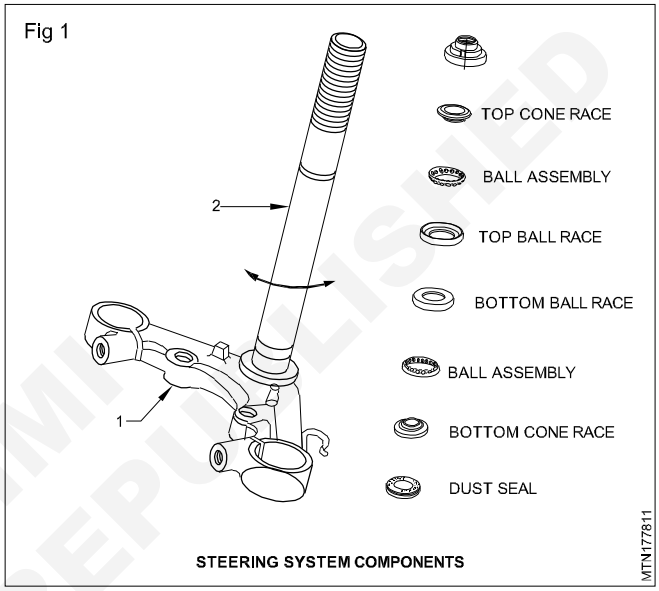
Steering arm: Steering arm (1) consists of a solid shaft called stem (2) which is inserted into steering head of the frame by set of balls (3), races (4) and cones (5).

The stem is allowed to turn 'to and fro' for about 45o to 60o towards left and 45° to 60° towards right sides that determines the direction of path.

The steel balls used for rotation is supported by set of races and cones at top and bottom ends of the stem. And adjusting nut (6) at the top of fix with upper bridge plate in Fig 2.

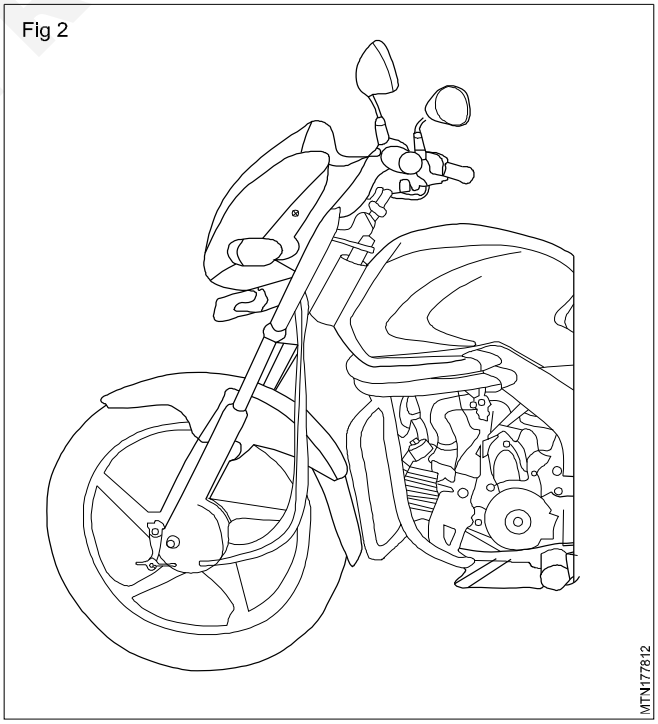
The end of the stem is fixed with arm, which a projected side ways. The both projected arms are cost to hold the fork tubes rigidly.

Fig 1



STEERING SYSTEM COMPONENTS

Fig 2



Handlebar-types and construction (Fig 3): Handlebar communicates the effort of driver to the steering the driver has to turn the steering system from one side to other even on the straight line motion. Therefore, design and

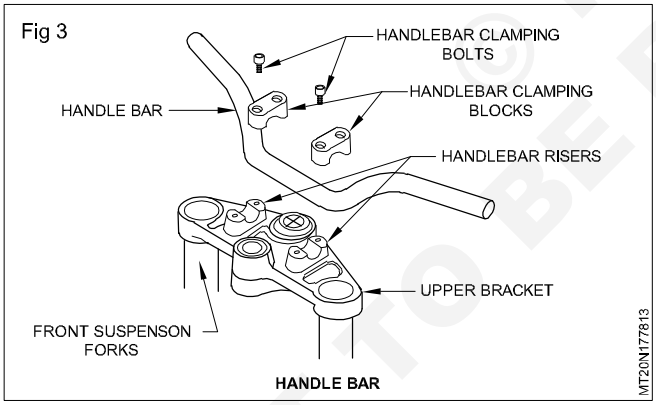
contour of the handlebar plays vital role on driver's fatigue. Handlebars are classified according to their colour. The contour decides how easily the driver can govern the vehicle and can access the control levers and various switches. Handlebars are made from hollow metal tubing, typically aluminium alloys or chrome plated steel but also of carbon fiber and titanium. Holes may be drilled for the internal routing of control cables such as brake, throttle, and clutch. Risers hold the handlebars at their mounting position on the upper bracket of triple trees as shown in Figure Bar-end weights are often added to either end of the handlebar to damp vibration by moving the bars'. Both the ends of handlebar mount the grips which are equipped with various electrical control switches.

- Width from grip to grip may vary from 30.5 inches to 37 inches.
- Rise above mounting location may vary from 0 inch to 20 inches.
- Pullback, the distance grips are behind their mounting location, may vary from 4.25 inches to 17 inches.
- Diameters vary, commonly 7/8 inch, 1 inch, and 1 1/4 inches

Types of handlebar

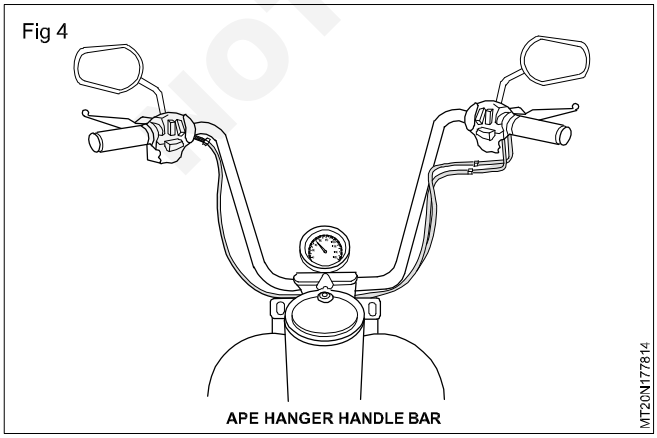
Ape hanger Handlebars (Fig 4): Age hanger handlebars are only for styling purpose which are vertically raised far above from the upper bracket. The rider has to reach up to grips to use them. They are mostly used on custom chopper motorcycles.

Fig 3



HANDLE BAR

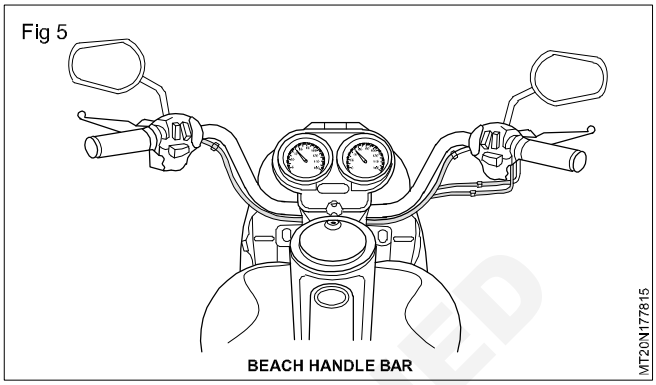
Fig 4



APE HANGER HANDLE BAR

Beach Handlebars (Fig 5): This handlebar is first slightly raised and then bent backward to reach up to the rider. They are mostly used on cruiser motorcycles. The rider slightly leans backward which gives appropriate riding posture for long distance travelling. Overall width of the beach handlebar is larger then the other types of handlebars.

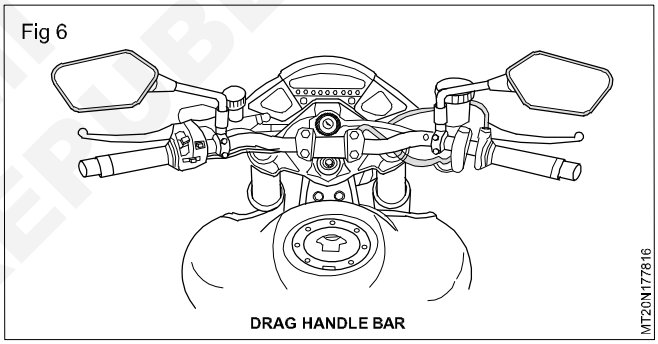
Fig 5



BEACH HANDLE BAR

Drag Handlebars (Fig 6): Drag bars are nearly straight tubing. This arrangement creates a minor forward leaning for the rider which is helpful to achieve aerodynamic riding position. Forward leaning of rider helps to locate centre of gravity nearer to middle of vehicle.

Fig 6



DRAG HANDLE BAR

Clip-ons Handlebar: These are widely used on sport bikes, in which two separate short handlebars are assembled directly to the front fork tubes instead of a single tube with risers. The upper bracket is locked with the steering stem after inserting the clip-ons on the front fork. learning for the rider which is helpful to achieve

Trouble shooting in steering system

Trouble	Cause	Remedies
Hard steering steer to one side	• Steering ball race rust	Lubricate or replace
	• Steering stem bend	Straighten or replace
	• Steering stem thread w/o	Rethread or replace
	• Steering improper adjustment	Adjust
	• Frame bend	Straighten
Front wheel wobbling	• Front wheel rim bend	Remove bend
	• Wheel bearing wornout	Replace
	• Tyre wear one side	Align the fork
	• Fork bend	Replace
Soft suspension	• Suspension shock absorber defective	Replace
	• Shock absorber spring weak	Replace
	• Shock absorber oil leak	Check and replace
Hard suspension	• Defective shock absorber	Replace
	• Telescopic shock absorber spring tension high	Replace the spring
	• Shock absorber oil leak	Replace the shock absorber
Front suspension noise	• Unbalanced front forks	Adjust
	• Telescopic shock absorber spring broken	Replace
	• Telescopic shock absorber improper adjustment	Adjust

Front suspension/Fork

Objectives: At the end of this lesson you shall be able to
- **state the functions of suspension system**
- **explain about fork assembly**
- **state hole plugging mechanism**
- **describe its construction and function.**

Function of suspension system

- It maintains of the body level
- It prevents road shocks reaching the frames and other units and provides riding comfort to passengers
- It gives cushioning effects
- It transfers the braking torque to the chassis
- It transfers the braking torque to the chassis.

Front Fork Assembly (Fig 1): Fork assembly is the main unit of the front suspension, system in two wheelers. It is linked to the steering head (1) of the frame, with the help of steering stem (2) and ball-races (3). The fork stem is aligned to form (caster angle) of about (25o - 30o) for ease of steering.

It consists of one or two telescopic type shock absorbers, which are of double acting type. Two wheelers like mopeds and scooters are equipped with single shock absorber and also called mono-front suspension. Where as the motor cycles are equipped with two shock absorbers each at left and right of front wheel.

Fig 1

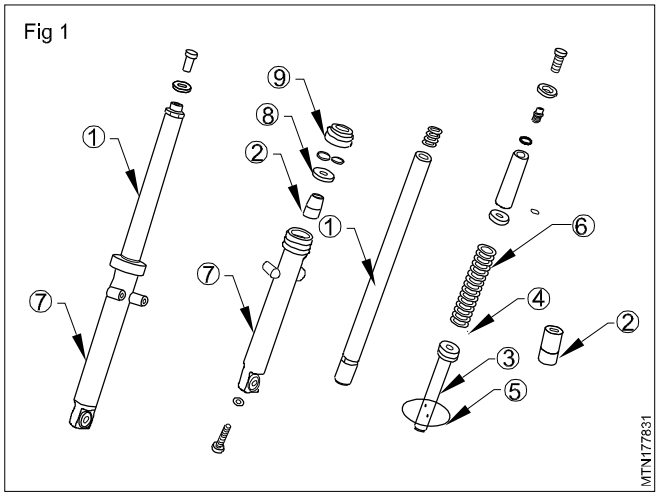
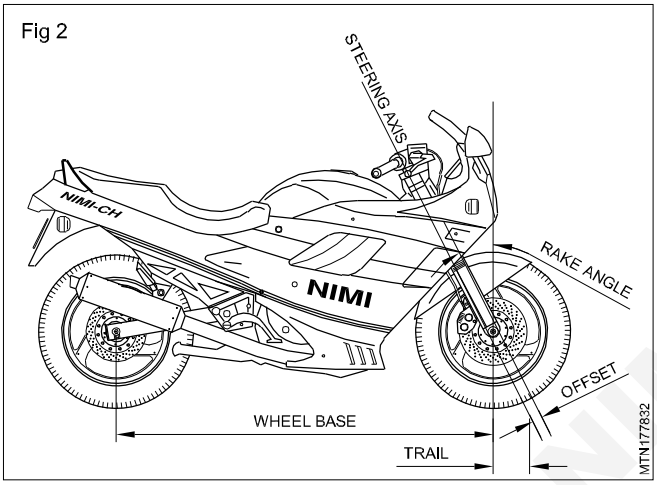


Fig 2



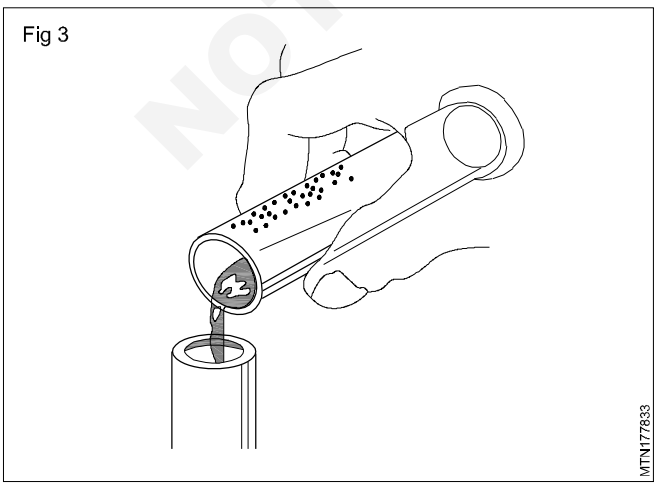
In this telescopic system, the front fork is rigid and strong. Springs and oil inside the fork tube provide cushion and damping effect. The main parts of fork are;

1 Fork tube
2 Fork piston
3 Rebound spring
4 Bottom case
5 Lock piece
6 Oil seal

Construction and function (Fig 3)

Fork tube (1) is a steel pipe coated with material of very high surface finish and high resistance to wear during sliding motion. A value oil lock piece (2) is fitted at the bottom of the tube.

Fig 3



Fork piston (3) contain a ring (4) at top for sealing the oil escape from the side walls of fork tube. This has a through hole at the centre and also side holes (5) for oil passage. There is a rebound spring (6) situated on the piston.

The bottom case (7) is a cast tube, which has a precise machining at the inner surface. This has oil seal (8) and dust seal (9) fitted at the top.

The oil lock piece is made up of steel is fitted at the bottom case. This oil lock piece is used to reduce the metal to metal contact during the full travel of shock absorber.

The suspension oil or fork oil (10) has special damping effect and should provide smooth sliding moment and effect and should provide smooth sliding movement and effect on oil seal material.

This is have the fork of front suspension work in the two wheelers.

Front Fork inspection

- Examine each fork for any sign of damage. Scratching of the sliding surface or for oil leaks.
- And to check that the forks operate smoothly.
- Position the motor cycle on level ground.
- While holding the handle bars and applying the front brake, pump the forks up and down several times.
- Of found roughness or excessive stiffness then it is recommended to get serviced.

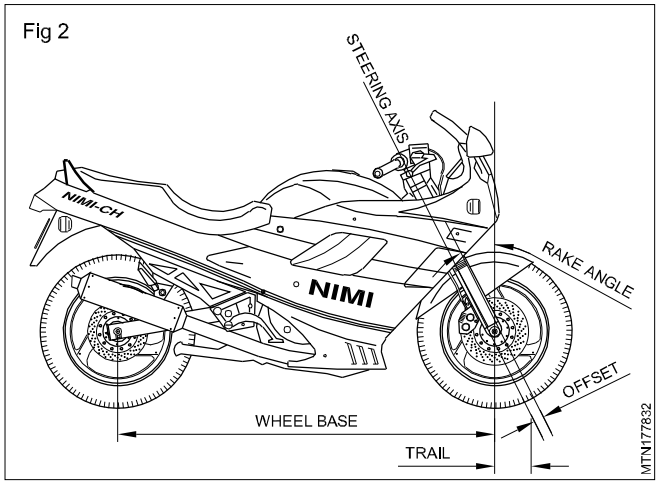
Suspension system

Introduction: A Motorcycle Suspension System consists of a spring coupled to a viscous damping element, a piston, in a cylinder filled with oil. The piston smooths out vibrations induced by the vehicle while moving as it moves through the oil. The flow of oil through the piston is regulated by an adjustable elastic deformable flap called a shim.

Types of motorcycle suspension

Front suspension: The predominant type of front suspension is the suspension fork. The bottom part of the fork is fitted over the tubes that connect the fork to the frame. When the vehicle hits a bump, the spring gets compressed and the piston forces fluid through the orifice.

Fig 2



Rear suspension: Most of the time the rear suspension are used as a shock absorber.

Maintenance and adjustment

Inspecting the steering (steering head) bearings for free play

Position the motorcycle on level ground, in an upright position.

Raise the front wheel above the ground and support the motorcycle.

Standing at the front of the motorcycle, hold the lower end of the front forks and try to move them forward and backward.

If any free play can be detected in the steering (headstock) bearings, ask your authorised triumph dealer to inspect and rectify any faults before riding.

Warning: Riding the motorcycle with incorrectly adjusted or defective steering (headstock) bearings is dangerous and may cause loss of motorcycle control and an accident.

Remove the support and place the motorcycle on the side stand.

Wheel bearings inspection

If the wheel bearings in the front or rear wheel allow play in the wheel hub, are noisy, or if the wheel does not turn smoothly, have your authorised Triumph dealer inspect the wheel bearings.

The wheel bearings must be inspected at the intervals specified in the scheduled maintenance chart.

Position the motorcycle on level ground, in an upright position.

Raise the front wheel above the ground and support the motorcycle.

Standing at the side of the motorcycle, gently rock the top of the front wheel from side to side.

If any free play can be detected, ask your authorised Triumph dealer to inspect and rectify any faults before riding.

Reposition the lifting device and repeat the procedure for the rear wheel.

Warning: Operation with worn or damaged front or rear wheel bearings is dangerous and may cause impaired handling and instability leading to an accident. If in doubt, have the motorcycle inspected by an authorised Triumph dealer before riding.

Remove the support and place the motorcycle on the side stand.

Front suspension

Front fork inspection

Examine each fork for any sign of damage, scratching of the slider surface, or for oil leaks.

If any damage or leakage is found, consult an authorised Triumph dealer.

To check that the forks operate smoothly;

- Position the motorcycle on level ground.
- While holding the handlebars and applying the front brake, pump the forks up and down several times.
- If roughness or excessive stiffness is detected, consult your authorised Triumph dealer.

The suspension movement will be affected by adjustment settings

Warning: Riding the motorcycle with defective or damaged suspension is dangerous and may lead to loss of control and an accident.

Warning: Never attempt to dismantle any part of the suspension units, as all units contain pressurised oil. Skin and eye damage can result from contact with the pressurised oil.

Suspension system

Objective: At the end of this lesson you shall be able to
- **state the need of the suspension system**
- **list out the different types of suspension systems**
- **differentiate between rigid and independent suspension systems.**

Functions of motorcycle suspension

The main functions of the motorcycle suspensions are:

To insulate both the rider and the bulk of the machine from road shocks. It makes a much safer and comfortable ride and is important for proper mechanical reliability and longevity.

To keep the wheels in the closest possible contact with the ground and gives control of the vehicle to the rider.

The front suspension helps to guides the front wheel, to steer, to spring, to dampen, and to provide support under braking.

Materials used for making suspensions

The materials most commonly used for making suspensions are;

- Steel
- Aluminum

Maintenance of suspensions: The suspensions should be checked for loose nuts and bolts and leaks.

The swing arm bearings should be lubricated monthly.

While moving on the road the wheels are thrown up and down due to the unevenness of the road. This results in strain on the components of the vehicle and the passengers. To prevent damage to the working parts and also to provide riding comfort, suspension is used in the vehicles.

The following types of suspensions are used in automotive vehicles.

- Conventional suspension system (fixed axle suspension)
- Independent suspension system
- Air suspension system
- Rubber spring suspension system

Chassis: The two-wheeler chassis consists of the frame, suspension, wheels and brakes.

The chassis is what truly sets the overall style of the two-wheeler. Automotive chassis is the main carriage systems of a vehicle. The type determines the gearing configuration, flex and the type of modifications that can be accommodated.

Frame: The frame serves as a skeleton upon which parts like gearbox and engine are mounted. It can be made of steel, aluminum or an alloy. It keeps the wheels in line to maintain the handling of the two-wheeler.

Suspension

It is a collection of springs and shock absorbers. It can be of two types: front suspension and rear suspension. It insulates both the rider and the bulk of the machine from road shocks and also keeps the wheels in the closest possible contact with the ground and gives control of the vehicle to the rider. The front suspension helps to guide the front wheel, to steer, to spring, to dampen, and to provide support under braking.

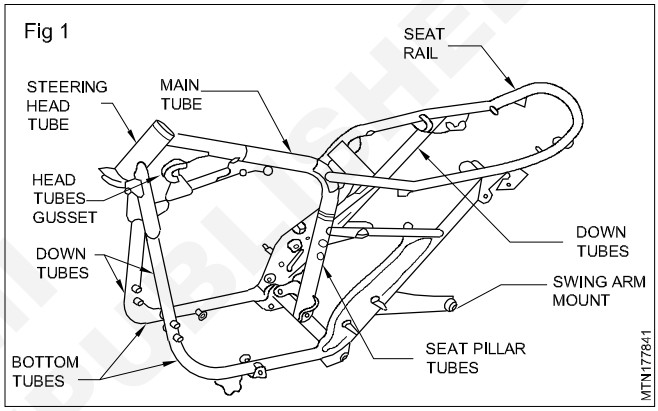
Types of frames: Motor cycles / Mopeds use three basic frame designs;

1 Cradle frame 2 Back bone frame

3 Stamped frame

The cradle frame is one of the most enduring type and is shown in Fig 1.

Fig 1



Shock absorbers

Objectives: At the end of this lesson you shall be able to
- **state the need of a shock absorber**
- **state the different types of shock absorbers**
- **explain the function of a shock absorber**
- **state the maintenance of shock absorber.**

Need of a shock absorber

When the vehicle is running on a rough road, or a stone gets below the wheels or the wheel falls into a pit, heavy shocks are experienced. A bouncing wheel makes it difficult to control the vehicle and it is to avoid such bouncing of the wheels, a shock absorber is provided in the vehicles. The shock absorber is connected between the chassis cross-member and the spring axle or suspension control arm.

Different types of shock absorbers: Shock absorbers are mainly classified into two types.

1 **Mechanical type:** This is called a dry or friction type. It absorbs shocks with the help of friction discs and spring.

2 **Hydraulic type:** These shock absorbers absorb shock by the resistance of a fluid. There are three types.

1 Vane type 2 Piston type

3 Telescopic type

Now a days the telescopic shock absorber is most popular and is in use because of easy replacement and handling.

Construction of a shock absorber

Mechanical shock absorber

It consists of two discs with a small clutch, spring and centre bolt. One disc is fixed to the chassis and the other to the axle. A friction disc works between these two discs.

All discs are assembled with the spring and centre bolt.

When the axle is lifted up the friction produced in between the discs due to the spring pressure, absorbs the vibration.

Telescopic shock absorber: It is widely used in a two and three wheelers.

Functions of two wheeler shock absorbers

They absorb the shock from bumps on the road and helps to

1 Make riding safe and smooth.

2 They allow the use of soft springs while controlling the rate of

3 Suspension movement in response to bumps.

4 They also, along with hysteresis in the tire itself, damp the motion of the unspring weight up and down on the springiness of the tire.

5 Shock Absorber system make the vehicle manageable.

Materials used for making shock absorbers

The most commonly used materials for making these absorbers are;

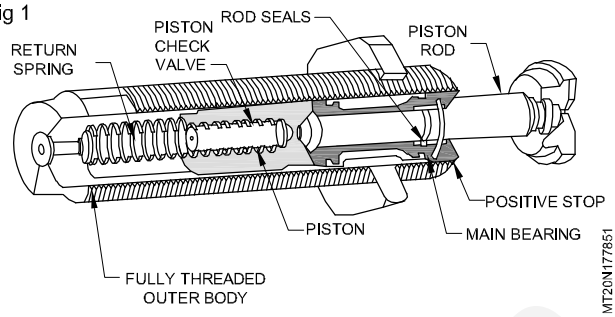
- Steel
- Aluminum

Maintenance of shock absorbers (Fig 1)

It should be checked regularly.

Oils should be changed according to the recommended time.

Fig 1



Rear suspension/swing arm

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

- **state purpose of rear suspension of two wheelers**
- **state main parts of rear suspension**
- **explain about swing arm**
- **explain need of shock absorber**
- **state types of shock absorbers with construction and function.**

Rear suspension: The rear suspension in two wheelers is to absorb the road shocks, which is similar in function of the front suspension.

In addition it supports the more load and drive train mechanism for rear wheel.

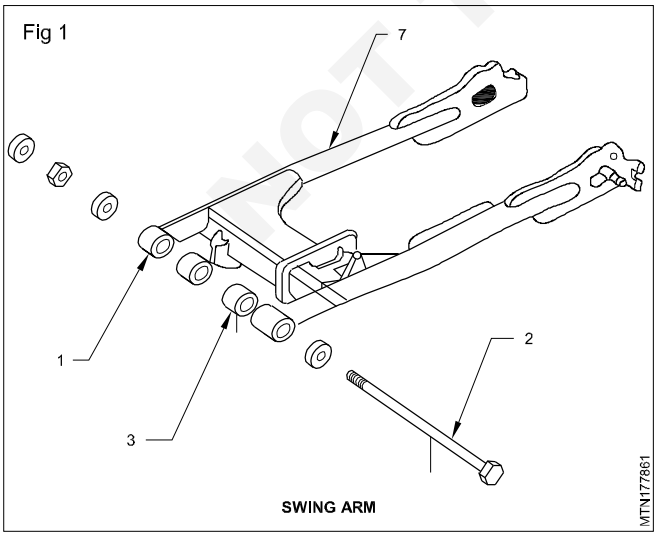
In two wheelers usually two shock absorbers equipped at rear suspension and in some cases only sing shock absorber called mono-rear suspension system.

1 Swing arm 2 Shock absorber

Swing arm (Fig 1): It is a base arm to support the axle of rear wheel and the lower and of rear shock absorber.

Its fulcrum (1) is linked to the rear lower and of main frame (rear fork head) with the help of flange bolt (2) and rubber bushes (3).

Fig 1



SWING ARM

The swing arm normally requires no maintenance but the bushing in the swing arm should be lubricated or changed periodically. The flange bolt should be tightened during service intervals if found loose. This is done to prevent slack or vibration in running.

Types of shock absorbers: The various types of shock absorbers (telescopic type) used in two wheelers are

1 Conventional type hydraulic

2 Gas charged type

3 Mono tube type

1 Conventional type (Hydraulic) (Fig 2): It is widely used in a vehicles nowadays.

Construction: The telescopic shock absorber is made of two thin steel tubes, the inner forms the cylinder (6) and the outer (7) forms the reservoir. It is called telescopic because the tubes are concentric. The outer tube (7) is connected to the axle or suspension member by an eye (11). A block (4) is welded in the bottom of the inner tube. The block (4) has two non-return valves (10).

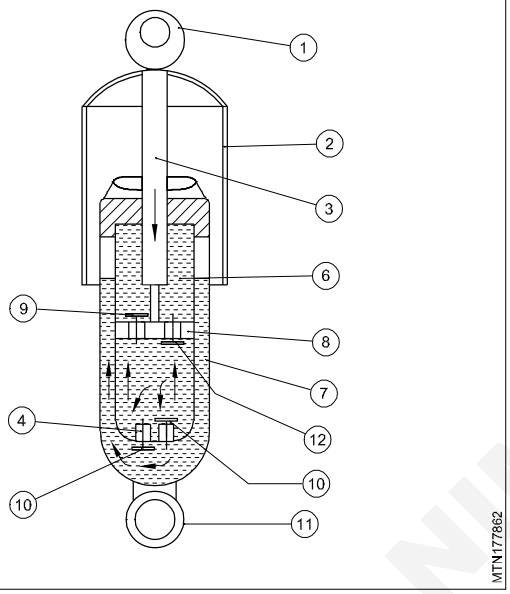
One valve allows oil from the reservoir (7) to the lower cylinder (6) and the other from the lower cylinder (6) to the reservoir (7). At the upper end of the shock absorber a dust excluder (2) is provided. The piston (8) has a rebound valve (12) and bump valve (9). The piston rod's (3) upper end is welded to an eye (1). This eye (1) is attached to the frame. The cylinder (6) is fully filled with hydraulic fluid and the reservoir is partly filled.

During the rebound stroke the eye (1) moves away from each other. The piston (8) moves upward. The rebound valve (12) opens and the fluid passes to lower the portion

of the cylinder from the upper portion. Since the upper portion does not have enough fluid to fill the lower portion completely, a vacuum is created in the lower portion. Now the extra fluid flows into the lower portion from the reservoir (7) through the foot valve (10). This passage of fluid provides necessary damping during rebounding.

This way, the shock absorber controls the quick bouncing of the wheels on the road. This provides stability to the vehicle. It also controls the slow balancing of the body to provide comfort to the passenger and avoid damage of other parts.

Fig 2

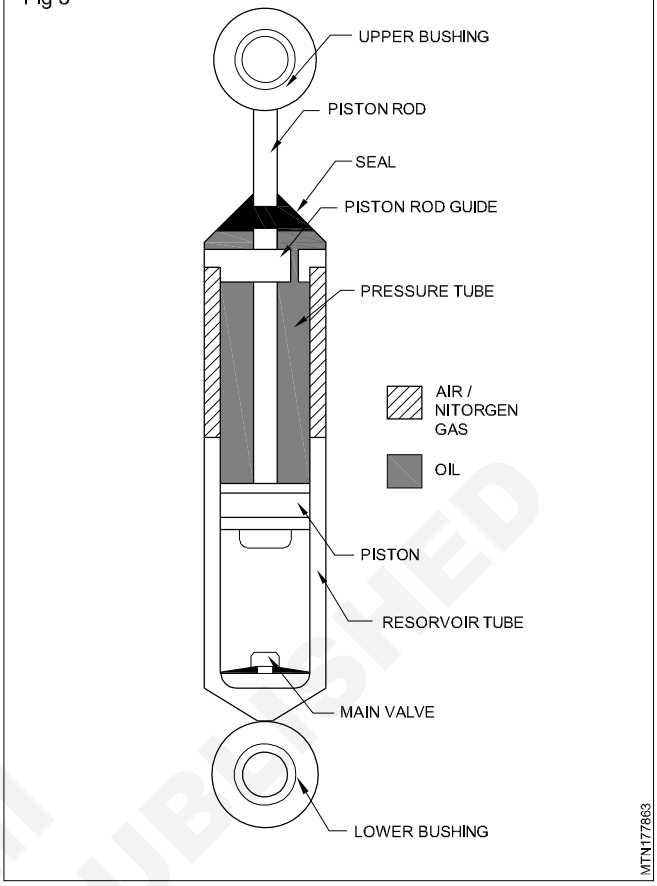


2 **Gas charged shock absorber (Fig 3):** The lower part of the reservoir tube contains hydraulic fluid (oil). At the top of the pressure pipe, piston rod passes through sealed guide. The movement of the suspension causes piston rod to be lowered (in low position) pumping excess fluid through the valve at the base of the tube. The valve counteract the fluid flow that causes retarding effect of the movement of the springs. The three main types of double-acting shock absorbers are gas, PSD (Position Sensitive Damping) and ASD (Acceleration Sensitive Damping).

Design of twin tube gas shock absorbers solves many of today's problems of stability by adding nitrogen gas with low pressure at the bottom of the pipe. Pressure of the nitrogen gas is in the range between 100 and 150 psi, depending on the amount of liquid in the bottom of the reservoir tube. This gas provides several important features to improve damping of the movement of the car:

1 The main (primary) function is to minimize aeration of the liquid in the tube rezrvoarnata. This prevents the oil and air from mixing and prevents foaming. Foam affects the damping function, because it can be pressed and the liquid can not. By reducing aeration shock absorber responds more quickly and allows retention of the tire of the car firmly to the road.

Fig 3



2 Another function of the gas filled shock absorbers is that softens movement of the spring. This does not mean, however, that the shock absorber can raise the car and adjust the height if the springs are worn.

3 The third function of gas filled shocks is that they allow engineers more flexibility in the design of valve function. In the past, factors such as softening and aeration have caused compromises in the design of the valve.

Advantages

- Improves stability by reducing the rotation, swing and momentum when braking
- Reduces aeration, thereby improving control over a wider variety of road surfaces compared with non-gas filled shock absorbers
- Reduces wear on suspension as it does not heats up as oil filled shocks, which retains the ability to absorb vibration.

Disadvantages

- They can only be mounted in one direction due to the specifics of their functioning

Usage

They are used in passenger and light commercial vehicles

Oil filled shock absorbers

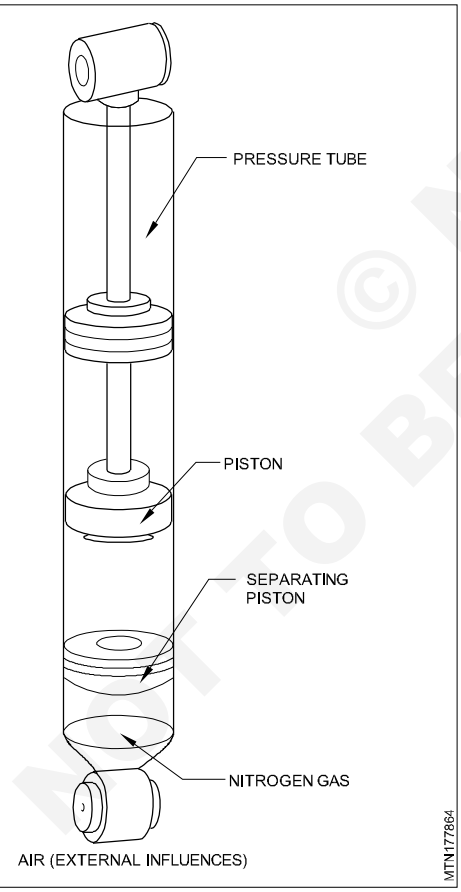
Oil filled shocks are made on the same principle as a two-pipe gas filled, but do not contain nitrogen gas but air. This gives the feeling of a softer suspension of the car.

Comparison of the oil filled and gas filled shock absorbers

Oil filled	Gas filled
Air chamber	Insensitive to temperature
Mostly for normal driving	Mostly for sports driving
Maintains driving comfort	Mostly for different road surfaces and conditions
Mainly city driving and short distances	Mostly to drive long distances
Shock absorber works only with oil	Shock absorber works with gas and oil

3 **Mono tube shock absorbers (Fig 4):** These shock absorbers are gas filled under high pressure, which consist only of a tube and have main valve, so no matter which way it would be installed. In the tube there are two pistons - separating piston and working piston. Working piston design is very similar to that of twin tube shock absorbers. This type of shock absorbers has a better prevention of aeration, allowing better performance.

Fig 4



The tube of these shocks is wider than that of a twin tube and this makes difficulties of using this type of shock absorbers in cars whose OE shocks are twin tube type. Separation valve is moving freely and divide gas from oil at the bottom of the shock absorber. The area below the valve is filled with gas at a pressure of about 360 psi. This gas helps to absorb some of the weight of the car. The oil is placed over the separating piston.

Advantages

- Can be mounted in any direction
- Cool easier because the main pipe is exposed to air (external influences)

Disadvantages

- Difficult to apply to cars whose OEM shocks are twin tube
- Break the tube causes the destruction of the shock absorber.

Factors affecting suspension: The following factors affect suspension in any vehicle;

- Irregularities of road surface
- Bumps and holes
- Heavy load or unequal weight distribution
- Tyre traction and pressure
- Side forces while negotiating corners.

Effects of weak suspension

- Directional unstability of the vehicle
- Excessive/abnormal tyre wear
- Damaging of chassis frame and other parts
- More shocks and uncomfortable riding

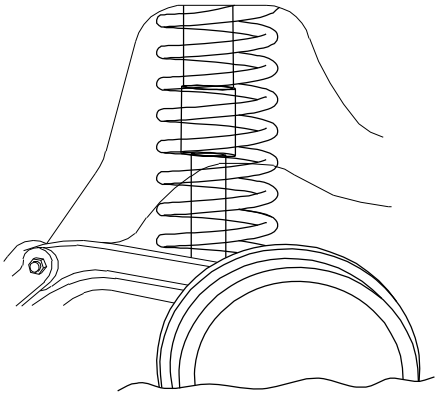
Load adjustable shock absorbers (Fig 5)

The rubber air cylinder in the load-adjustable shock absorber can be pressurized to assist suspension springs that are under load. Changing the pressure in the cylinder can alter ride height, and the stiffness of the suspension.

When vehicles carry heavy loads, their suspension is compressed, causing the rear of the vehicle to be lower than normal.

As a result, steering becomes lighter, the alignment of the headlights becomes too high. and the compression length of travel of the suspension over bumps is reduced, causing discomfort to passengers.

Fig 5



To reduce these effects, a manually adjustable air spring can be incorporated into each rear shock absorber. The air spring consists of a flexible rubber cylinder which seals the outside of the upper and lower halves of the shock absorber.

The shock absorber is a standard hydraulic type, providing normal dampening action, but when a heavy load is placed on the rear of the vehicle, the rubber air cylinder can be pressurized to assist the suspension springs. By changing the air pressure in the cylinder, the ride height can be adjusted, as well as the stiffness of the suspension.

Compressed air in the pneumatic cylinder can absorb smaller road shocks, and provide better ride characteristics than just stiff springs alone.

The rubber air cylinder is connected to a filling valve by a flexible plastic hose. Air from a tire pump or a hand unit forces more air into the rubber cylinder, allowing the suspension to support more weight.

The maximum air pressure setting must not be exceeded as this can damage the shock absorber and its mounting points on the vehicle frame.

When the load is removed, the extra air is released through a filling valve, which allows the suspension to return to its original setting.

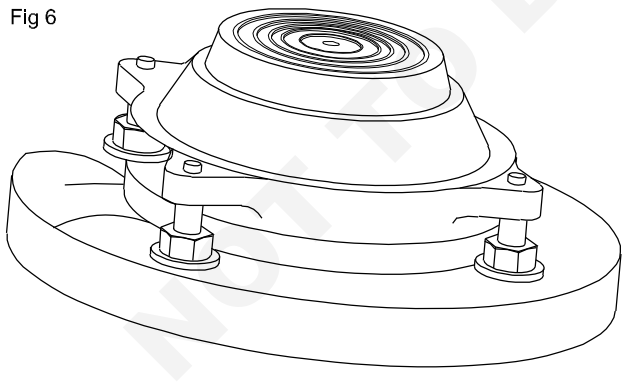
A minimum air pressure must be maintained in the cylinder to prevent tearing of the rubber as it collapses internally with shock absorber action.

Electronic adjustable - rate shock absorbers (Fig 6)

The electronic adjustable-rate shock absorber has a rotary solenoid that can alter dampening rate by changing the number of restrictions the oil must pass through, and varying the force needed to open the valves.

Adjustable rate shock absorbers provide a means of changing their rate of dampening of the spring oscillations, to suit road conditions. Electronic controls let the changes occur either automatically, or as the driver prefers. Each shock absorber has a rotary solenoid that can alter the dampening rate by changing the number of restrictions the oil must pass through.

Fig 6



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COIL SPRING REAR SUSPENSION

In this position, all orifices are open. Oil can flow more easily through the passageways in the piston. Only a small dampening effect is applied to the oil.

This provides a dampening force that emphasizes ride comfort when traveling at low speeds.

Closing some orifices makes it harder for fluid to flow through the piston. This increases the dampening effect of the shock absorber, providing a firmer ride, more suitable for higher speeds, and faster cornering.

The solenoid is operated by an electrical signal from the electronic control unit or ECU.

The ECU allows different modes of operation, according to a selector switch on the dash-board. In the Auto position, the dampening effect at the front wheels is increased at road speeds above 80 kilometers per hour. This improves vehicle stability at high speeds. The rear shock absorbers stay at their normal setting.

The manual position has two setting-normal or sport. In normal setting. all shock absorbers remain at a rate suited to ride comfort. There is no change to the settings at high speeds.

The sport setting increases the dampening rate of all the shock absorbers. This is more suited to brisk driving, with heavy acceleration and cornering.

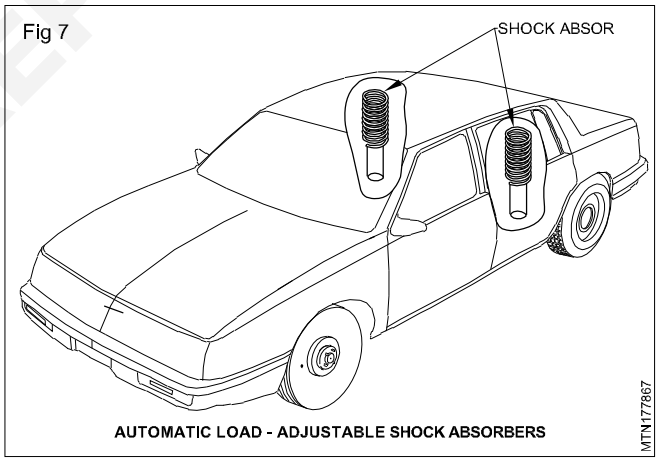
Automatic load - adjustable shock absorbers (Fig 7)

Automatic load - adjustable shock absorbers maintain vehicle ride at a pre-set level, according to the load placed over the rear axle.

The section examines automatic load-adjustable shock absorbers. They are also called self-leveling.

When vehicles carry heavy loads, their suspension is compressed, causing the rear of the vehicle to be lower than normal.

Fig 7



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AUTOMATIC LOAD - ADJUSTABLE SHOCK ABSORBERS

As a result steering becomes lighter, the alignment of the headlights becomes too high, and the compression length of travel of the suspension over bumps is reduced, causing discomfort to passengers.

A lower vehicle handles better on smooth roads, but on a rough road, reduced suspension travel can let harsh road shocks be transmitted to the passenger compartment, and cause discomfort.

An automatic load adjustable suspension system controls the vehicle ride height automatically, according to the load placed over the rear axle.

It consists of air-adjustable shock absorbers fitted to the rear suspension, an electrically driven compressor and air-dryer assembly, and an electronic control unit, and associated wiring and tubing.

The ECU is mounted to the cross-member over the rear axle and a moveable link connects it to a rear suspension member.

As the vehicle is loaded, the normal suspension springs are compressed, which lowers the height of the vehicle.

When the ignition is switched on, the ECU senses the inwared ride height and switches on the air compressor. Air is directed to the shock absorbers, causing the airbag around them to expand the raise the suspension to the normal trim height.

If the load is removed, the suspension springs expand, raising the height of the vehicle. The ECU senses the raised ride height, and air is exhausted from the shock absorbers, causing the air bag to deflate, and lower the suspension to the normal trim height.

During normal suspension operation, continual adjustment of vehicle ride height is prevented by a time delay, in the ECU.

This allows the trim height to be adjusted only when the ECU reads an out-of-trim signal for 5 to 15 seconds. The compressor run-time or exhaust-time is limited to 2 minutes. This prevent it continuing to operate, if the system develops an air leak, or if an exhaust vent remains open.

Hydraulic shock absorbers	The dampening action of a hydraulic shock absorber comes from transferring oil, under pressure, through valves that restrict the oil flow. Resistance to motion is low when the piston moves slowly, and high when its velocity is high.
Gas pressuized shock absorber	Shock absorber 'dissolve' can be reduced by pressuring the fluid with nitrogen.
Load-adjustable shock absorber	The rubber air cylinder in the load - adjustable shock absorber can be pressurized to assist suspension springs that are under load. Changing the pressure in the cylinder can alter ride height, and the stiffness of the suspension.
Munual adjustable shock absorbers	In a manual adjustable - rate shock absorber, the position of the valves in the piston can be changed to vary the number of restrictions the oil has to pass through and to vary the force needed to open the valves.
Electronic adjustable rate shock absorbers	The electronic adjustable - rate shock absorber has a rotary solenoid that can alter dampening rate by changing the number of restrictions the oil must pass through, and varying force needed to open the valves.
Automatic load adjustable shock absorbers	Automatic load - adjustable shock absorbers maintain vehicle ride at a pre-set level, according to the load placed over the rear axle.

Front wheel

Objectives: At the end of this lesson you shall be able to
- **define front wheel in two wheelers**
- **explain the front wheel construction in two wheelers**
- **describe the spoked wheel**
- **describe alloy wheel.**

Front Wheel (Fig 1): There are two types of wheels.

One is spoked wheel and the other is cast wheel (Alloy wheel)

1 **Spoked wheel:** The wheel was installed with all components including rim, spoker, hub, bearings, oil seal and spacer and excluding brake shoes.

2 **Alloy wheel:** Aluminium is the first alloy wheel. Recently magnesium alloys have been used widely due to it's light weight.

- The alloy wheels increasing the power to weight ratio of the bike.
- The wheel is mode up of disc and a flange. Disc and flange are integral.
- The wheel is fixed to up with bolts.

Front wheel construction of motor cycle

1 Front wheel assembly always installed between the fork legs.

2 If it is disc brake. Front brake disc is inserted between the front legs brake pads.

3 Front axle is inserted from the right side of the vehicle and installed with front axle nut with specified torque.

The two axle lamp bolts alternately tighten two times to ensure even tightening torque.

4 The speedometer cable is inserted on the lug which is on the brake panel.

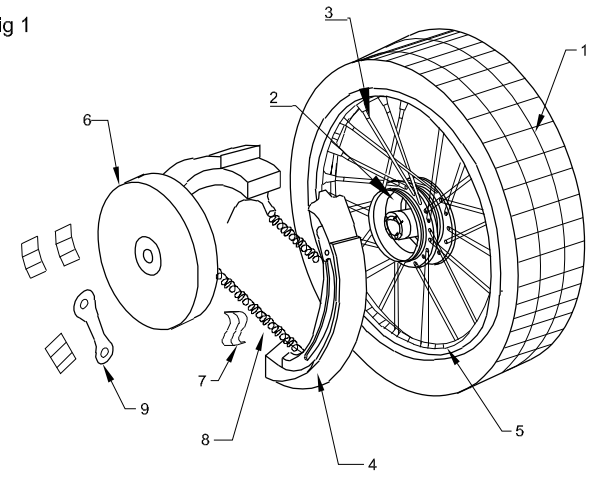
5 Broke cable is connected to the brake arm which is on the brake panel by the brake adjusting nut.

6 The axle torque around 5.4 kg/m.

7 If it is drum brake the brake shoes are located inside the brake drum.

8 The front wheel construction details are same for the spoked wheel and disc wheel.

Fig 1



1. TYRE
2. HUB
3. SPOKES
4. BRAKE SHOES
5. RIM
6. BRAKE PANEL
7. SCAM
8. BRAKE SHOE RETURN SPRING
9. BRACKE ARM
10. AXIL NUTS

FRONT WHEEL

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Wheels and tyres

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

- **state the various types of wheel discs**
- **describe the construction of the wheel**
- **state the need of spokes and cost wheel**
- **explain wheel balance adjustment**
- **state the various types of tyres**
- **state the construction of tyres**
- **state the materials of tyres**
- **explain the structure of the tyre**
- **state the specification of tyres**
- **state the importance of inflating tyres to the correct pressure**
- **state the method of storing tyres**
- **state the various types of tyre wear patterns, their causes and remedies.**

The wheel assembly consists of a hub, rim, tyre and tube. To perform its function the wheel should be:

- able to withstand the driving and braking torque, and support the weight of the vehicle
- able to absorb road shocks
- statically and dynamically balanced
- able to grip the road surface.

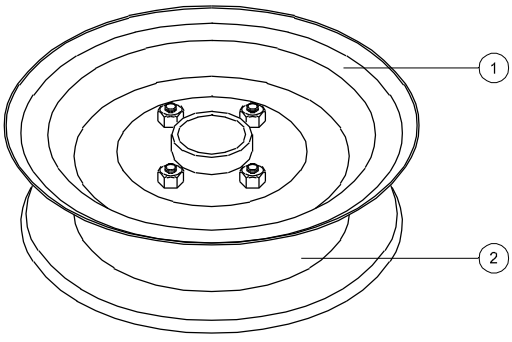
Types of wheels

- Disc wheel
- Wire wheel
- Split wheel
- Heavy vehicle wheel

Disc wheel (Fig 1)

In this type, a steel rim (1) is welded on to a steel disc (2). The tube and tyre are fitted on to the rim (2). The disk is provided with holes to mount it on the hub.

Fig 1



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Wire wheel (Fig 2)

In this type the hub and rim are connected by a number of wire spokes. Alternate spokes are screwed to slope forward and backward towards the rim to absorb the braking and driving torque respectively. (Eg. Bicycle wheel)

Split wheel (Fig 3&4)

In this type two separate discs are clamped together and a flange of discs provide seating surface for the tyre and tube.

Fig 2

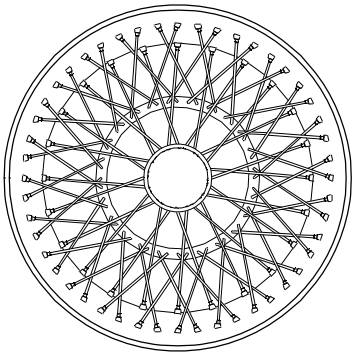

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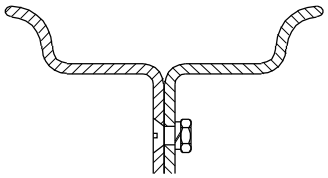
Fig 3



COMMERCIAL VEHICLE WHEEL RIMS

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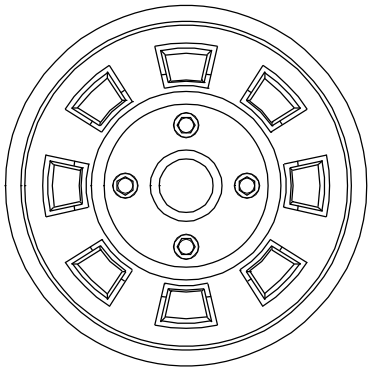
Fig 4



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Wheel Construction

Function of each part

Wheels must have the strength to endure shocks and repulsion forces from the road surface as well as braking and driving forces. At the same time they must have the rigidity to maintain stability and maneuverability. Lastly, they must be light in order to reduce unspring weight.

Hub (Fig 5) (3)

Wheel hub (3) linked with the frame. It has bearings in the center. The bearings link the rotating wheel to the non-rotating frame. High linkage rigidity and dimensional precision are required for the non-rotating part, while smooth rotation and no play are required for the rotating part. This part supports the spokes and is required to have the appropriate supporting function. It is also designed to facilitate the rotating parts of the brake, the drive system and speedometer.

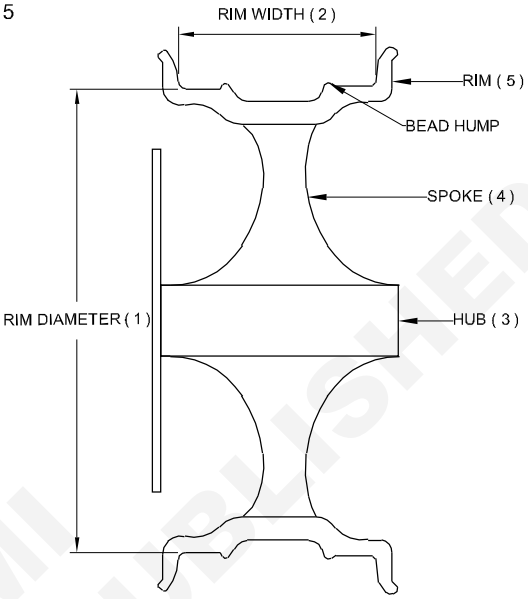
Spokes (Fig 5): The spokes (4) support the rim while fulfilling the following conditions:

Assure accurate roundness of rim and ensure its center aligns with the center of the axle shaft (vertical vibration). Ensure high degree of flatness with no distortion, and the surface is perpendicular to the axle shaft (horizontal vibration).

RIM (Fig 5)

The rim holds the tyre in the correct position. In the case of tubeless tyres, internal pressure is maintained by close adhesion between the bead surface of the tyre and the flange surface of the rim. (5)

Fig 5



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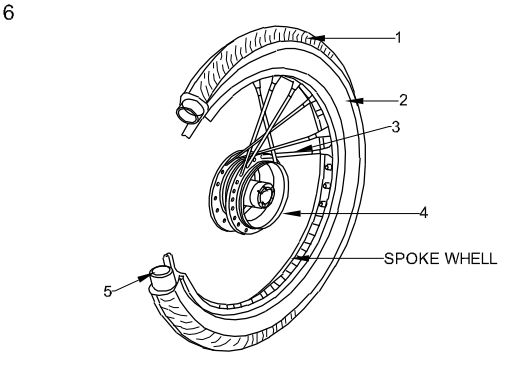
The rim width indicates the internal width of the flange and is given in inches. The rim diameter is the diameter at the bottom of the rim and is also given in inches. A rim on which tubeless tyre can be fitted is stamped, “Tubeless Tyre Applicable”.

Wire Spoke Wheels (Fig 6)

Thin steel spokes connect the rim and the hub. This type of wheel is light and inexpensive.

Main parts of spokes wheel are 1- Tyre, 2 - Rim, 3 - Spokes, 4 - Hub, 5 - Tube, 6 - Valve.

Fig 6



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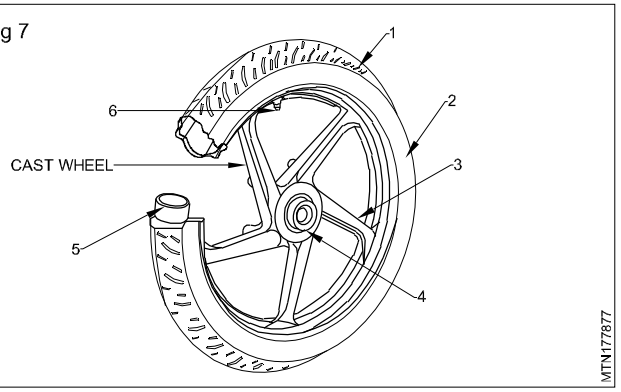
Cast Wheel (Fig 7)

This wheel is cast from aluminium alloy as a single component. The design became possible following technological development of new materials and manufacturing methods.

This type of wheel has high precision, lightweight, high rigidity and high flexibility of design.

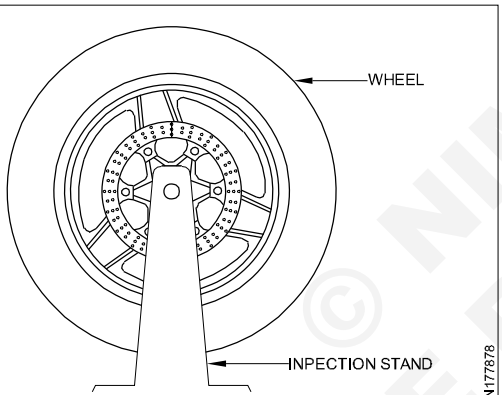
Major part of cast wheel are 1- tyre, 2 - Rim, 3 - Spoke arm, 4 - Hub, 5 - Tube.

Fig 7



Balance Adjustment (Fig 8): After replacing a tyre, the wheel should be balanced. A tyre is composed of cords and rubber material which may not necessarily be perfectly weight balanced, and a rim also has seams and deflection. Because of this, a tyre may not necessarily have a perfectly circular shape and an uniform weight.

Fig 8



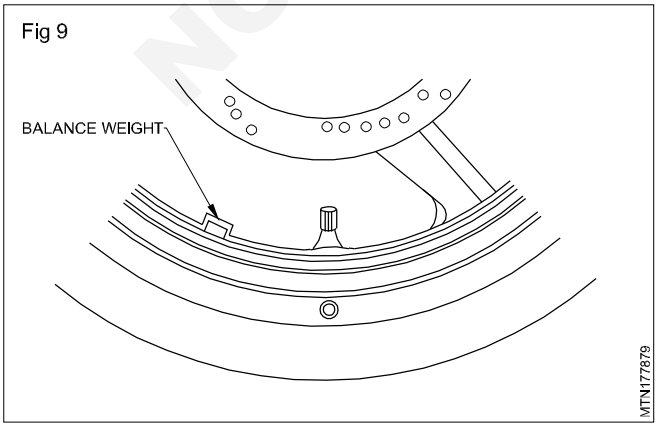
If tyres rotate in an unbalanced state, both the tyre and the rims vibrate, and this vibration is transmitted to the machine, resulting in a loss of performance. The vibration increases as the speed rises. Therefore tyre balance must always be adjusted so that tyres do not cause vibration.

1 Wheel and

2 Inspection stand.

Method of balance adjustment (Fig 9)

Fig 9



Mount the wheel (1), tyre and brake disc assembly in an inspection stand (2).

Spin the wheel, allow it to stop, and mark the lowest (heaviest) part of the wheel with chalk. Do this two or three times to verify the heaviest area. If the wheel is balanced, it will not stop consistently in the same position.

To balance the wheel, mount balance weights on the lightest part of the rim. Adjust the weight so that wheel does not stop long time in the same position when it is spun.

Tyres: Tyres should be able to;

- absorb shock
- grip the road surface in both wet and dry condition
- withstand vehicle load.

Types of tyres

- Tube tyre
- Tubeless tyre

Tube tyre

It is the most commonly used tyre. A tube (1) is used inside the tyre (2). The tube is inflated with air at a pressure recommended by the manufacturer.

Fig 10

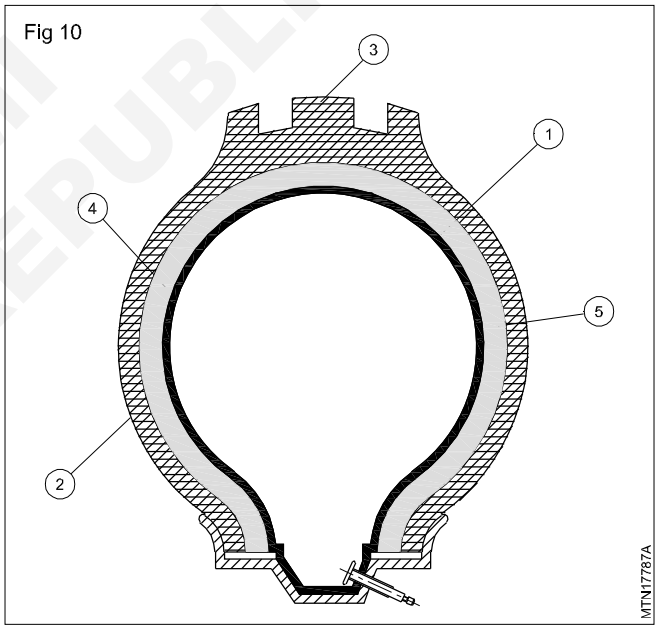
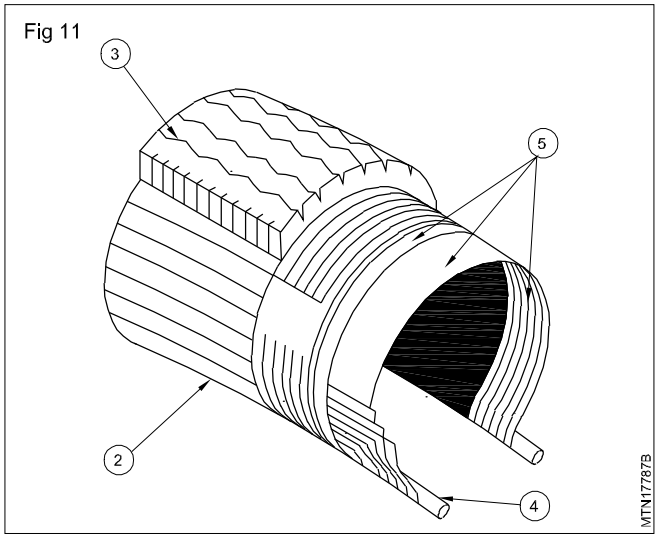


Fig 11

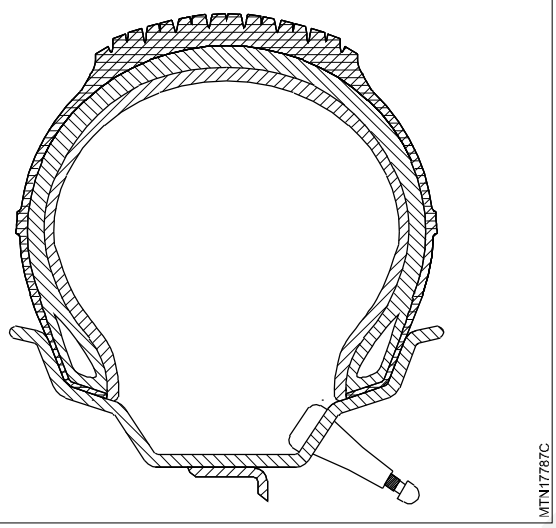


It provides cushioning. The outer portion of the tyre which keeps contact on the road is made of synthetic rubber. This portion is called tread (3). Steel beads (4) are provided at the inner edge. A number of plys (5) of rayon cord are provided to give strength to the tyre. The beads (4) and plys (5) provide strength to the tyre.

Tubeless tyre

Its construction is similar to that of the tube tyre except that it does not have a tube and air is directly inflated in the tyre. The tubeless tyre can retain air for a longer period than the tube type tyre after puncture.

Fig 12



MTN17787C

This tyre need not be removed from the wheel to set right a puncture.

Construction of a tyre: It is divided into two types.

- Radial ply
- Cross-ply

Radial ply: In this type plys are provided radially from bead to bead.

Cross-ply: In this type alternate plys are provided in opposite diagonal directions.

Material of tyre

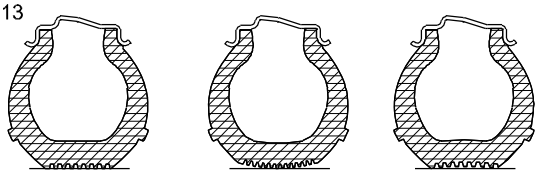
- Rubber - for tread
- Nylon/rayon - for cord
- High tensile steel wire - for bead.

Here the shoulder width is 9". The bead circle diameter is 14" and the No. of plies (Ply rating PR) is 14.

Tyre inflation

All vehicle manufacturers specify pressure at which air should be inflated in the tyre. It depends upon the tyre size and load of vehicle etc.

Fig 13



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A tyre should be inflated at the specified pressure to have complete contact on road (1). If the tyre is over-inflated, it will have contact with the road only at the centre and the tyre will wear out faster at the centre (2). If it is under-inflated it will have contact with the road only at the edges which will wear out faster (3).

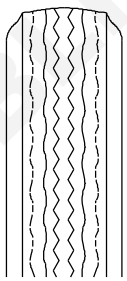
Tyre storage

- Tyres should be stored on a clean surface free from oil, grease, diesel or other liquid.
- Tyres should be kept vertically on the surface. So that they rest on their treads.
- Tyres should be stored away from electric appliances, gas heaters etc.
- Tyres should be protected from strong sunlight.

Tyre wear: Tyre wear depends upon its position (front or rear), load, road condition, inflation and mechanical faults of the car. The different types of tyre wear are as follows.

Rapid wear at shoulders: Tyre wears out faster at the shoulder. Under-inflation is the main cause for this.

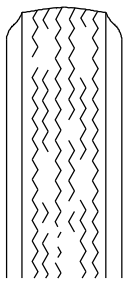
Fig 14



MTN17787E

Rapid wear at centre: Over-inflation is the main cause for this.

Fig 15



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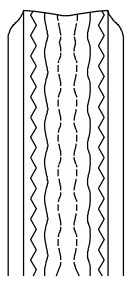
Cracked treads: The main causes for this are under-inflation or excessive speed.

Wear on one side: The main cause for this is improper camber.

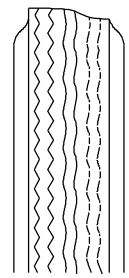
Fig 16



MTN17787G

Feather edge: The main cause for this is incorrect toe-in.

Fig 17



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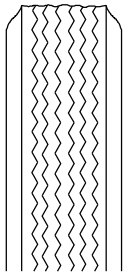
Bald spots wear: The main cause for this is improper dynamic and static balancing of wheels.

Fig 18



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Structure of Tyre (Fig 19)

Type outer diameter

It is the outer most diameter of the tyre (1)

Tyre width

The width of the tyre corresponds to the distance between the most protruding portions on both sides.

Over all tyre width: Rectilinear distance between both side, including all patterns and characters on tyre sidewalls.

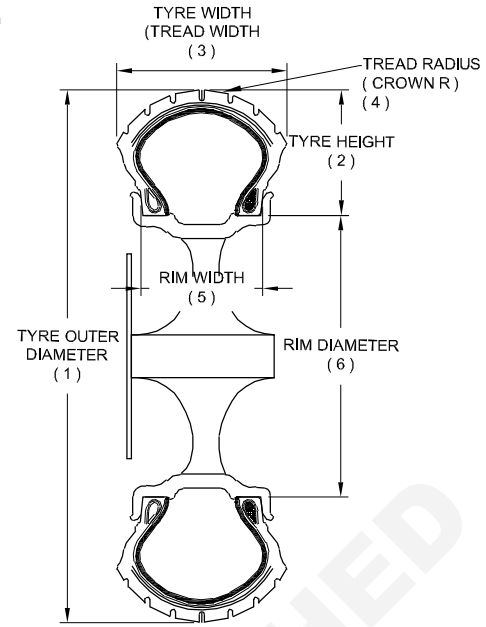
Tyre height: Half of height (2) obtained by subtracting the rim diameter from the tyre outer diameter.

Tread width: The width (3) of the tyre tread surface. This corresponds, as a rule, to the distance between the most protruding portions on both sides.

Tread Radius (4): This is also referred to as the crown R. The radius of curvature is expressed in millimeters.

Rim Width (5): Rim width suitable for effective tyre performance.

Fig 19



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Bead circle diameter (6): The inside diameter of the tyre (or) rim diameter is called as bead circle diameter of tyre.

Aspect Ratio (Fig 20)

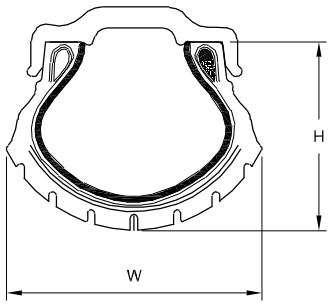
The aspect ratio is, as shown in Fig 20 the drawing, a percentage ratio of tyre height to tyre width

Aspect Ratio (% age) = H/W x 100

H : Tyre Height (mm)

W : Tyre Width (mm)

Fig 20



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Tyre specification (Fig 1D): 1 - Tyre outer diameter, 2 - Tyre height, 3 - Tyre width/tread width, 4 - Tread radius, 5 - Rim width, 6 - Rim diameter (or) bead circle diameter.

Specification of tyre

Size Designation

Metric Indication

110 / 70 R 17 54 V a b c d e f		
a: Tyre Width (110 mm)	b: Aspect Ratio (70 %)	c:Radial Structure
d: Rim Diameter (17 inch)	e: Max. Load (212 kg at 290 kpa)	f :Speed Limit (240 km/h)
130 / 90 - 18 69 H a b c d e f		

a: Tyre Width (130 mm) d: Rim Diameter (18 inch)	b: Aspect Ratio (90 %) e: Max. Load (325 kg at 280 kpa)	c:Bias Structure f :Speed Limit (210 km/h)

Inch Indication

4.00 H - 18 4PR a b c d		
a: Tyre Width (4 inch) d: Tyre Strength (4 ply rating)	b : Speed Limit (210 km/h)	c: Rim Diameter(18 inch)

Tyre tube

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

- **state tuff up tube**
- **state the structure of tuff up tube**
- **state hole plugging mechanism**
- **state the rubber types**
- **state the tyre properties**
- **state the tube functions**
- **state the conversion table for air inflating.**

Tuff up tube: The two-chamber tube has two separate chambers that are independent from each other. One is the air and other is the liquid chamber. The newly developed anti-puncture sealant gel is sealed in the chamber located on the tyre tread side during the manufacturing process. As the sealant chamber is always pressed against the tyre by the pressure from the air chamber, when there occurs a hole, the sealant gel enters in the hole and closes it.

Structure of tuff up tube: This shows how the two-chamber tube closes the hole. Usually in an event of a puncture, a hole is pierced through the sealant gel chamber to the air chamber. When a hole occurs, the gel is forced into the hole, and the fibrous material contained in the gel is squeezed out. At that time, the fine ceramic particles fill the openings of the fiber, and the vacant spaces are filled with the gel. As there is a pressure inside of the inner tube, minimal quantity seeps into the air chamber but without causing any harm as it is a water based gel.

Hole Plugging Mechanism: This shows a picture of the cross-section of the hole closed by the newly developed anti-puncture sealant gel, taken after the sealant gel oozes out, dries and seals the puncture.

Tuff up tube can be reparted like an ordinary tube: Though it is an innovative technology, Tuff Up tube is easy to repair and with some simple precautions, it can be repaired at any repair shop or by road side mechanic.

Nitrogen filling in tyres

- Car tyres are normally inflated with compressed air.
- Air is approximately 80% Nitrogen, 20% Oxygen.
- Nitrogen is comparatively inert, Oxygen is a reactive gas.
- The Nitrogen used for inflation in tyre depots is normally generated by a separation process from compressed air. It still contains about 5% Oxygen.
- Nitrogen used at race tracks and in industry may be 99%+ pure and contained in high pressure cylinders at 2000+ psi.
- Both sources of Nitrogen will be treated to reduce the amount of water vapour.

Nitrogen is used in many tires and not specifically tubeless. It is used because it doesn't expand and compress like normal air does in altitude and temperature change,which is why it is used in aviation applications

Nitrogen is chemically a non-flammable, non-toxic inert gas. An inert gas does not fuse with any other gas at any temperature. This basic nature of nitrogen first of all helps in keeping minimum moisture in the tyres.

The basic idea of Nitrogen gas is that it is cooler than compressed air and therefore it is useful in any driving conditions. The cooler tyre means that the stress levels on the tyre while moving are lesser. The tread wear and tear is also lesser due to the lesser temperature.

Higher temperature in tyres also has a tendency to burst after long hours of running. Nitrogen reduces the chances of tyre burst by 90%. This can prove to be a lifesaver while on the highway where long hours and high speed, both pose a threat to the car and its passengers.

Pros

- Nitrogen reduces the running temperature of the tyre. The moisture content of nitrogen leads to a cooler running tyre, which is advantageous when the car or bike is operating at its maximum load and speed capacity.
- Nitrogen in tyres improves the ride quality. That gas is very slightly lighter than air and thus, benefits the tires in terms of un-sprung weight.

- It is assumed that Nitrogen increases tyre life. It reduces the operating temperature during times of load and speed and thus, enhances the life of a tyre.
- It is believed that nitrogen keeps tyre pressures more constant. The gas is assumed to provide more stable pressure range in connection to the tyre temperature. However, again, the factor is applicable in times of heavy load/high-speed conditions.
- Tyres are susceptible to loss of pressure as a result of being porous in nature. Due to its chemical structure, Nitrogen leak out slowly as compared to compressed air. Therefore, it slows the rate of pressure loss.
- Oxygen reacts with the tyre and rim materials causing oxidation or the rust formation in the metal parts. Nitrogen, being an inert gas, does not react with the tyre and rim materials.

Cons

- Inflating tires with Nitrogen is quite costly.
- Filling tyres with nitrogen requires more maintenance as compared to compressed gas.
- The availability factor is the biggest disadvantage of inflating tyres with nitrogen, as the gas is not readily available. It is usually found only with specialist tyre dealers.
- Generally it is not that much advantageous in case of commuter bikes. Moreover 78% of air is itself nitrogen. It is advantageous only in case of Formula cars, High speed racing cars & motorcycles & High load carriage vehicle.

Parts of a rubber tire

The Bead: Fits inside the rim of the wheel and is held in place by tire pressure.

The Sidewall: Protects the cord plies and has all the tire information printed on it.

The Tread: Provides strength and stability and is the interface that provides traction to the road surface.

The Belt Plies and Body Plies: Give the tire its stability and resistance to road damage.

An inner liner: Combats permeability (keeping the air in the tire).

Sipes: are small slits in the tread that improve traction.

Functions of rubber tires

Rubber tire absorbs the shock of road roughness and can provide a smooth, safe ride.

They protect the wheel from wear and tear.

They provide a high-friction bond between the vehicle and the road to improve acceleration and handling.

They also provide other functions such as traction for moving, stopping and steering as well as providing a cushion for the vehicle.

Tyre properties: A tyre must have the following desired properties;

1 **Non-skidding:** The tyre should not skid or slip on the road surface. It should have good grip.

2 **Uniform wear:** The tyre must get wear uniformly over its outer circumference.

3 **Load carrying:** The tyre should be able to carry the vehicle load.

4 **Cushioning:** The tyre should be able to absorb vibrations set-up by the road surfaces, thus providing cushioning effect.

5 **Power consumption:** While rolling on the road, the tyre should consume least power developed by the engine.

6 **Noise:** The tyre should create minimum noise while running on the road.

7 **Balancing:** The tyre should be balanced dynamically as well statically.

Tube: The tube which is made of rubber moulding to conform the inner shape of tyre. Air is forced into the tube under pressure through a non-return valve which projects outside through a hole in the rim. Tubes are made of rubber by moulding to conform the shape tyre. Special tyres of tubes are available which minimize the danger of punches or blowouts. These tubes are self sealing constructions.

Tubes are manufactured with the same care and attention as tyres. Raw material are analysed and tested before use. In the manufacture of tubes butyl rubber is used instead of natural rubber because of its vastly superior qualities, front warm-up mills the tube stock goes to an extruding machine from which it comes out on to a conveyor as endless sleeve. This is then marked with the proper size, cut to length and stored in the specially designed skids.

The ends of the tubes are then joined together on automatic splicing machines and are then fitted with the valves specified for each size. Each tube is then put around a forming ring and inflated to mould shape and is then cured in a steam heated mould. The mould opens automatically at the end of curing period and the cure tube is taken out. Each tube is thoroughly inspected for defects, then polished, packed and made ready for shiping out.

Brakes

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a brake**
- **state the various types of brake systems**
- **state the function and operation of mechanical brakes.**

Purpose

- To stop the vehicle.
- To slow down the vehicle.
- To park the vehicle.

Types

According to application

- Foot brakes
- Hand brakes

According to operation

- Drum type
- Disc type
- Mechanical brake
- Hydraulic brake

Foot brake

The brake which is applied by foot is called the foot brake.

Hand brake

The brake which is applied by hand is called the hand brake, e.g. a scooter's, motor cycles and auto.

Drum brake

In this type of brakes, the brake shoes (1) & (2) are placed inside the brake drum (3). When the brake is applied, the brake shoes expand through linkages, come in contact with the brake drum and stop the wheels.

Disc brakes (Fig 3&4)

In this type the brake pads (4&5) are arranged at both the sides of the disc (6) which is connected with the wheel hub. When the brake is applied the pads (4&5) move towards the disc (6) and stop the wheels. The following types of disc brakes are used.

Fig 1

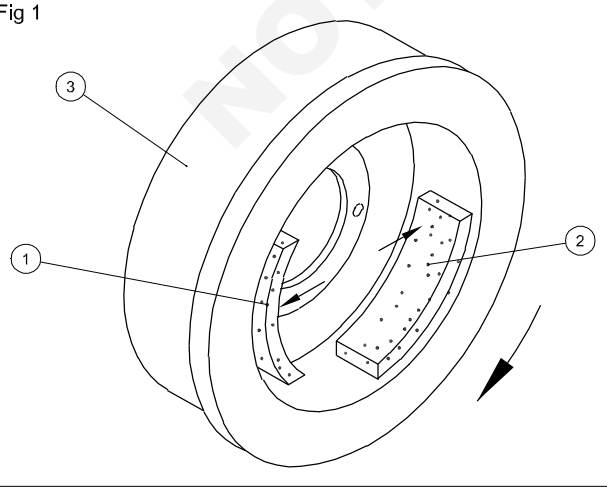


Fig 2

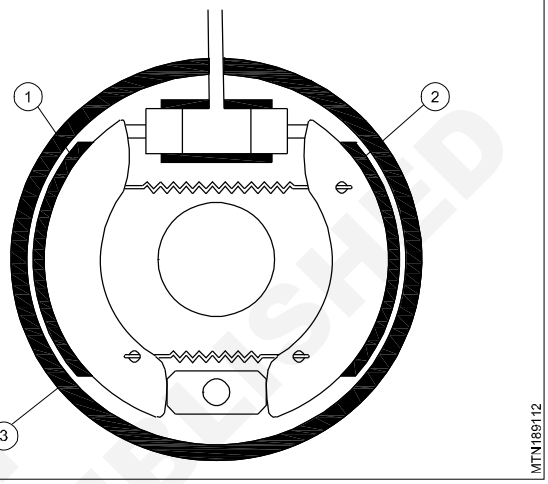


Fig 3

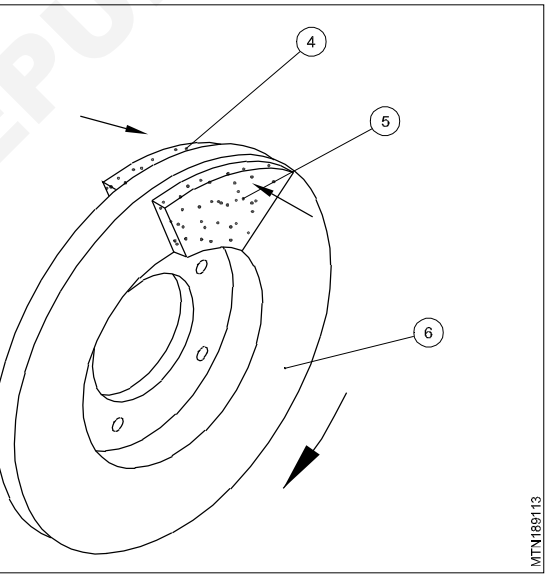


Fig 4

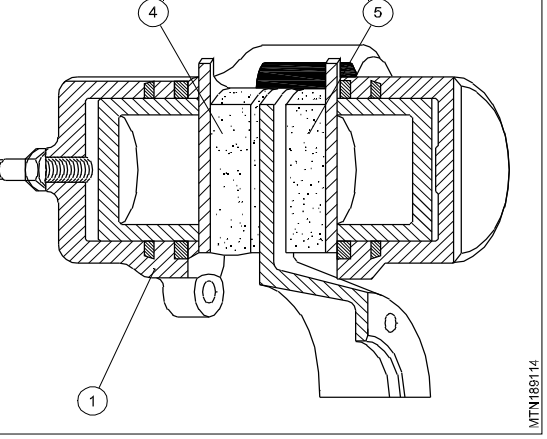
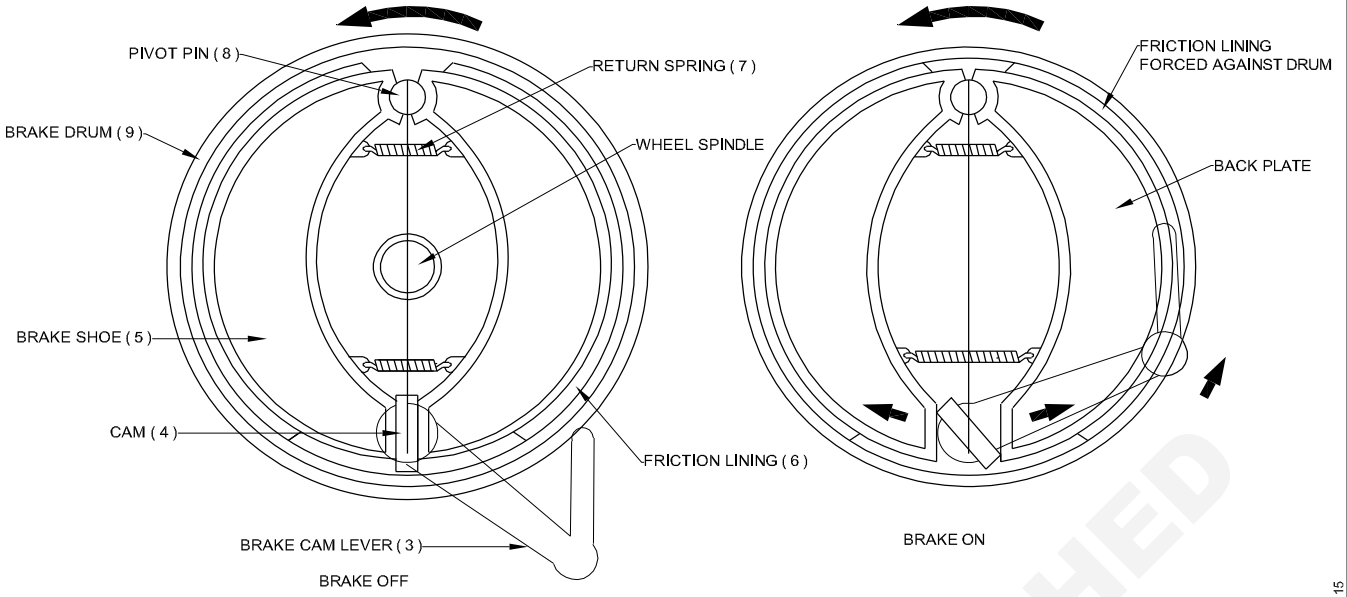


Fig 5



OPERATION OF A SIMPLE SINGLE LEADING SHOE OF DRUM BRAKE

Hydraulic brakes

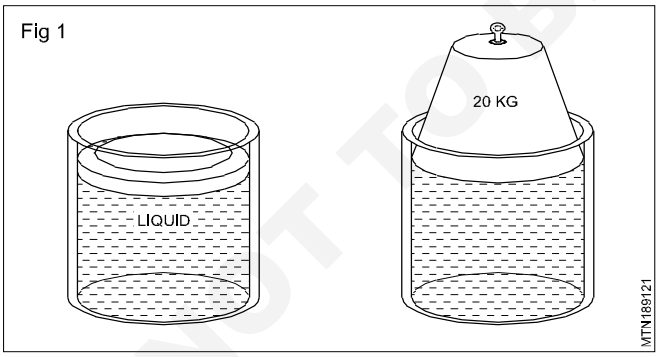
Objectives: At the end of this lesson you shall be able to
- **state the principle of a hydraulic brake**
- **state the functions of master cylinder**
- **state the functions of wheel cylinder**
- **state the functions of components of disc brake**
- **state the characteristics of brake fluid**
- **state the brake lining of pad materials.**

Principle: Hydraulic brakes work under the principle of Pascal's law.

PASCAL'S LAW

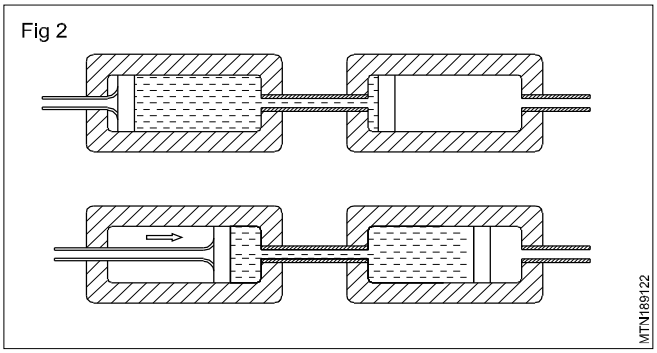
- Liquid cannot be compressed.

Fig 1



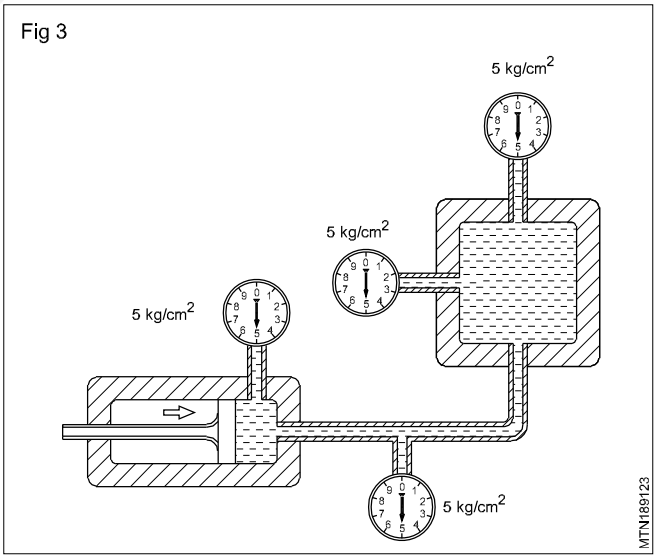
- Motion can be transmitted through a liquid.

Fig 2



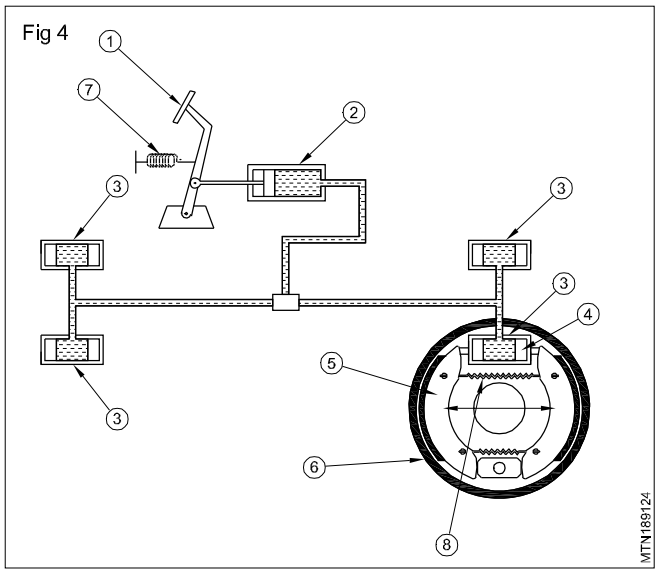
- Liquid pressure is transmitted equally in all directions.

Fig 3



Operation

When the brake pedal (1) is pressed the fluid inside the master cylinder (2) is pressurized and supplied to the wheel cylinders (3). The wheel cylinder pistons (4) push the brake shoes (5) towards the brake drum (6). The friction between the brake shoe lining and the brake drum stops the rotation of the brake drum (6).



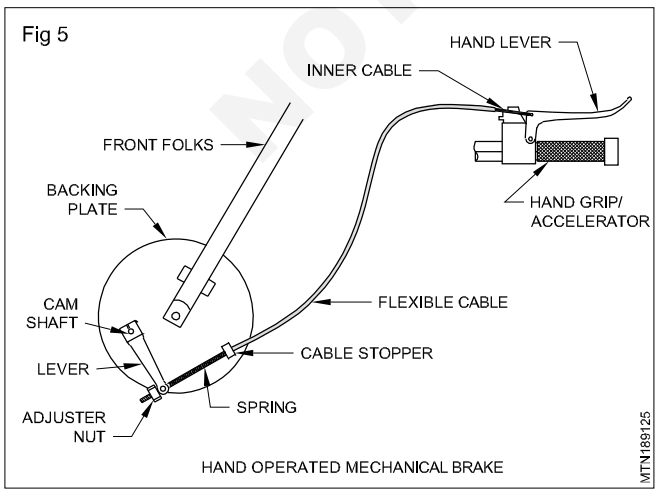
When the brake is released the brake pedal comes to its original position with the help of the pedal return spring (7). The brake shoes come to their original position with the help of the brake shoe retracting spring (8). When the brake shoe returns to its position, it pushes the wheel cylinder pistons inside, and the pressurized fluid is sent back to the master cylinder.

Mechanical brake control system

Mechanical brake controls are operated by means of levers, pivots, adjusters, cables, springs and camas. Each of these items plays an important role in stopping the motorcycle. Generally front brake is actuated with hand operated lever and rear brake is operated with foot operated lever. More or less, in all scooters with CVT, both brakes are actuated with the help of hand operated levers.

Hand Operated Mechanical Brake (Fig 5)

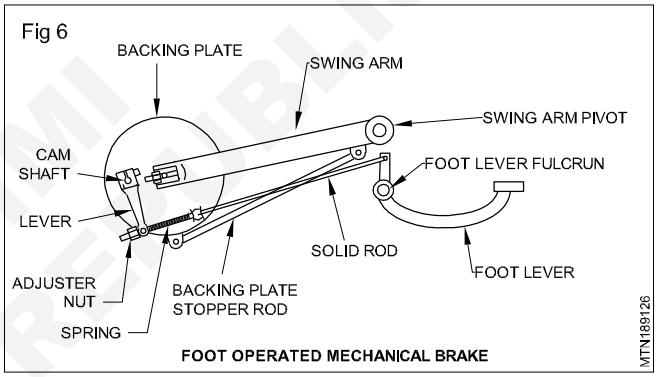
Fig 5 shows hand operated mechanical brake generally used for the single leading drum type front brake. A lever assembly helps the rider to gain mechanical advantage over the braking system of a vehicle. About a 6-10-1. mechanical advantage is gained at the lever. It is important to keep the pivot of hand lever lubricated to easy operation. The adjustor at the back plate side provides a quick, easy way to compensate for stretch that develops in the cable and wear of shoes over the time.



The cable is basically a steel wire inside of a flexible rubber covered steel tube. It provides a flexible coupling between the rider and the brake. If the outer tube is held stationary at the ends, motion can be transmitted via the inner cable. The cable is attached to a brake lever that is splined to the brake activating cam shaft. The lateral movement of the cable is restricted by the stopper embossed on the backing plate. The backing plate is also provided with embossed guide-ways for the front fork. The guide-ways restrict the backing plate movement during braking.

Foot Operated Mechanical Brake

Fig 6 shows foot operated mechanical brake generally used for the single leading drum type rear brake. A foot lever assembly helps the rider to gain required mechanical advantage. The foot lever is pivoted on the frame. The adjustor at the back plate side provides a quick, easy way to compensate for wear of shoes over the time. The cable is replaced by a solid rod which links the foot lever with the brake operating lever. The rod is attached to a brake lever that is splined to the brake activating cam shaft.



Hydraulic brake control system

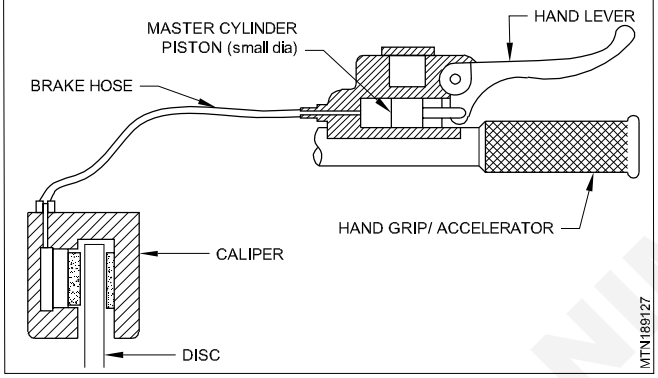
In hydraulic brake control system, levers, master cylinders, brake fluid and brake lines are used to perform the braking action. Just as lever can be used to increase mechanical advantage, a hydraulic system can accomplish the sane task. In a hydraulic system, a force applied to a small piston over a long distance can be converted to a much stronger force on a larger piston to cover a short distance. This increase in force takes place when the original force from a smaller piston is applied through a liquid medium to a larger piston. A two-wheeler braking system uses this principle to increase hand or foot pressure on a lever to the great energy required to clamp two pads together on a disc. To accomplish this, the hydraulic brake system uses a master cylinder, brake line, and a slave cylinder in the calliper assembly. Just like mechanical brake control system, hydraulic systems also differ with method of actuation. Generally, hand operated system is used for the front brake while foot operated system is used for the rear brake.

Hand Operated Hydraulic Brake (Fig 7)

Fig 7 shows the hydraulic circuit generally used in two wheelers for front distance. The master cylinder is the central unit in which hydraulic pressure is developed.

Press the rider's hand on the lever is transmitted to the master cylinder piston. This small enclosed in the cylinder full of brake fluid. The brake hose connects the master cylinder the caliper. The entire passage is filled with the brake fluid kept airtight. Since the brake and caliper piston are filled with fluid, the column of fluid forces the caliper piston toward disc. As hand lever pressure increases, pressure on the caliper piston increases. This research increased pressure of the pads against the disc. These pressures build up uniformly through the system and results in quicker stopping. According to space availability and also with different manufacturer. The caliper is mounted on the swing arm. Just like front brake, as foot lever pressure increases. Pressure on the caliper piston increases. This results as increased pressure of the pads against the disc. These pressures build up occurs uniformly throughout the system and results in quicker stopping.

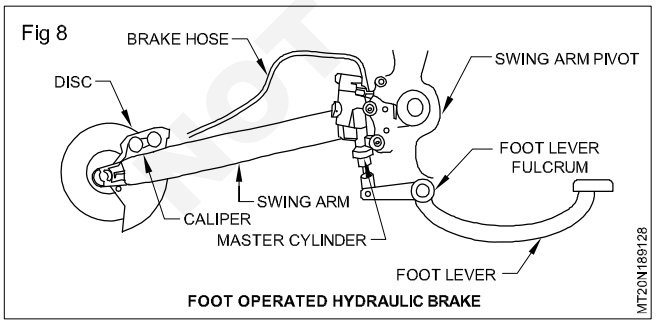
Fig 7



Foot Operated Hydraulic Brake (Fig 8)

Fig 8 shows the hydraulic circuit generally used in two wheelers for rear disc brake. The master cylinder is directly attached to the foot lever. Orientation of master cylinder varies according to space availability and also with different manufacturer. The caliper is mounted on the swing arm. Like front brake, as foot lever pressure increases, pressure on the caliper piston increases. This results as increased pressure of the pads against the disc. These pressures build up occurs uniformly throughout the system and results in quicker stopping.

Fig 8

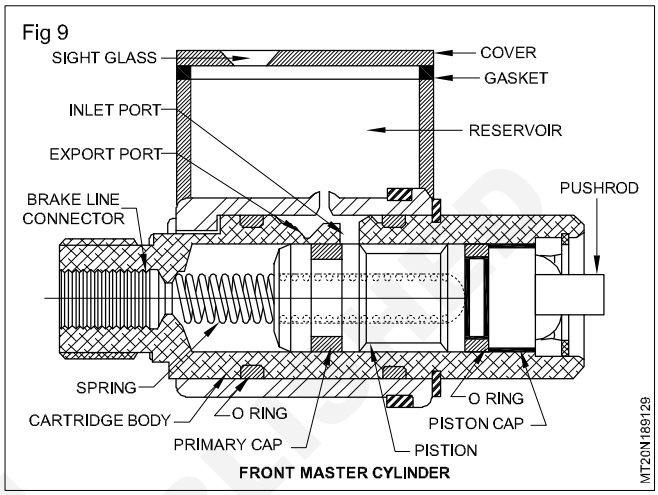


FOOT OPERATED HYDRAULIC BRAKE

Mater cylinder (Fig 9&10)

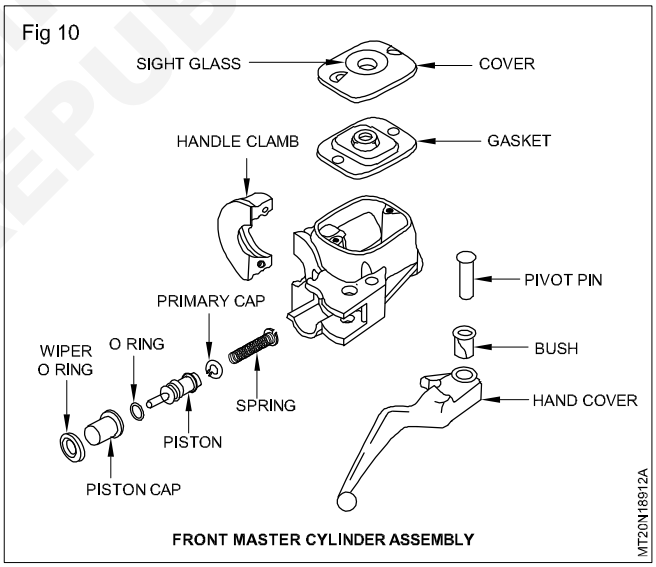
Fig 9 illustrates details of front master cylinder. There are mainly two chamber: fluid reservoir and compression cartridge. The fluid in the reservoir compensates for any change in the fluid volume in the brake lines due to temperature variations and due to leakage. Compression cartridge from a close chamber in which the fluid is pressurized due to reciprocating motion of the piston. O rings and washers at various locations are used to prevent leakage of brake fluid. O rings also serve the purpose of cleaning the piston during each stroke. Piston cap and push rod, together, transmit the force of hand lever to the piston. A spring loaded fluid check valve is used to control the flow of pressurized fluid to the brake line. It also maintains the pressure in the brake line even when the brake is released.

Fig 9



FRONT MASTER CYLINDER

Fig 10



FRONT MASTER CYLINDER ASSEMBLY

Two holes connect the fluid reservoir to the compression cartridge. The smaller one is known as bypass or compensation port and the second hole is called the intake or the recuperation port. The push rod and piston cap and the second hole is called the intake or the recuperation port. The push rod and piston cap are operated by the lever is pressed, push rod and piston cap move the piston to left against the force of the spring, till it cover the bypass port. Further movement of the push rod causes building up of pressure in the compression cartridge. Finally, when sufficient pressure has built up, the fluid check valve is deflected, forcing the fluid under pressure in the lines. The fluid enters the caliper and moves the pistons thereby applying the brake.

When the brake lever is released, the spring pressure in the compression cartridge moves the piston to the right extreme position. This same force of the spring keeps the fluid check valve pressed on its seat for sometimes and thereby delays the return of fluid from the lines into the compression cartridge again. This produces a vacuum in the compression cartridge and unless this is destroyed immediately, there are all chances of air leaking into the system.

This problem is solved by having intake port. As soon as some vacuum is formed, the fluid from the reservoir is forced through the intake port due to pressure difference between compression cartridge and reservoir. The fluid enters the compression cartridge through the reduced diameter region of the piston, destroying the vacuum. Some pistons consist small holes to transfer the fluid from reservoir to the cartridge. By the time this vacuum is destroyed, the fluid form the brake line comes back into the compression cartridge.

This extra fluid now has to be accommodates some how, because compression cartridge is already full. If this is not done, the pressure in the lines will not relieved fully and there are all chances of brake pads rubbing with the disc. This extra fluid is compensated through the bypass port. The extra fluid coming from the lines passes back to the fluid reservoir because of pressure difference between compression cartridge and reservoir.

In case brake pads are worn so that there is excessive clearance between pad and disc a quick released of brake pedal will draw extra fluid from the reservoir into the compression cartridge and thereafter a quick pressing of the pedal will send this extra fluid into the brake lines, thus taking up the excessive clearance. In this way a quick pumping up of the brake lever helps compensate for the wear of the brake pads. Fig 10 shows actual assembled of front master cylinder.

Fig 11 shows construction of rear master cylinder. Components and working of rear master cylinder, more or less, remains same as the front master cylinder. Few additional components like rubber boot, auxiliary spring, push rod with ball joint etc. are necessarily added to the rear master cylinder.

The force from the foot lever is transmitted to the piston through the push rod and the ball joint. The ball joint facilitates force transmission even with the inclined push rod. The auxiliary spring helps to return the push rod and ball joint to their initial position. A rubber boot protects the ball joint and push rod assembly from dust, mud and water contamination.

The rubber boot is essential on rear master cylinder as it is mostly located nearer to road surface. Reservoir on the rear master cylinder may be located remotely. Fig 12 shows actual assembly of the rear master cylinder.

Hydraulic Brake System

Disc Brake: The brake surface of the disc is exposed to air, it displays superior heat dissipation in comparison with the drum brake. The resistance to fading is also good. The disc brake system operates by also good. The disc brake system operates by hydraulic pressure. The pressure is generated on the piston of master cylinder from lever. This hydraulic pressure is transmitted to the connected caliper pistons.

Operation

1 Rider operates the brake lever

2 Hydraulic pressure is generated in the master cylinder.

3 The pressure is transmitted to the caliper cylinder pushing the caliper piston out.

4 the piston pushes the pads against the disc and braking force is generated.

Fig 12

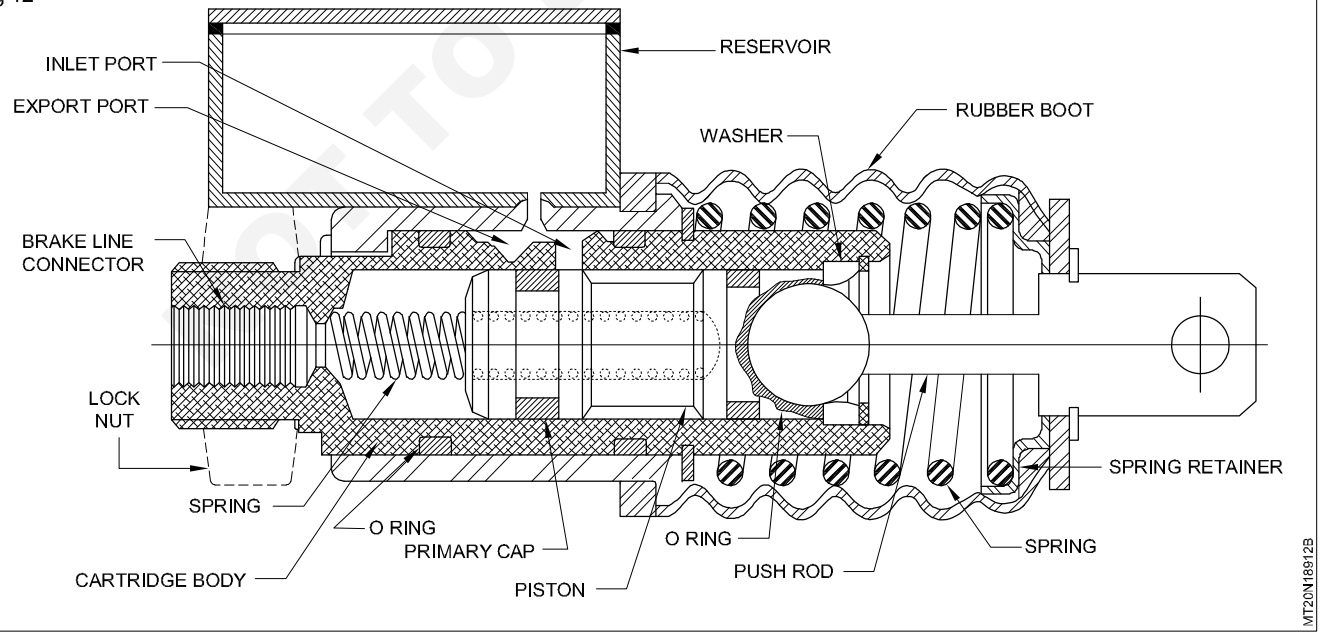


Fig 12

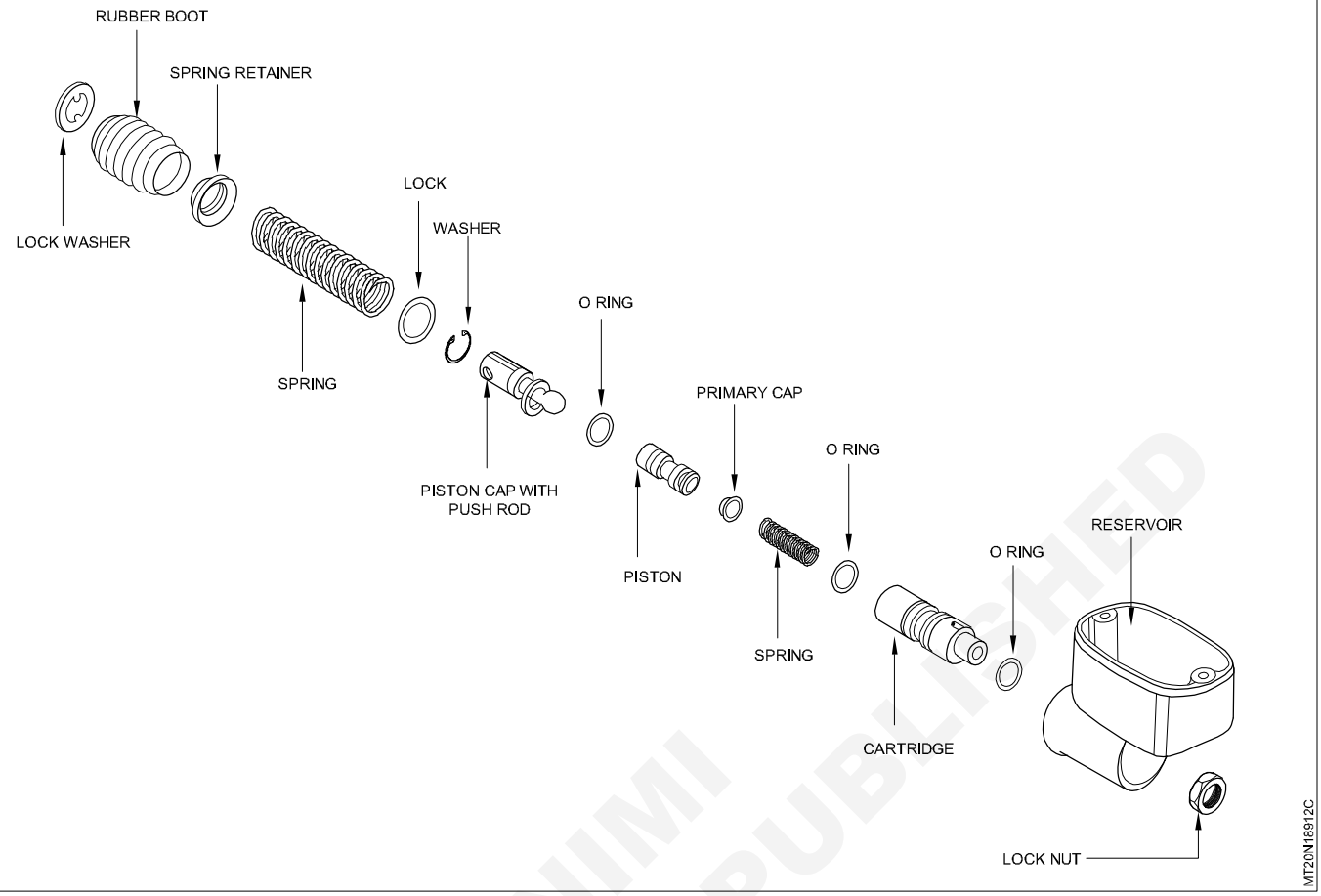
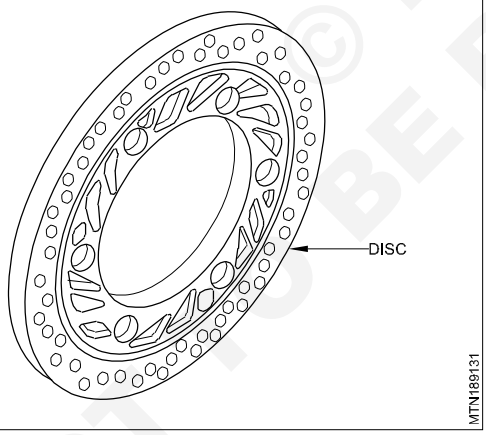


Fig 13



Advantages over drum brake

1 Heat dissipation is more during braking hence more braking efficiency.

2 Force transmission is by hydraulic pressure hence free from functional deterioration like breakage, elongation or rust.

3 There is high degree of freedom for hose routing.

4 Brake system provides large output force with small input.

Construction

Disc brake system consists of following parts:

Disc

Disc is the rotating part fitted on the front wheel hub.

Disc is made up of steel and is called standard type as the braking surface and hub - mounting surface are of single body.

Further this is classified as dish type because the braking surface and hub mounting surface are having offset.

Pad

The pad consists of backing plate and lining.

The liner material is made of non-asbestos.

As the brake is applied the pads will be pushed to the rotating disc, so periodic inspection of pad wear is required.

Caliber: Caliber is made of die cast aluminum and is fitted on the vehicle body. Caliper converts pressure into force and it consists of piston, piston seal, dust seal, pad and pad spring. Type of the caliper is double piston floating caliper. In this type the caliper body will move on the slide pin in the opposite direction of piston movement.

Piston, Piston seal, dust seal

As the disc brake basically has no return mechanism once the piston has been pushed out, it will not return to original position. The elasticity of the piston seal pulls back the piston slightly, which reduces the contact between pads and sic hence reduces heat generation and wear.

Fig 14

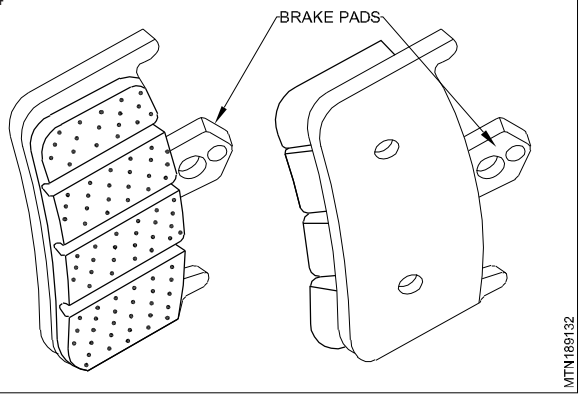


Fig 15

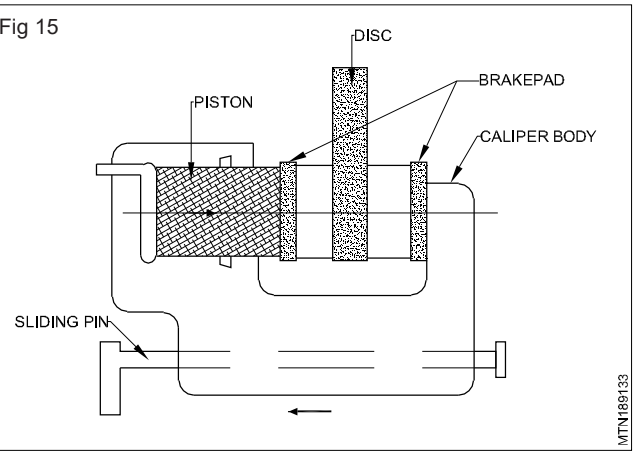
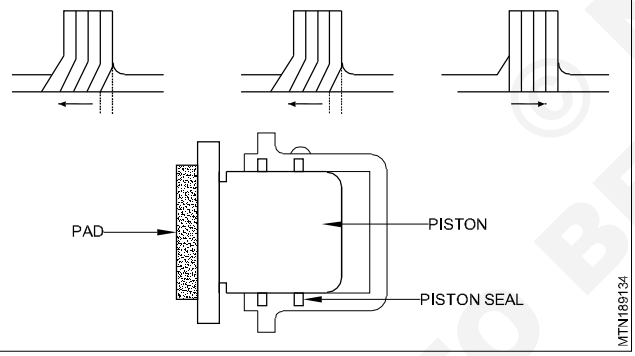
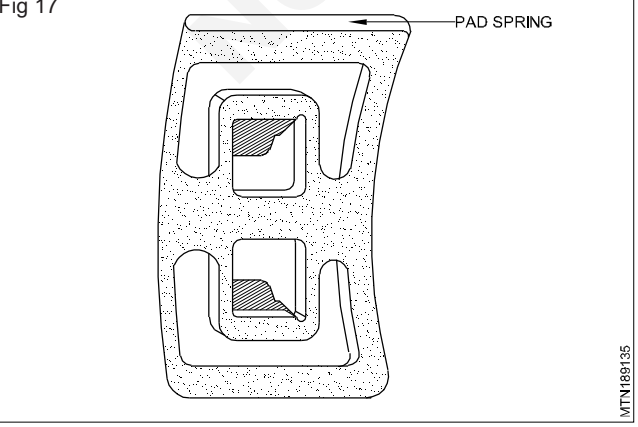


Fig 16



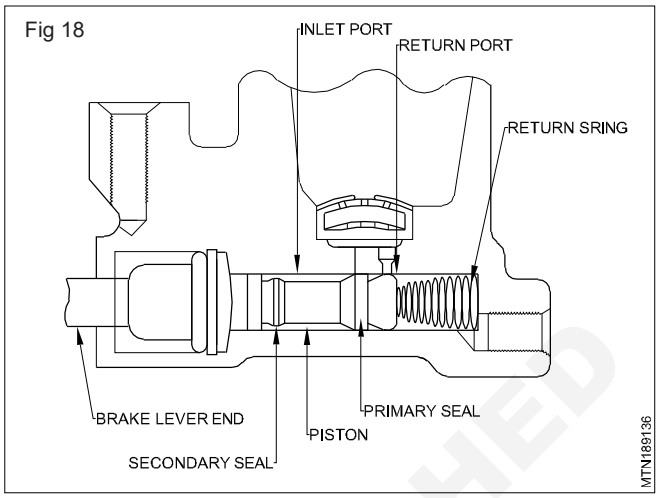
Pad Spring: The pad is subjected to considerable heat and stress. It is also a moving part. The pad spring suppresses pad play and holds the pad in a suitable position while also providing suitable clearance with the caliper.

Fig 17



Master Cylinder: Master cylinder receives input from the lever and regulates hydraulic pressure in the system. A piston with the rubber cap and return spring is installed in the master cylinder. The cup receives the hydraulic pressure and adjusts fluid volume in the system.

Fig 18



Brake Fluid: There are three grades of brake fluid, DOT 3, DOT 4 and DOT 5. This classification of grades is based on the performance required, which is determined by the boiling point in the presence of water contents. DOT 3 or DOT 4 grade brake fluid are commonly used which are made of complex alcohol fluid.

1 High boiling point.

2 Moisture absorption

3 Anti corrosive

4 Stable chemical characteristic in regard to heat

5 Adequate lubricating characteristic

6 Suitable viscosity over high temperature range

Changing of brake fluid as recommend in the workshop manual is necessary because over the period of time the brake fluid absorbs moisture and it's boiling point reduces. When the boiling point is lesser than the required boiling point, brake failure may occur.

GRADE	BOILING POINT	
	DRY	WET
DOT 3	205o C or More	140o C or More
DOT 4	230o C or more	155o C or More
DOT 5	260o C or more	180o C or More

Caution for use of brake fluid

1 Brake fluid can easily absorb the moisture (highly hydrophilic), which reduces its boiling point. The container must always be closed tightly.

2 Brake fluid will cause damage to paints and plated surfaces. To avoid the spillage of brake fluid on nearby painted and plated parts, they should be covered with cloth.

3 Different grades of brake fluids should not mixed, as the chemical changes lead to the severe damage to the system.

Brake lining and pad material

These linings are mostly used for front disc brakes. It is made of fine polished steel wool. It also includes iron powder and graphite. Plastic resin is used as a binder. The mixture is heated and pushed to form the lining. Semi metallic linings are more wear and heat resistant than organic linings. Semi metallic linings can retain their co-efficient of friction when operating at high temperature.

Brake linings are made of carbar derived material, cellulose or other organic material, melted metal semi metallic material.

Brake fluid

Objectives: At the end of this lesson you shall be able to
- **state the necessity of bleeding the brake system**
- **state method of brake pedal adjustment**
- **state the characteristics of brake fluid**
- **state the advantages and disadvantages of a hydraulic brake.**

Bleeding of hydraulic brake system

The hydraulic brake system must be bled whenever the fluid line has been disconnected or air gets into the system. A leak in the system may sometimes be indicated by a spongy brake pedal. Air trapped in the system is compressible and does not permit pedal effort to be transmitted to the brakes. The system must be absolutely free from air at all times.

Brake pedal adjustment

There should be always at least 12.7mm (1/2") free pedal travel, before the push rod engages the master cylinder piston. This adjustment is accomplished by shortening or lengthening of the brake master cylinder eye-bolt. This is done so that the primary cup will clear the bypass port when the piston is in the off position. This will prevent the compensating action of the master cylinder against temperature changes of the brake fluid.

Brake fluids

Characteristics of brake fluid

- It should be able to flow freely at extremely high and low temperatures.
- It should be able to serve as a lubricant.
- It should be anti-corrosive and anti-rust.
- It should show resistance to evaporation.
- It should not damage or swell the rubber parts.

Use only approved brake fluids in a brake system. Any other fluid such as power steering fluid, automatic transmission fluid, or engine oil, which has a petroleum base, must never be used in the brake system. Petroleum based fluids will damage the rubber components in the brake system, like the piston cups and seals, and cause them to swell and disintegrate.

Advantages of a hydraulic brake

- Simple in construction.
- Equal braking at all the wheels.
- Wear of the parts is less.
- Little maintenance is required.

Disadvantages

- Any leakage of fluid in the line will lead to brake failure.
- Chances of the brake fluid reaching the brake shoes are very high. This will damage the brake shoes.
- If fluid enters the lining it reduces the braking efficiency.

Brake lining

Objectives: At the end of this lesson you shall be able to
- **state the material required for the brake lining.**

Two types of brake linings are used.

- Organic brake lining
- Semi-metallic brake lining

Organic brake lining

These linings are moulded from a mixture of asbestos, fibre glass, asbestos fibres etc. Resin is used as a binding material.

Semi-metallic brake linings: These linings are mostly used for front disc brakes in front wheel drive vehicles. It is made of fine polished steel wool. It also includes iron powder and graphite. Plastic resin is used as a binder. The mixture is heated and pressed to form the lining. Semi-metallic linings are more wear and heat resistant than organic linings. Semi- metallic linings can retain their coefficient of friction when operating at very high temperatures.

Anti-lock brake system

Objectives: At the end of this lesson you shall be able to
- **state the advantages of ABS**
- **list out the different types**
- **state wheel lock up condition**
- **state the brake hold mode**
- **state normal braking**
- **state electronic brake distribution advantage.**

Anti-lock brake system

Advantages of ABS: Anti-lock brake systems are designed to prevent wheel lockup under severe braking conditions irrespective of any type of road conditions.

The result is that, during heavy braking ABS;

- Retains directional stability (vehicle stability)
- Stops faster (shortened stopping distance)
- Retains max. control of vehicle (steerability)
- If front wheels lock-up it is no longer possible to steer the vehicle.
- If rear wheels lock-up the car can become unstable and can start to skid side ways.

Split surface braking: When brakes are applied on a combination of slippery and high friction surfaces, the wheels on the slipper surface easily locks-up and the vehicle loose stability and will be dragged towards the high friction side, which may lead to accidents through the oncoming vehicle. But ABS prevent this and offers stability until the vehicle comes to a complete halt.

Layout of anti-lock braking system (Fig 1)

Operating the brakes on most two wheelers is much more complicated than on four wheel vehicles. Most two wheelers have separate controls for the front and rear brakes, with front brake usually controlled by a lever on the right handlebar and the rear brake control by a pedal operated by the rider's right foot. During braking, a rider must decide how much force to apply to each control.

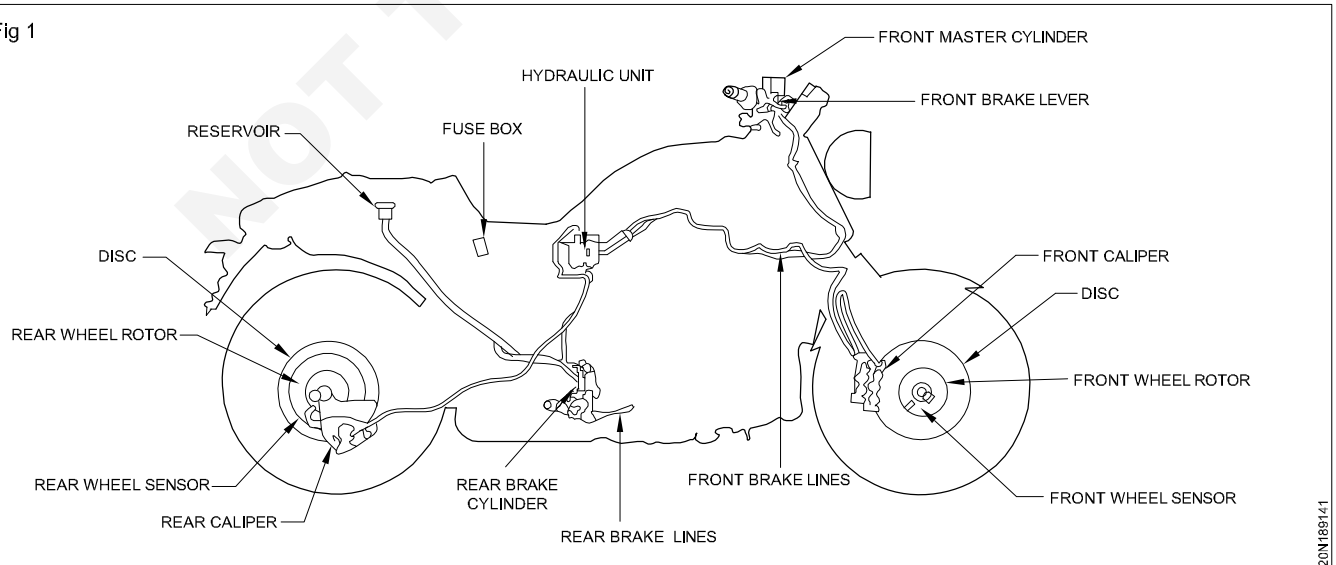
ABS has been adapted and tuned for two wheelers to helps riders solve this dilemma. Antilock braking systems monitor wheel speed and reduce brake pressure when impending wheel lock is detected. Brake pressure is increased when traction is restored, and the system evaluates and adjusts brake pressure many times per second. These systems allow riders to apply brakes fully in an emergency without chance of wheel lock.

The operation of the ABS brakes is the same as conventional brakes on other vehicles, with a brake lever for operating the front brake and a brake pedal for operating the rear brake. When wheel lock is detected during emergency braking, hydraulic control is performed by the hydraulic system on the front and rear brakes independently.

The rotation speed of the front and rear wheels are called wheel speed. The braking force applied to reduce the wheel speed during braking. When the brakes are applied, wheel speed and chassis speed are reduced. However, the chassis travels forward by its inertia even though the wheel speeds are reduced. A condition that occurs when the rotation of one or both of the wheels has stopped, but the vehicle continues to travel is known as skidding.

In braking as explain before, the brake lever is directly connected with caliper. The force applied by the rider on brake lever is directly exerted on the caliper and the disc without any interrupt. In the case of ABS, this braking force is exerted through ECU and Hydraulic valve. The ECU calculates the wheel speed of each wheel according to the rotation signal received from the front and rear wheel sensors.

Fig 1



LAYOUT OF ABS

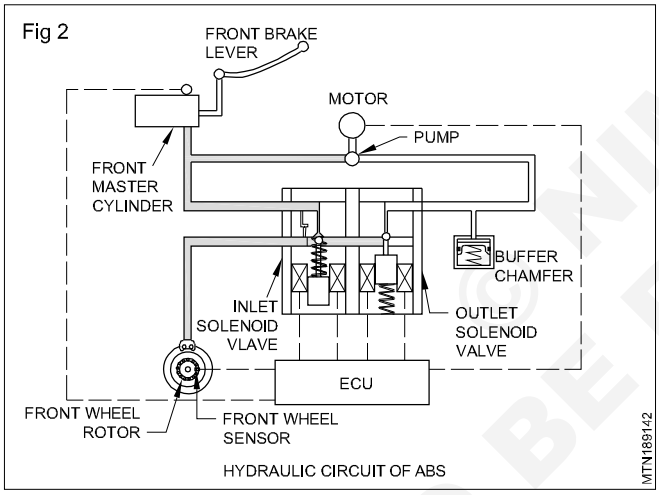
In addition, the ECU calculates the vehicle chassis speed and the rate of speed reduction based on the wheel speed values. The difference between the chassis speed and the wheel speed calculated gives the value of the wheel slip. When the wheel speed is suddenly reduced, the wheel has a tendency to lock.

When the wheel slip and the wheel speed reduction rate exceed the present values, the ECU determines that the wheel has a tendency to lock. If the slip is large and the wheel has a tendency to lock, the ECU reduces the brake fluid pressure in the brake caliper.

Once the ECU determines that the tendency of the wheel to lock has diminished after the brake fluid pressure is reduced, it increases the hydraulic pressure again. This in turn again applies the brake. This cycle takes place approximately 15 times per second. Fig 1 shows the layout of ABS used for two wheelers.

Components of ABS (Fig 2)

Fig 2 illustrates the hydraulic circuit for front brake in which major components of ABS are shown. Each component has to perform its function accurately and within fraction of second.

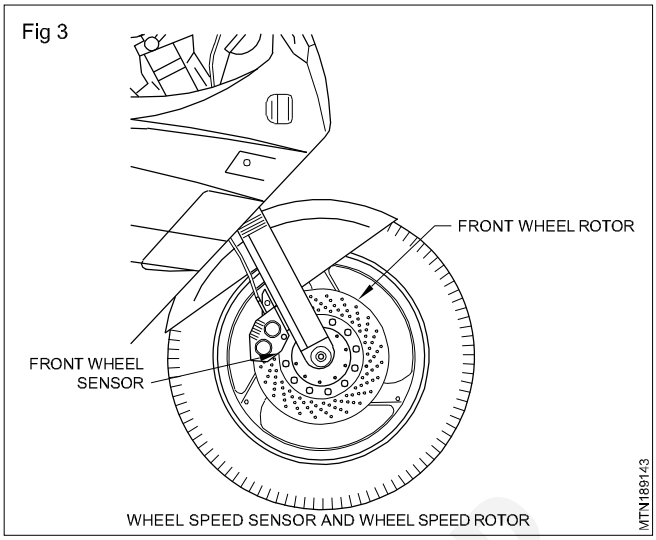


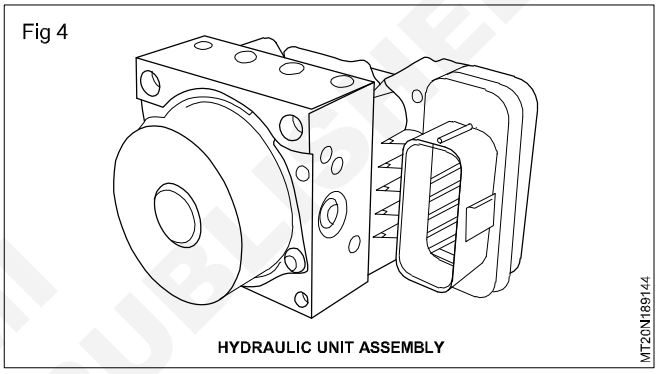
Wheel sensors and wheel sensor rotors (Fig 3)

Wheel sensors detect the wheel rotation speed and transmit the wheel rotation signal to the ECU. Each wheel sensor contains a Hall IC. The wheel sensors are installed in the sensor housing for each wheel as shown in fig 3 sensor rotors are installed on the inner side of the front and rear wheel hubs and rotate with the wheels.

The front and rear sensor rotors each have magnetic poles and arc installed close to the wheel sensors. As the sensor rotor rotates, the Hall element in the Hall IC installed in the wheel sensor generates pulses. The pulse frequency, which is proportional to the magnetic flux density, is converted into a wave in the Hall IC so that it can be output. The ECU calculates the wheel rotations speed by detecting the pulse frequency.

Hydraulic unit assembly: The hydraulic unit assembly is composed of hydraulic control valves, buffer chambers, hydraulic pumps, an ABS motor, and ECU. Fig 4 shows a complete hydraulic unit assembly.





The hydraulic unit adjusts the front and rear wheel brake fluid pressure to control the wheel speed according to signals transmitted from the ECU. The pressure monitoring is accomplished with the help of hydraulic control valves.

The hydraulic control valve is composed of an inlet solenoid valve and outlet solenoid valve. The electromagnetic force generated in the inlet solenoid valve varies proportionally with the duty cycle control voltage that is supplied to it. since this voltage is continuously variable, the solenoid valve moves smoothly and the hydraulic pressure is adjusted linearly. When the brakes are operated normally (without ABS), the inlet solenoid valve is opened and the outlet solenoid valve is closed. The brake line between the brake master cylinder and brake caliper is open. When the ABS is activated, the inlet solenoid valve closes and the outlet solenoid valve opens using the power supplied from the ECU signals.

This reduces the hydraulic pressure in the line. When the ECU sends a signal to stop reducing the hydraulic pressure, the outlet solenoid valve closes and the brake fluid is pressurized again. The inlet solenoid valve controls the hydraulic pressure difference between the brake fluid in the upper brake lines (brake master cylinder side) and the brake fluid in the lower brake lines (brake caliper side).

Buffer chamber: The buffer chamber accumulates the brake fluid that is depressurized through the outlet solenoid valve while the ABS is operating. The accumulated fluid is circulated again through pump.

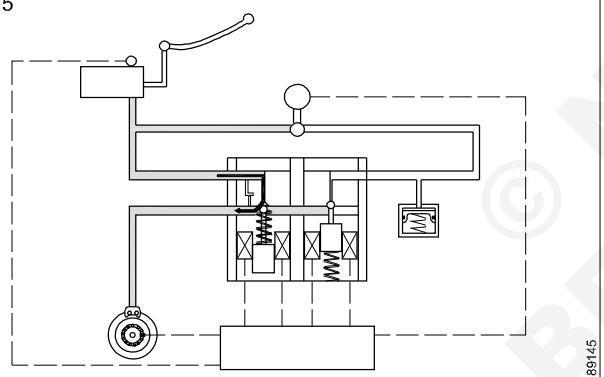
ECU: The ECU is integrated with the hydraulic unit to

achieve a compact and lightweight design. The ECU receives wheel sensor signals from the front and rear wheels and also receives signals from other monitor circuits. The necessary actions and confirmed using the monitor circuit and control signals are then transmitted to the hydraulic unit assembly.

ABS Operation: The ABS hydraulic circuit consists of two systems: the front wheel and rear wheel. The following describes the system for the front wheel only. Similar actions are simultaneously performed for the rear wheel also.

Normal braking (without abs): When the ABS is not activated, the inlet solenoid valve is open and the outlet solenoid valve is closed because a control signal has not been transmitted from the ECU. Therefore, when the brake lever is squeezed, the hydraulic pressure in the brake master cylinder increases and the brake fluid is sent to the brake caliper. At this time, the inlet and outlet check valves of the hydraulic pump are closed. As a result of eliminating the orifice, the brake master cylinder directly pressurizes the brake caliper during normal braking. When the brake lever is released, the braked fluid in the brake caliper returns to the brake master cylinder. Fig 5 shows the normal braking condition on hydraulic circuit.

Fig 5

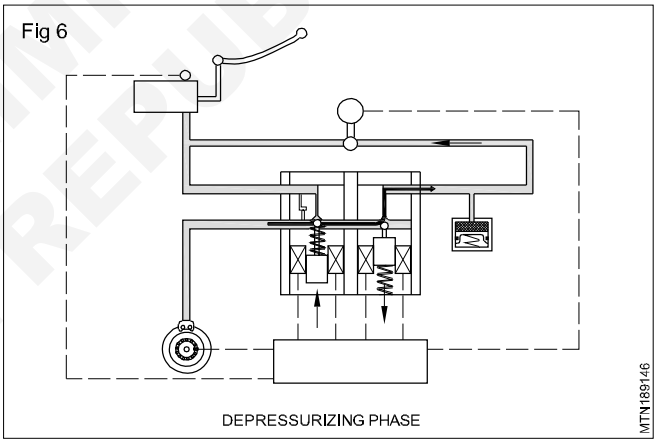


Emergency braking (with abs): When the front wheel is about to lock, the when this occurs, the inlet solenoid valve compresses the spring and closes the brake line from the brake master cylinder. Because the outlet solenoid valve is open, the brake fluid is sent of the buffer chamber. As a result, the hydraulic pressure in the brake caliper is reduced. The brake fluid stored in the buffer chamber is pumped back to the brake master cylinder by the hydraulic pump linked to the ABS motor. This phase is known as depressurizing phase and shown in Fig 6.

The outlet solenoid valve is closed by the “pressurization” signal transmitted from the ECU. At this time, the ECU controls the opening of the inlet solenoid valve. As the inlet solenoid valve open, the brake line from the brake master cylinder opens, allowing the brake fluid to be sent to the brake caliper. This phase is known as pressurizing phase.

These two phase take place approximately 15 times in a second, wheel under braking is clamped and released by the caliper 15 times in a second. This high frequency braking action allows easy control of vehicle even during turns. The braking force is appropriately distributed and exerted on the wheels which results as safe and straight-line braking on a wet surface also. Therefore, the ABS features a compact and lightweight design to help maintain the basic maneuverability of the vehicle. Modern ABS also includes a highly developed self-diagnosis function. The ABS detects any problem condition and allows normal braking even if the ABS is not operating property.

Fig 6



Maintenance of ABS Brake Systems

The following table should only act as a guide; the manufacturer's recommendations should always be followed

Interval	Attention required	Note
Every 2000 km (About 1000 miles) or 1 month intervals	Check fluid level and top up if necessary	If frequent topping up is necessary, system should be examined for leaks
Every 10000 km (About 5000 miles)	Check friction pads and linings. Adjust brakes which are adjustable types	Linings and pads should be free from oil and grease. Replace when thickness of: 1. pads approaches 2 mm 2. lining is less than one third of original thickness
Every 15000 km (About 10 000 miles)	Check system for leaks and rubber hoses for weakness	Defective parts should be renewed
Every 40000 km (About 24000 miles) or 18 month intervals	Change fluid	Brake fluid absorbs water from the atmosphere: this lowers the boiling point of the fluid
Every 60000 km (About 40000 miles) or 3 year intervals	Renew operating components	All rubber parts should be replaced

Clutch

Objectives: At the end of this lesson you shall be able to
- **state the need for a clutch in a vehicle**
- **list out different types of clutch**
- **state the function of the clutch**
- **state the various types of clutch actuation systems.**

Need for a clutch

While shifting gears, the speed of the sliding sleeve and the respective gear on the main shaft should be synchronized to avoid gear collision noise. This is achieved by disconnecting the transmission of power from the engine flywheel to the gearbox shaft with the help of the clutch. The clutch is used to connect and disconnect transmission of power from the engine flywheel to the gearbox drive shaft.

Different types of clutches: They are:

- Cone clutch
- Dog clutch
- Single plate clutch with coil spring
- Diaphragm clutch
- Multi-plate dry and wet clutches
- Semi-centrifugal clutch
- Fully centrifugal clutch
- Fluid coupling.

Function of the clutch

The clutch should connect and disconnect the power from the engine to transmission smoothly and gradually without affecting the other components.

It should damp vibrations and shocks during operation.

It should not slip under high torque transmission.

Torque transmission by clutch depends upon the:

- Size of the clutch plate
- Co-efficient of friction
- Spring pressure, and
- Number of clutch plates used.

Types of clutch actuation

Type	Features	Advantages
Mechanical Actuation	Pedal effort is transmitted by linkage to withdrawal bearing	Less maintenance and easy to repair.
Hydraulic Actuation	Pedal effort is transmitted through fluid to withdrawal bearing	Less pedal effort to engage and disengage the clutch.

Drive train of a three wheeler

Objectives: At the end of this lesson you shall be able to
- **define drive train**
- **state the main function of the engine**
- **state the function of the clutch**
- **list out the types of clutches.**

Drive Train: All the moving components of 2 & 3 wheelers such as the engine, clutch, transmission (Gear box) drive shaft, differential, axles and wheels is known as drive train.

1 Three wheeler transport vehicles also known as auto rickshaws.

2 Commonly used for public transportation urban areas in many countries.

3 There are characterized by a sheet metal body or open frame resting on three wheels.

4 There are covered with canvas roof with drop down sides, and a small cabin in the front of the vehicle for the driver.

5 Never models fitted with CNG - fueled zoocc four stroke engine.

6 Public transportation auto rickshaws fitted with rear engine. And goods transport auto rickshaws fitted with front engine.

Main parts of a clutch: Main parts of a clutch divided into three groups;

1 Driving member

1 The driving member consist of a fly wheel mounted on the engine crank shaft.

2 The fly wheel is bolted to the cover which carrier a pressure plate or driving disc, pressure springs and releasing levers.

3 Entire assembly of the fly wheel and the cover rotate all the times.

2 Driven member

1 The driven member is the clutch plate.

2 It is free to slide on the splines of the clutch shaft.

3 It carrier friction material both surfaces.

4 It is gripped between the flywheel and the pressure plate and rotates the clutch shaft through splines.

3 Operating member

1 Operating members consists of a fort pedal, linkage release or throw-out bearings, and release levers.

2 Springs necessary to ensure the proper operation of the clutch.

Types of clutches

1 The clutches used in motor vehicle are almost very similar in construction and operation.

2 The dry plate clutch operates dry- without using oil.

3 The wet plate clutch operates in a bath of oil.

4 The clutch is operated dry it is called dry clutch. Different types of clutches are as follows.

1 Friction clutch

a Single plate clutch

b Multiplate clutch

i Wet

ii Dry

c Centrifugal clutch

d Semi centrifugal clutch

a Single plate clutch

1 It consists of only one clutch plate (4) mounted on the splines of the clutch shaft (7)

2 The pressure plate (5) is bolted to the flywheel (1) through clutch springs (2) and is free to slide on the clutch shaft when pedal is operated.

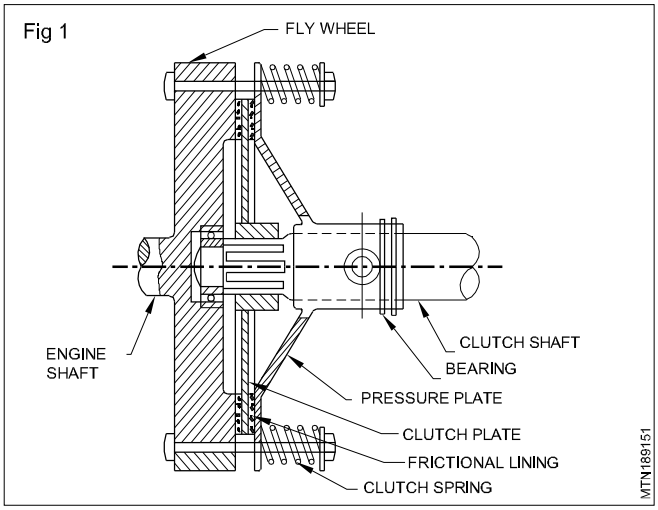
3 the clutch plate is gripped between the fly wheel and the pressure plate.

4 Due to friction (3) the clutch plate revolves with the flywheel.

5 thus engine power is transmitted to the crank shaft to the clutch shaft.

6 When the clutch pedal is pressed pressure plate moves back against the force of the springs and the power does not transmitted to the gear box.

Fig 1



Multiplate clutch (Fig 2)

The multiplate clutch mainly used on two wheelers because of less space availability two wheelers engine run at high speed and can develop huge amount of power and torque. The multiplate clutch helps to transmit this power and torque. The multiplate clutch helps to transmit this power and torque to the gear box with nearly 98% efficiently more than one set of plates generate sufficient friction without increasing considerable heat dissipation. (Fig 2,3&4) shows the construction details of two wheeler multiplate clutch.

To transmit more torque, instead of using a bigger flywheel and clutch plate, two or three small clutch discs are used to increase the frictional area. The pressure plates (2) and clutch plates (1) are alternatively arranged on the clutch shaft (3) and compressed by a number of pressure springs (4). This type works in the same way as a single plate clutch does.

These clutches may be dry or wet. When the clutch is operated dry it is called a dry clutch, but where the oil is used in the clutch it is called a wet clutch.

The wet clutches are generally used along with or as a part of automatic transmission.

Fig 3

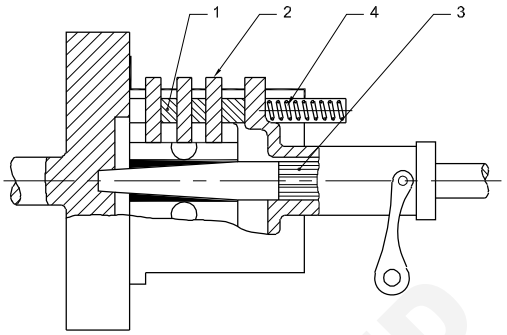
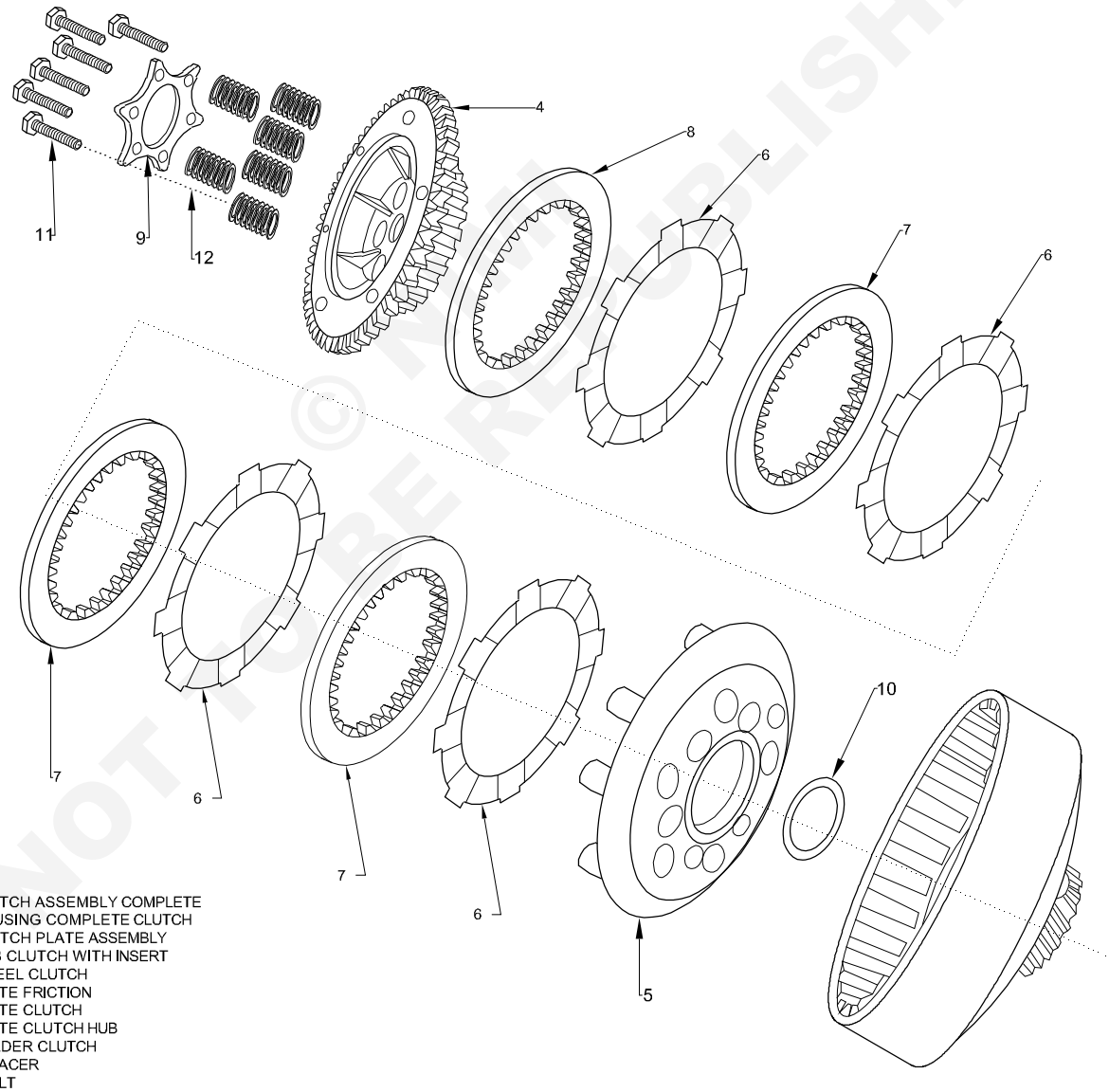


Fig 2



1. CLUTCH ASSEMBLY COMPLETE
2. HOUSING COMPLETE CLUTCH
3. CLUTCH PLATE ASSEMBLY
4. HUB CLUTCH WITH INSERT
5. WHEEL CLUTCH
6. PLATE FRICTION
7. PLATE CLUTCH
8. PLATE CLUTCH HUB
9. HOLDER CLUTCH
10. SPACER
11. BOLT
12. SPRING

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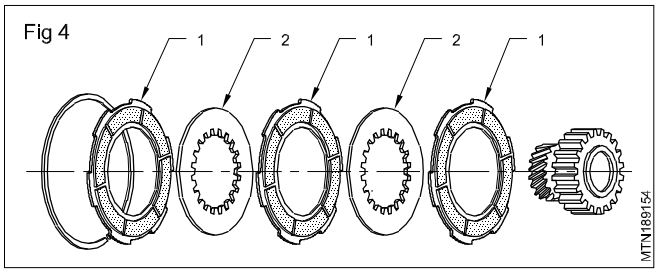
CLUTCH EXPLODED VIEW



These types of clutches are mostly used in scooters, motorcycles, heavy commercial vehicles, earth moving machines, race cars etc,.

Transmission system

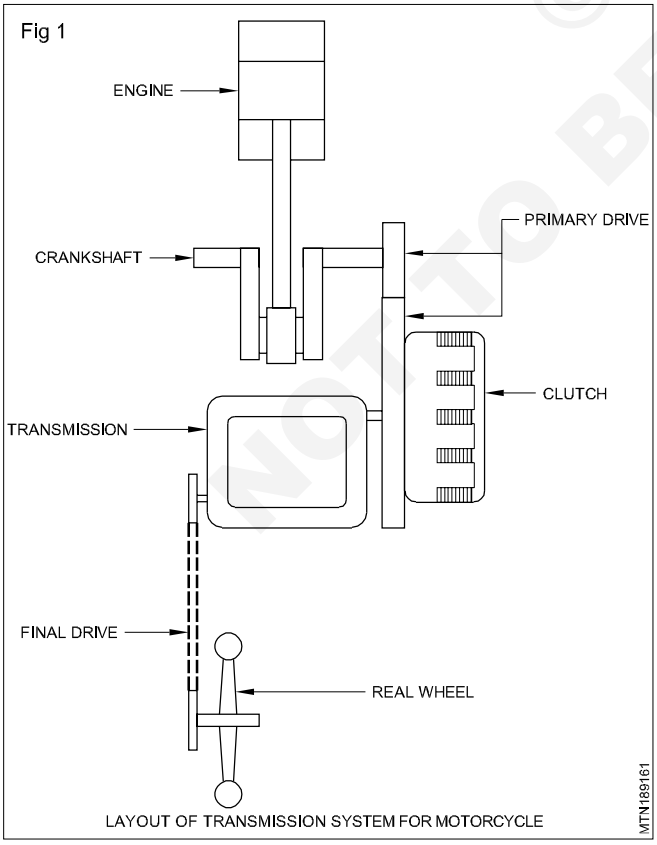
Objectives: At the end of this lesson you shall be able to

- **state the various types of primary drive is used in two wheelers.**

Transmission system of two wheelers (Fig 1): The transmission power train of any two wheeler fundamentally includes primary drive, clutch, transmission and final drive. Fig 1 shows layout of transmission system used in motorcycles. The engine crankshaft is connected to the clutch through primary drive.

Primary drive helps in initial speed reduction. Various types of primary drive is used in two wheelers which includes belt drive, chain drive or gear drive. Clutch is used to disconnect the engine from the rear driving wheel as and when required, two wheelers the multiplane clutch or centrifugal clutch.

The transmission, also known as gearbox, encloses set of four or five gear pairs to provide correct torque ratio as per the requirements. Basically, two wheeler can be equipped with either manual transmission or CVT. Generally, CVT is used in modern scooters. The final drive transmits the output torque and power from the gearbox to rear driving wheel.



Belt drive, chain drive, shaft drive or gear drive is used as a final drive to transmit the torque and power. Fig 2 shows layout for scooters with manual transmission. The power to the primary drive is transmitted through clutch. Therefore, primary drive is also disconnected from the engine whenever the clutch is disengaged. All scooters with manual transmission use content mesh gearbox.

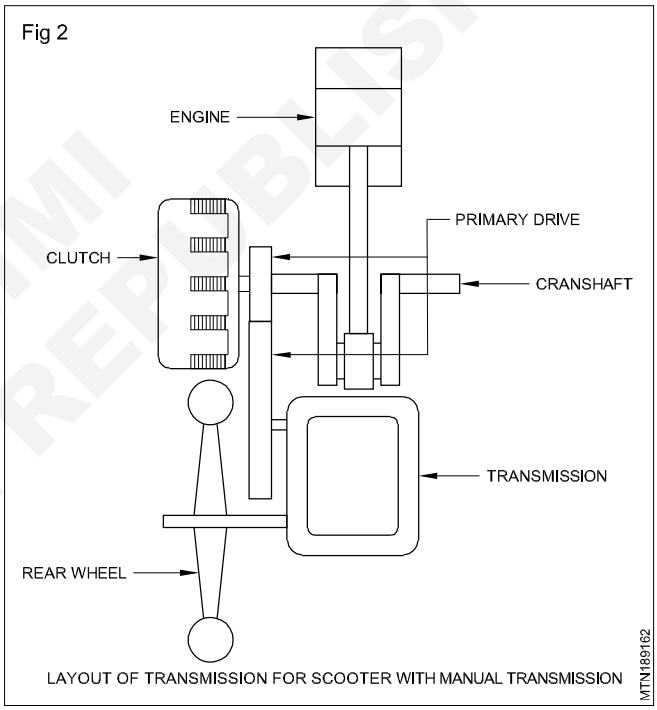


Fig 3 shows transmission layout for scooter with CVT. The crankshaft is connected to the driving pulley of DVT. The flexible metallic belt transmits the power to the driven pulley.

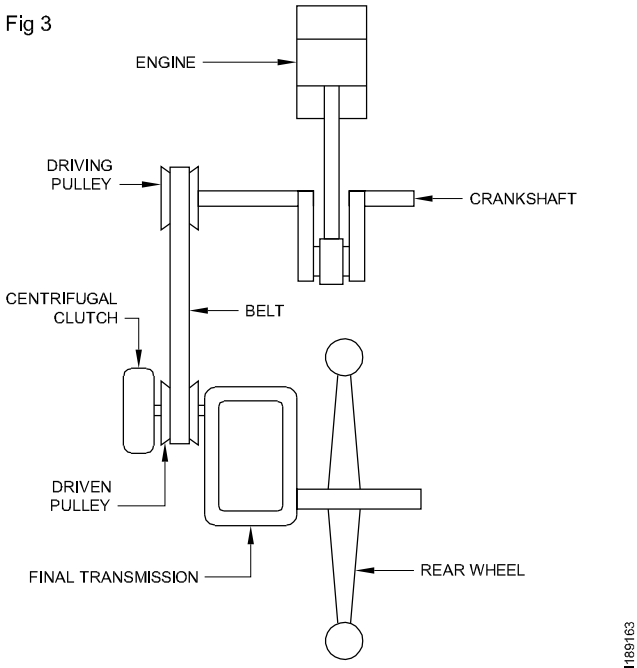
Different torque ratio are achieved through varying diameters of both pulleys. The diameter of pulley is varied with the speed of engine crankshaft. The centrifugal clutch engages the CVT with final transmission due to centrifugal action. Two speed automatic gearbox is used as a final drive to transmit required power and torque to the rear driving wheel.

Primary reduction

Two-wheeler engines are small, compact and have to revolve the crankshaft much faster to produce sufficient power. Two-wheeler engines can work up to the speed

15000 RPM. Speed reduction is provided between engine and clutch in the form chain drive or belt drive or gear pair. The reduction ratio is kept 3:1.

Fig 3

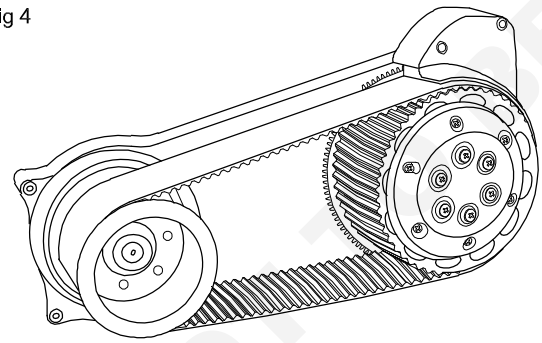


LAYOUT OF TRANSMISSION FOR SCOOTER WITH CVT

Belt Drive (Fig 4)

Belt drive system includes driving pulley, timing belt and driven pulley for power transmission. Timing belts have teeth on the contact side of the belt. These teeth match with the grooves provided on the driver and driven pulleys. Driver pulley is attached on crankshaft while driven pulley is mounted on clutch housing. Timing belts provide positive drive and can transmit high power.

Fig 4

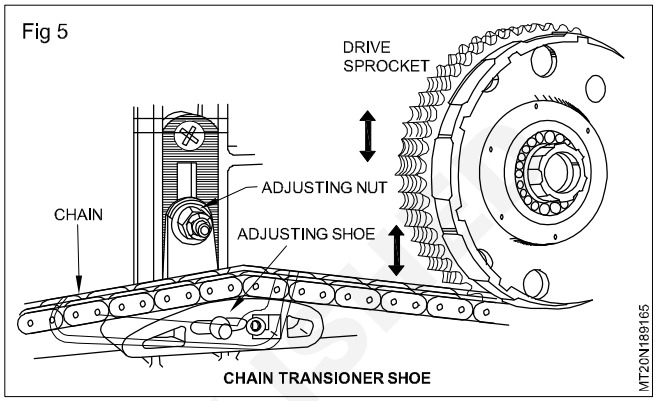


BELT DRIVE AS PRIMARY REDUCTION

In belt drive reduction system, the clutch turn in the same direction as engine crankshaft. The belt drive does not require any lubrication and adjustment but the life of belt drive is very less. It requires frequent replacement due to wear of teeth or tearing of belt.

Chain drive (Fig 5): Chain drive is used as an alternative to belt drive for primary reduction. The components of chain drive include driving sprocket, the chain, driven sprocket and chain tensioner. The drive sprocket is splined to the crankshaft and can accommodate single, dual or even triple roller chain.

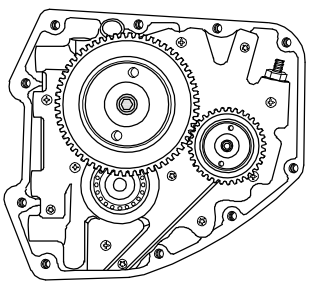
Fig 5



CHAIN TRANSIONER SHOE

Gear drive (Fig 6): Two wheelers, the primary drive is used the set of two gears. A small driver gear is splined to the engine crankshaft and larger driven gear is an integrated part of the cloth housing. The difference in size allows necessary speed reduction and allows crankshaft to rotate three times faster than the clutch. The clutch housing is removed from the larger driven gear.

Fig 6



GEAR PAIR AS PRIMARY REDUCTION

There are two types of gears used as primary gears: spur gears and helical gears. The spur gears are strong, efficient and cheap while helical gears are silent in operation but costly. The gear pair as a primary drive rotates the clutch in opposite direction to the direction of engine crankshaft.

Comparison of Various Primary Drive

	Belt Drive	Chain Drive	Gear Drive
1.Construction	Requires three components 1. Driver pulley 2. Belt 3. Driven pulley	Requires four components 1. Driver pulley 2. Belt 3. Driven pulley 4. Chain tensioner	Requires only two components 1. Driver gear 2. Driven gear 3. Bushes
2. Efficiency	98%	100%	100%
3. Life	Short	Long	Perpetual
4. Manufacturing cost	High	Low	Very low
5. Maintenance	Difficult	Moderate	Easy
6. Lubrication	Not required	Frequently required	Required
7. Replacement	Needs frequent replacement	Need frequent adjustment	Practically no replacement needed

Gearbox

Objectives: At the end of this lesson you shall be able to
- **state the need for a gearbox**
- **state the various resistances in vehicle motion**
- **calculate gear ratios**
- **state the different types of gearboxes**
- **describe the various components and their functions in a sliding mesh gearbox**
- **describe the construction of the gear box need in the motor cycle**
- **draw the power flow sketch in various gears and state the different types of gears.**

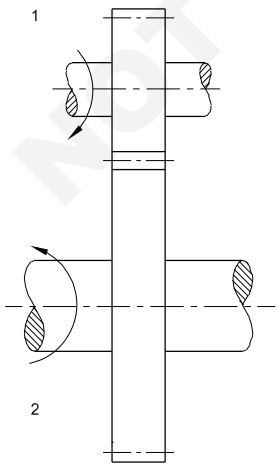
Gearbox

A gearbox is used to get different torques and speeds which are required to overcome the following resistances.

- Road resistance
- Air resistance
- Gradient resistance
- Load on vehicle

By engaging different gears, engine torque is increased while speed is decreased. In the top gear the r.p.m. and torque of the engine and gearbox remain the same.

Fig 1



When a small gear (1) drives the bigger gear (2) the r.p.m. of the bigger gear (2) is reduced in proportion of the gear tooth. For example: Gear (1) is having 10 teeth and gear (2) is having 20 teeth. Assuming gear (1) rotates at 50 r.p.m.

$$\text{Gear ratio} = \frac{T_1}{T_2} = \frac{10}{20} = \frac{1}{2} = 1:2$$

linear velocity 'V' remains the same for both the gears.

So, $T_1 \times N_1 = T_2 \times N_2$

$$N_2 = \frac{T_1 \times N_1}{T_1} = \frac{10 \times 50}{20} = 25$$

Here the r.p.m. of gear (2) is half of gear (1). So torque will be double.

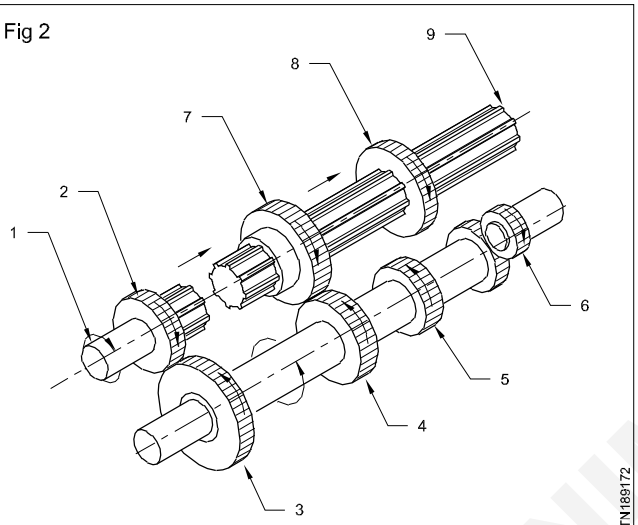
It means in higher gear the torque is less and in lower gear the torque is more.

Different sets of gears are used in the gearbox to achieve different speeds and torques.

Power train

The drive shaft (1) along with the gear (2) is always rotating at the engine r.p.m. The shaft (1) drives the countershaft gear (3), (4), (5) & (6) which are fixed on the countershaft. The gears (7) & (8) on the main shaft (9) get power from the countershaft's respective gear, when engaged. To get the desired r.p.m or the torque the respective gear on the main shaft (7) or (8) is engaged with the countershaft gears. The gears (7) and (8) are splined on the main shaft and when these gears are engaged with the countershaft gears, power is transmitted to the main shaft (9). To get the reverse speed the idler gear (6) is used in between the main shaft and the countershaft gears.

Fig 2



Variable automatic transmission

Gear Box

The motorcycle gear box contains a number of gears in different sizes. In the process of gear switching, different pairs of gearwheels lock together. A large and small wheel lock together in the lowest or slowest gear. Similar size wheels lock together in the highest or fastest gear.

The motorcycle gear box is the component that makes the actual ratio between the engine and the driving wheels. It is also referred to as transmission gear.

Types of Motor cycle Gear Box: In a general manner, the motorcycle gear box can be of three types, they are:

Horizontally Split: It has a seam on the horizontal plane.

Vertically Split: It has a seam on the vertical plane.

Cassette Type: The gears are loaded in from one side.

Characteristics of Gear Box: The gears are constantly meshed with one another and they are always spinning.

Uses of Gear Box

- It controls gear and shaft alignment.
- It controls the engine RPM.
- It protects the gears and lubricants from water, dust and other environmental contaminants.

Construction of the gear box

The gears are used in the motor cycle gear box is spun gear but all gears are constant meshing in neutral position. In the gear box two shafts are there one is main shaft and another one is counter shafts (2) are supported by bearings at its both ends.

In this gear box the gears M1, M2, M3 and M4 are an the main shaft (1) are in mesh with the corresponding gears C1, C2, C3 and C4 on the counter shafts (2). But power is not transmitted.

Main shaft gears

- M1 - Internally splined gear
- M2 - Floating gear with dog clutch
- M3 - Internally splined gears with dog clutch for engage with gears M2 and M4
- M4 - Floating gears

Counter shaft gears

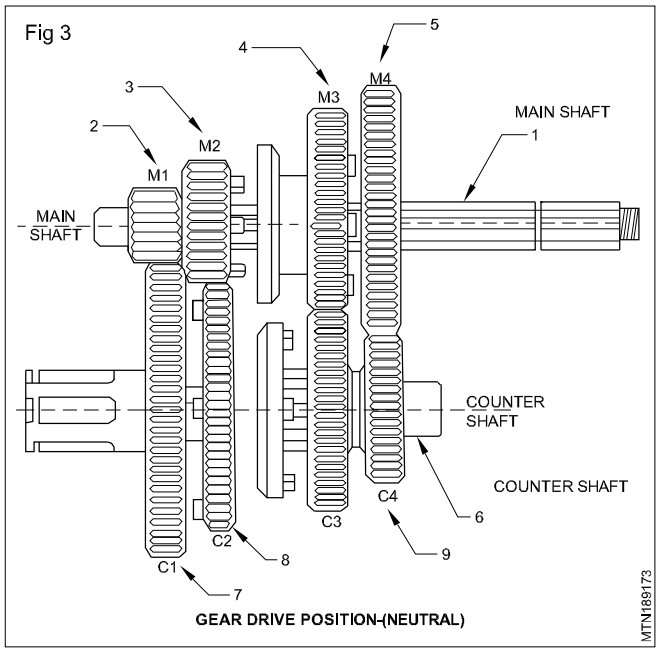
- C1 - Floating gear
- C2 - Internally splined gear with dog clutch able to engage with gears C1 and C3
- C3 - Floating gear
- C4 - Internally splined gear
- Working of gear box

Fig shows the 4 speed gear box.

Neutral position Fig 3

In neutral position all the gears on main shaft meshing with respective gears on counter shaft gears. But the power not transmitted from main shaft to counter shaft. Because of floating gears M2 and M4 on main shaft and floating gears C1 and C3 and counter shaft neither not transmitting and not receiving the rotating action.

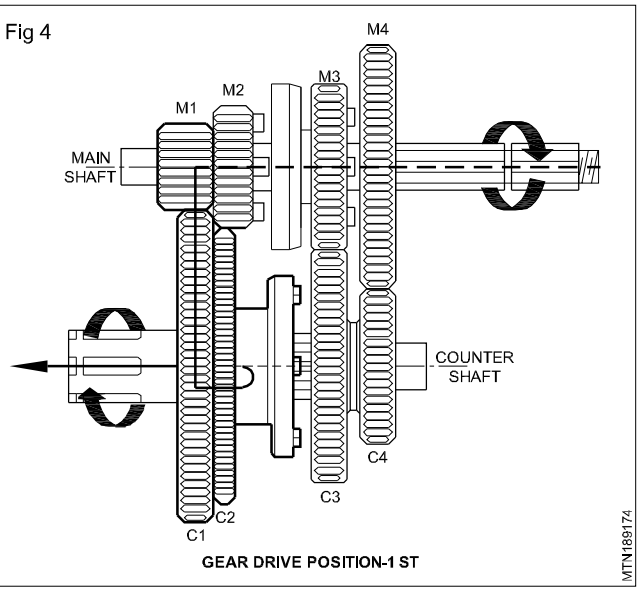
Fig 3



First gear position (Fig 4)

When selecting the first gear the C2 dog clutch gear engage with the gear C1. Engine power through clutch transmit to main shaft. The power is transmitted from main shaft to M1 gear - to - C1 and C2 gears to counter shaft delivering the high torque as output from gear box.

Fig 4

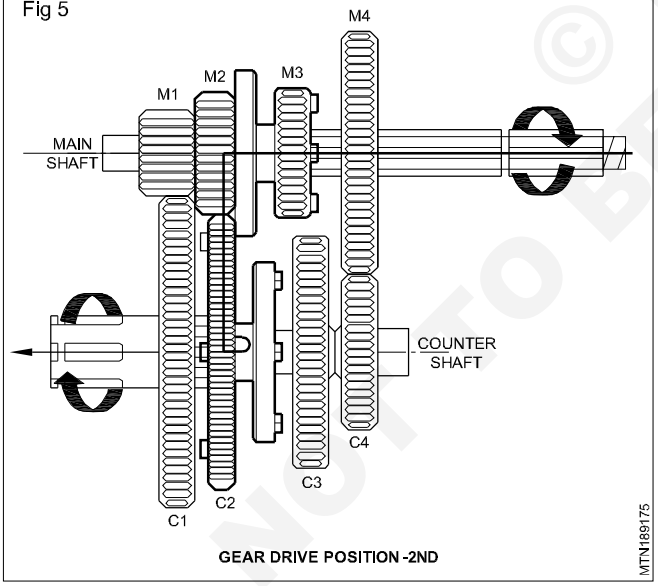


GEAR DRIVE POSITION-1 ST

Second gear position (Fig 5)

In this position Cn gear relieved from gear C1 an counter shaft out the same time m^3 gear slide out engage with gear m^2 or main shaft. So the power is transmitted from main shaft to m^3 gear to m2 gear to c2 gear to lay shaft.

Fig 5

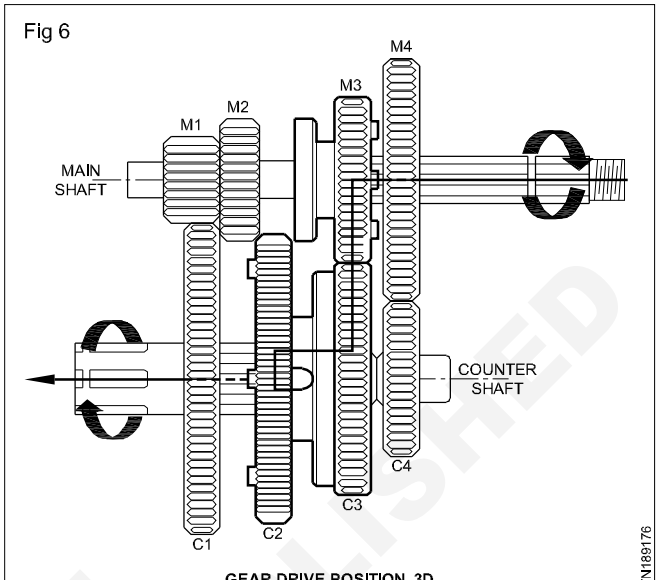


GEAR DRIVE POSITION -2ND

Third gear drive position (Fig 6)

When selecting the 3rd gear M3 gear moved from gear M2 to original position on main shaft at the same time the gear C2 slide and engage with gear on C3 on lay shaft. The power is transmitted from main shaft to M3 gear to C3 gear to C2 dog clutch to counter shaft.

Fig 6

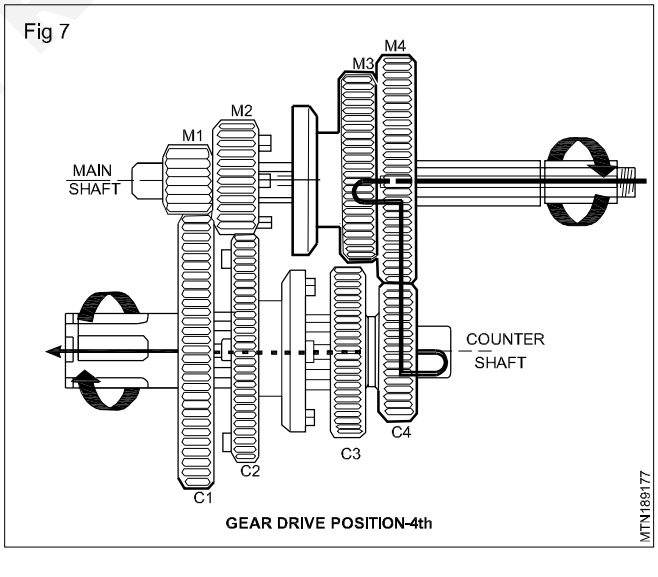


GEAR DRIVE POSITION -3D

Fourth gear drive position (Fig 7)

When selecting the fourth gear M3 gear slide and engage with gear M4 on main shaft at the same time dog clutch gear C3 moved to its original position. The power flow from main shaft to M3 dog clutch gear to M4 gear to C4 gear to counter shaft.

Fig 7



GEAR DRIVE POSITION-4th

Gear shift mechanism

Objectives: At the end of this lesson you shall be able to
- **state the parts of gear shift mechanism**
- **explain working of gear shift mechanism.**

Main parts of gear shift mechanism: This mechanism consists of

1 Gear shift pedal

2 Gear shift shaft or spindle

3 Gear shift lever (as) linkage

4 Gear selector drum/cam

5 Stop plate with spring assembly

6 Gear selector fork with shaft

Gear Shift Mechanism

Fig 1 : Gear Pedal - Gear selecting position

Fig 2 :

1 Gear lever

2 Gear shift shaft assembly

3 Gear shift shaft return spring

Fig 3

1 Gear selector fork

2 Gear shifter fork shaft

Fig 4

1 Gear selector drum

2 Stopper plate

Fig 5

1 Main shaft

2 Counter shaft

3 Dog clutch gear moving direction (on main shaft)

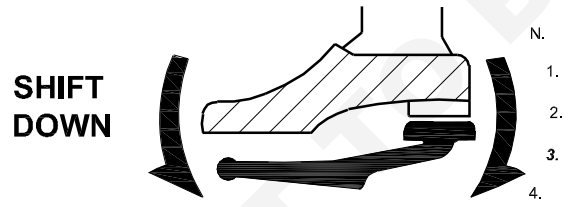
4 Dog clutch gear moving direction on counter shaft

Gear shifting mechanism

Four speed transmissions transmits engine power to the rear wheel.

Rider shifts gear using left foot operated gear pedal lever. Gear shifting pattern is N-1-2-3-4. The engine speed is transferred from crankshaft to the main shaft through primary gear & clutch outer gears.

Fig 1



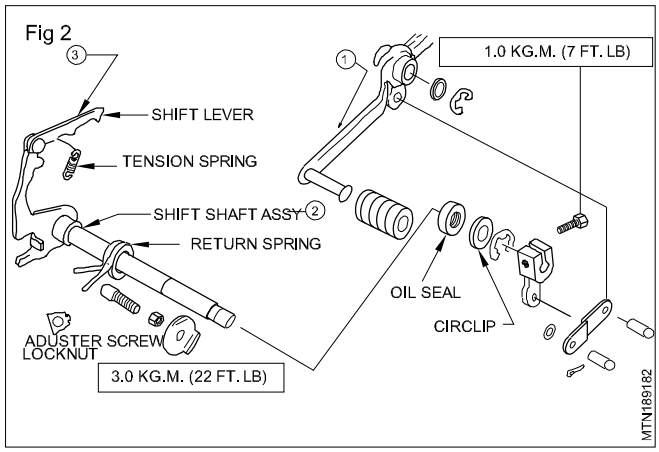
The gears fitted on the main and counter shaft can be divided into three types based on the method of fixation on to the shaft.

Sliding gears	Slide along the shaft axis
Fixed gears	Fixed on spline grooves on the shaft
Idling gears	Freely rotate on the shaft

Using combination of these gears, gear box allows gear shifting.

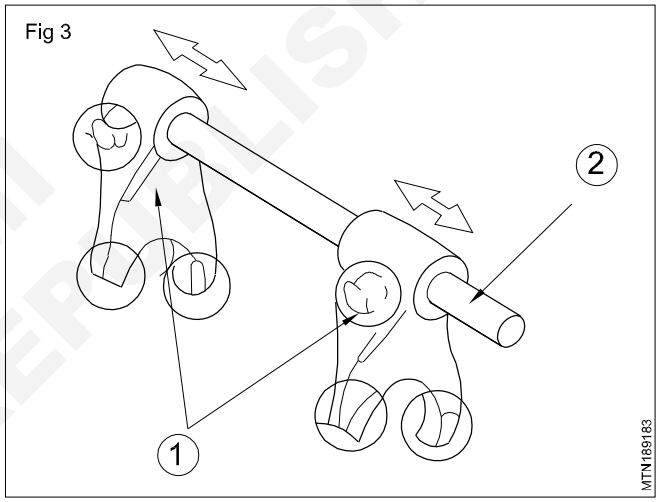
When the clutch is in engaged position, speed is transferred to the main shaft.

Fig 2



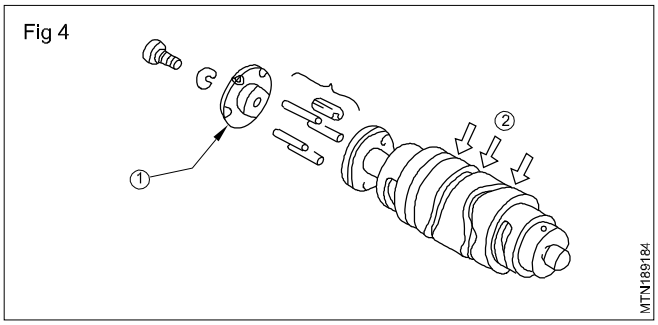
Gear pedal is mounted on gear shift spindle or through gear shift linkage. Up/down motion of the shift pedal turns the shift spindle. This turns drum stopper plate, which rotates the gear shift drum. The shifter forks are guided by grooves on the shifter drum and slide on the shifter forks shaft

Fig 3



this moves the sliding gears of the transmission which enables the rider to engage and disengages main shaft gears with the counter shaft gears, varying the torque and speed output from the counter shaft.

Fig 4

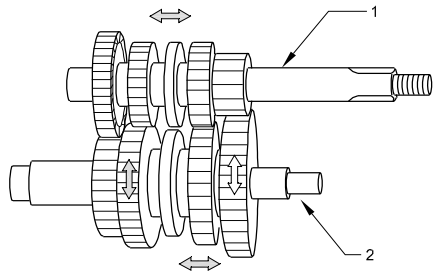


The engine power is transmitted from the countershaft to the rear wheel through the countershaft drive sprocket, drive chain and rear wheel driven sprocket.

The number of gear teeth and gear ratio of all four constant mesh gears are :

Gear	Main shaft (M)	Counter shaft (C)	Ratio
1st	13	36	2.769
2nd	20	30	1.500
3rd	21	23	1.095
4th	23	21	0.913

Fig 5



Final drive

Objective: At the end of this lesson you shall be able to
- **state the purpose of final drive**
- **state the various types of final drive**
- **state the function and operation of final drive.**

Purpose of final drive

1 Final drive is used to transmit the engine power from gear box to near wheel.

2 It is used to permanent speed reduction.

3 It is used to increase the torque.

Types of final drive

1 Gear reduction

2 Chain and sprocket drive

Chain and sprocket drive system: Main parts of this final drive consists of;

1 Driving sprocket 2 Drive chain

3 Rear wheel sprocket

Small driving sprocket (1) is fitted on the gear box output side of counter shaft - the bigger size sprocket is fitted with rear wheel hub. An endless chain fitted with the both drive and driven sprockets to connect and transmit the power from gear box to rear wheel. The drive chain of both end connected by a master link (4).

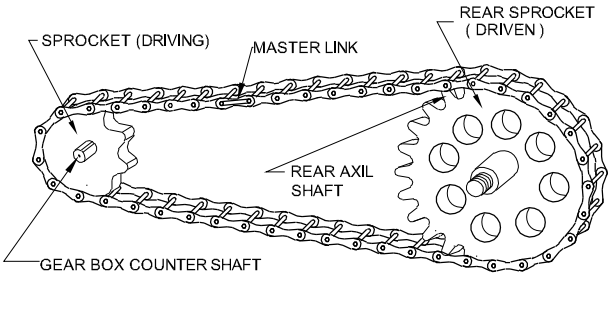
The reciprocating movement of piston is transmitted to the wheel with the help of flywheel, clutch, gear box and drive chain sprockets. In order to get the final rpm of the wheel, we have to taken into account the primary reduction, the gear box reduction, and the final reduction. It is not possible to change the primary are gear box reduction but it is very easy to change the final reduction. This is done by changing both the driving and rear sprocket of final drive or any one of them.

If you live in a hilly terrain and you want to improve the two wheeler's climbing power, all have to do is to use a bigger diameter rear sprocket as a small diameter driving sprocket or both.

On the other hand, if most of your driving is done on level roads, you can increase the top speed and mileage, by changing the rear sprocket with a smaller diameter sprocket, or driving sprocket with a layer one, or both which has the same pitch.

Lubricating the chain is vital for smooth running of bike - maintaining a proper chain tension is very important. Improper adjustment makes the chain sprockets wear fasten and will adversely effect performance of bite.

Fig 1



Trouble shooting in transmission system

Trouble	Causes	Remedies
Clutch slip	- Friction plate worn out	Replace
	- Less clutch play	Adjust
	- Friction plate warped	Replace
	- Pressure plate damaged	Replace
	- Clutch spring tension weak	Replace
	- Clutch holder bend	Replace
	- Clutch mounting bolt thread wornout	Replace
	- Friction plate inner teeth wornout	Replace
Clutch does not disengage	- More clutch play	Adjust
	- Clutch cable defective	Replace
	- Clutch linkage jammed	Rectify
	- Clutch spring uneven	Rectify
	- Clutch plate warped	Replace
	- Clutch release mechanism improper adjustment	Adjust
Motor cycle craps with clutch disengaged	- Clutch linkages improper lubricated	Lubricate
	- Clutch plate warped	Replace
	- Clutch cable defective	Replace
	- Clutch lever damaged	Replace
Excessive clutch lever pressure	- Incorrect clutch adjustment	Adjust
	- Improper clutch linkage lubrication	Lubricate
	- No oil engine	Refill the oil
Clutch operation feels rough	- Clutch plate warped	Replace
	- Clutch linkage mounting loose fitting	Rectify
	- Clutch lever mounting pin hole damaged	Replace
Gear shift hard	- Gear shift lever damaged	Replace
	- No oil in gear box	Refill the oil
	- Gear teeth wornout	Replace
	- Gear shift return spring weak	Replace
	- Excessive clutch play	Adjust
	- Clutch linkages improper adjustment & fitting	Rectify
Gear pedal does not return	- Gear shift return spring weak	Replace
	- Gear pedal damaged	Replace
	- Gear shift mechanism arm broken	Replace
	- Gear pedal splines worn out	Replace
Transmission jumps out of gears	- Gear shift fork work out	Replace
	- Gear groove worn out	Replace
	- Gear shift fork lock worn out	Replace
	- Neutral lock spring broken	Replace
	- Gear dogs and dog holes worn out	Replace
	- Gear shift drum groove worn out	Replace
	- Drive shift, output shaft splines worn out	Replace

Ignition system

Objectives: At the end of this lesson you shall be able to
- **classify the electrical system**
- **explain about ignition system**
- **state the types of ignition system**
- **describe about battery ignition system.**

Thermistor: A thermistor is a type of resistor whose resistance is strongly dependent on temperature, more so than in standard resistors. The word thermistor is a portmanteau of thermal and resistor. Thermistors are divided based on their conduction model.

Automobile electrical system: The automobile electrical system is classified under the main headings below;

1 Ignition system
2 Charging system
3 Starting system
4 Lighting system
5 Auxiliary system

Ignition system: The function of the ignition system is to provide a succession of high voltage sparks in order to ignite the petrol vapour and air mixture in the engine cylinder. This spark has to occur at the precise moment to ensure that the engine produces its maximum power at all speeds.

In two stroke engine a spark is required during each revolution of the engine, and in a four stroke engine a spark is required during every second revolution of the engine.

Requirement of ignition system

- It should provide a spark with sufficient strength
- It should not miss the correct timing to produce spark
- It should be light
- It should be compact and easy to maintain
- It should function efficiently over the entire range of engine speed.

There are mainly three types of ignition systems used on two wheelers. This includes magneto ignition system, battery ignition system and electronic ignition system.

Components of ignition system: There are mainly two circuits working together to produce spark at correct cylinder and at correct time. The first one is known as primary circuit and other is known as secondary circuit. Primary circuit contains ignition switch, battery, and primary resistor.

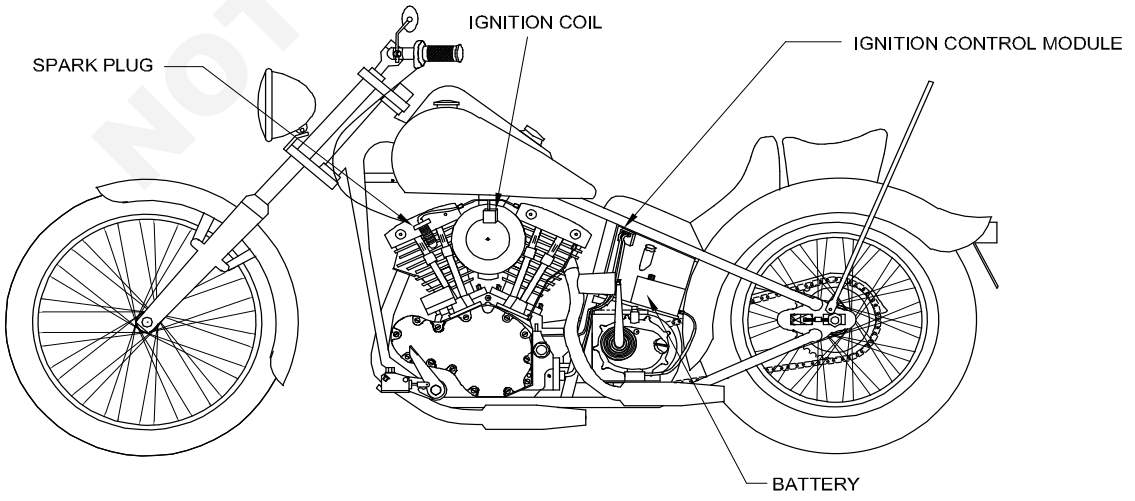
The secondary circuit contains spark plugs, distributor, contact breaker, capacitor and coil. Vehicle frame is used for grounding all circuits. Each component in ignition system plays vital role during operation as this system works at high speed. Fig 1 shows location of various components.

Type of Ignition system

1 Magneto ignition system
2 Battery ignition system
3 Electronic or CDI ignition system

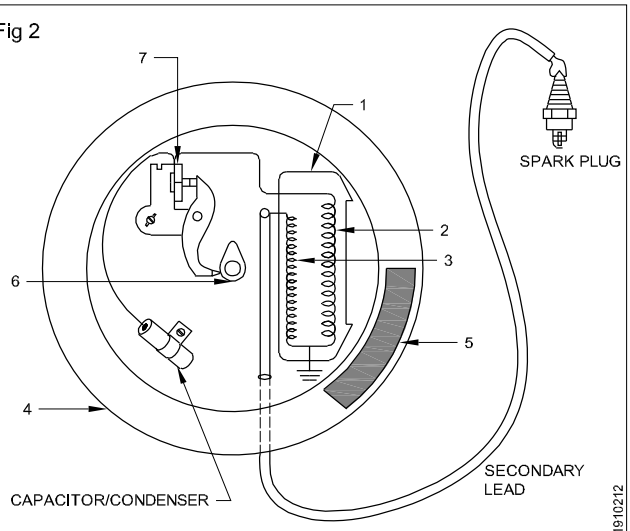
1 Magneto ignition system: This is also called fly-wheel magneto ignition system without battery. Most of the earlier model scooters, motor cycles and even the present day mopeds are fitted with a fly-wheel magneto (Fig 2) which functions very well on two-stroke engines without a battery and are able to generate a high voltage spark.

Fig 1



COMPONENTS OF IGNITION SYSTEM

Fig 2



MAGNETO IGNITION SYSTEM

The fly wheel magneto rotates around two or More coils (1) out of which one is always the ignition coil, which comprises of primary (2) and secondary (3) windings. The secondary winding has thousand of turns of very find insulated copper wire wound round a laminated soft iron core. Another thick wire called the primary winding is also insulated and is wound round the secondary winding. The primary winding has comparatively less turns when compared with the secondary.

When the fly-wheel (4) which has a number of permanent magnets (5) fixed on it's periphery, is made to rotate by cam (6) fixing to the crankshaft, an induced current starts flowing into the primary coil and a strong magnetic field is developed. To provide a spark once for every revolution of the crankshaft for a two stroke engine, a contact breaker (7) is used. It is a kind of switch which opens and closes by a cam mounted on the crank shaft.

The moment the turning cam opens the points, the current in the primary winding coil stops flowing, there by inducing a high voltage in the secondary coil and since the secondary coil is connected to the spark plug. This high voltage jumps at the spark plug gap and ignites the compressed air-fuel mixture. This cycle repeats itself over and over again.

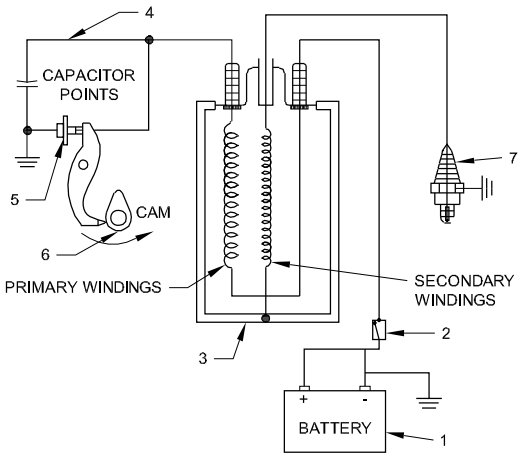
2 Battery ignition system: The battery ignition system is used in passenger cars, light trucks, and a few two wheelers. This system consists of the following parts.

- Battery (1)
- Ignition switch (2)
- Ignition coil (3)
- Distributor (4)
- Contact breaker (5)
- Spark plug (7).
- Cam (6)

Ignition switch: It is fitted on to the pannel board in between the battery and the ignition coil. It connects or disconnects the primary circuit from the battery (1).

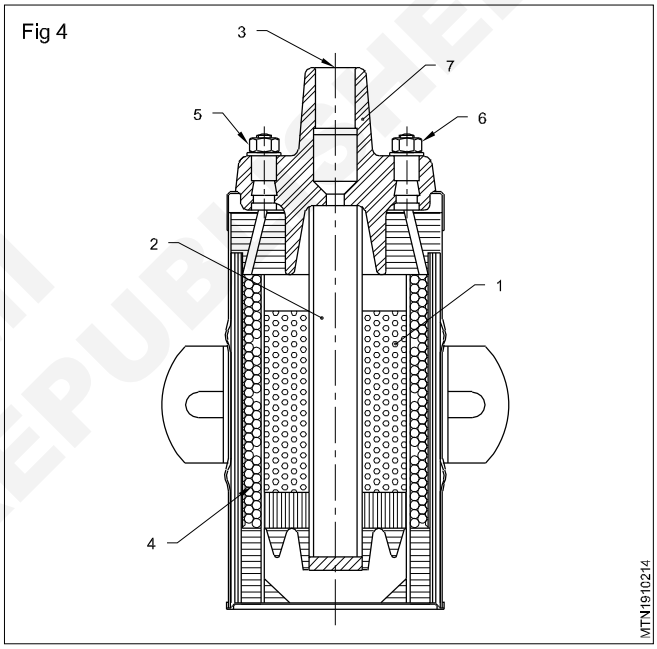
Ignition coil (Fig 4): It is used to step up low voltage to high voltage to generate sparks. It consists of two windings, one is wound over soft iron core. The secondary winding (1) is wound over the core (2). It consists of about 21,000 turns.

Fig 3



BATTERY IGNITION SYSTEM

Fig 4

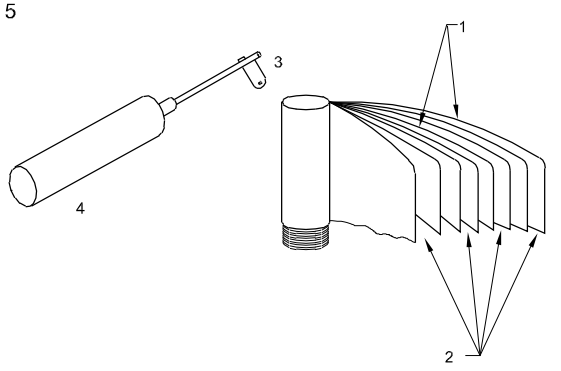


One end of the winding is connected to the secondary terminal (3) and the other end to the primary winding (4). The primary winding (4) is wound over the secondary winding (1) and consists of about 200 - 300 turns. The ends are connected to the external terminal (5,6) of coil. The bakelite cap (7) insulates the secondary terminal from the container and primary terminals.

Contact breaker: It connects and disconnects the primary circuit at regular intervals to produce high voltage in the secondary winding of the coil. The points are two in number, one is directly fitted to the base plate and the other is insulated and operated by the rotating cam.

Condenser (Fig 5): The condenser is fitted on the base plate of the distributor. It is connected in parallel to the contact breaker's points. The condenser absorbs current in the primary circuit which passes through the ignition points but which is suddenly stopped by their separator. It consists of aluminium or lead foil (1). Foils are insulated from each other. One end of the foil is connected to the condenser terminal (3) and the other end to the condenser case (4).

Fig 5



ASSEMBLED AND PARTLY UNWOUND CONDENSER

MTN1910215

The condenser prevents arcs at the points and helps the ignition coil to release its energy in the form of high voltage surge through the secondary winding.

Alternator

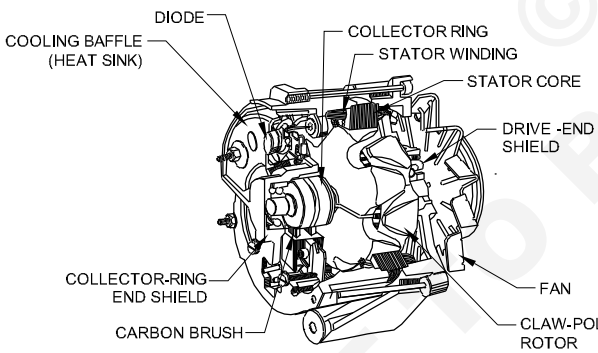
Objectives : At the end of this lesson you shall be able to

- **explain the purpose of an alternator**
- **describe the circuit of the alternator**
- **list out the different parts of the alternator**
- **explain the functions of the various parts of an alternator**
- **explain the working of an alternator.**

Purpose of alternator (Fig 1)

Right from the beginning, vehicles were fitted with dynamos for producing electricity. In present day vehicles the number of electrical accessories used has increased. Thus the demand for higher capacity generators has arisen. This can only be met by increasing the capacity of the generator and also by running it at higher speeds.

Fig 1



SECTIONAL VIEW OF BOSCH CLAW-POLE ALTERNATOR

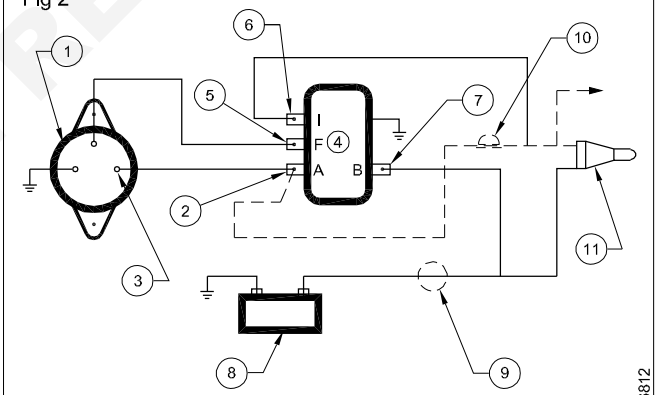
AEN186811

The vehicles in large cities have to often move at very slow speeds due to heavy tracffic. Normally a DC dynamo will not be able to charge the battery at such low speeds. The speed of the dynamo cannot be increased beyond a certain limit. Therefore, an alternator or AC generator is used. An alternator can produce more electricity at low r.p.m.

Alternator wiring circuit in a vehicle (Fig 2)

The alternator's (1) output terminal (3) is connected to the 'A' terminal (2) of the voltage regulator. The alternators (1) field terminal (5) is connected to the 'F' terminal of the voltage regulator (4). The 'B' terminal of the regulator is connected to the battery (8) via the ammeter (9). The battery's (8) connection is also connected to the 'A' terminal (2) of the regulator (4) via the ignition switch (11) and indication lamp (10). The terminal I (6) of the voltage regulator (4) is connected to the Ignition terminal (SW). Description of parts of an alternator.

Fig 2



ALTERNATOR WIRING CIRCUIT IN A VEHICLE

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Drive end frame (Fig 3): The drive end frame supports a pre-lubricated sealed bearing 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.

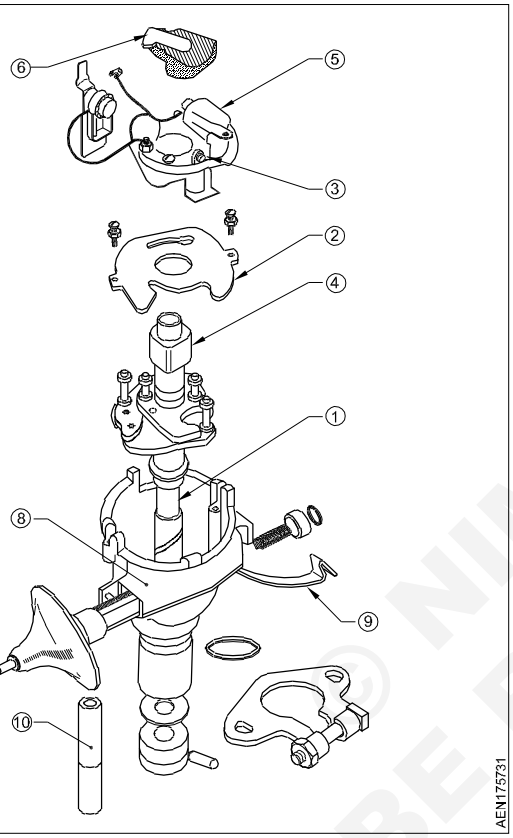
The rotor assembly (Fig 4): This consists of a steel shaft which carries the driving pulley and cooling fan, a cylindrical iron core, and two insulated slip rings. A large number of turns of insulated wire are wound over the core to from the field winding.

Distributor

Objectives: At the end of this lesson you shall be able to
- **state the need of a distributor**
- **state the constructional features of the distributor**
- **state the different types of advance mechanism**
- **state the function of the centrifugal advance mechanism**
- **state the function of the vacuum advance mechanism.**

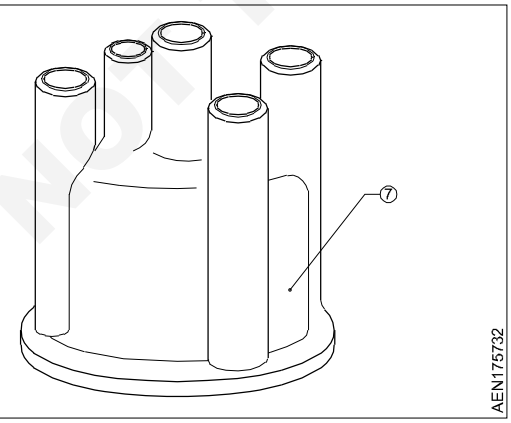
The distributor (Fig 1) is used to distribute the high voltage surges from the ignition coil to the individual spark plugs in a specified sequence and at the set time.

Fig 1



The distributor consists of a distributor shaft (1), advance mechanism, bushes, breaker plate (2) carrying C.B. points (3), cam (4) condenser (5) rotor (6) and distributor cap (7) (Fig 2).

Fig 2



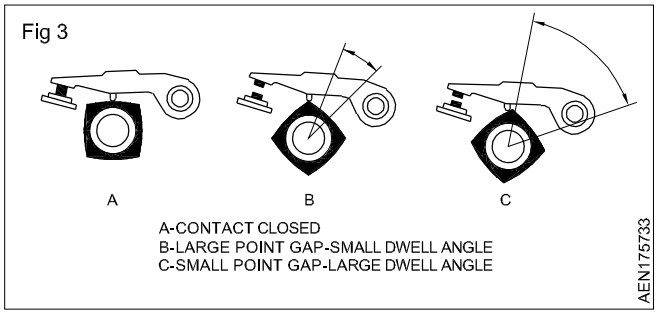
The bowl shaped distribution housing (8) closed from the top by a distributor cap (7) and clip (9) is made of high quality moulded insulating material (bakelite). The cap has segments terminal towers equal to the number of cylinders. These towers are connected by high tension leads with the spark plugs as per the firing order. The centre tower of the cap is connected with the H.T terminal of the ignition coil. A spring loaded carbon brush conducts the ignition surge to the electrode of the rotor (6). From the rotor arm (6) the H.T. current/ surge flows to the side segment of the distributor cap. (7), provided on its circumference.

The distributor housing has a cylindrical shaft supported by bush bearing (10). A shield made of a metal called 'breaker plate' (2) is fitted in between the distributor compartment and the contact breaker compartment. This shield also prevents dirt, carbon and moisture from entering into the distributor section.

A platinum contact and breaker points are provided in the distributor, which is operated by rotating the cam (4). When the point breaker's level rides on the rotating cam (4) it results in breaking the primary circuit of the ignition coil. During each rotation of the camshaft the contact breaker opens and closes an equal number of times, as the engine has cylinders. The points remain closed when the moveable point fiber block rests on the base circle dia. of the cam (4). It is called the dwell period is known as the dwell angle. During this period the ignition in the secondary winding of the coil drops is less.

The condenser or capacitor (5) is feed on the plate of the distributor. It is made of a number of aluminium and tin foils with a separator. The foils are rolled up in a solid roll. One end of the foil is attached to the terminal and the other to the body. It is connected to the moveable C.B point in parallel. (Fig 3) When the C.B. points close the condenser absorbs current and preserves it. When the C.B points open, the stored current is reversed to the ignition coil to impulse high tension surge in the secondary winding. The condenser also prevents arcing at the C.B. points.

Fig 3



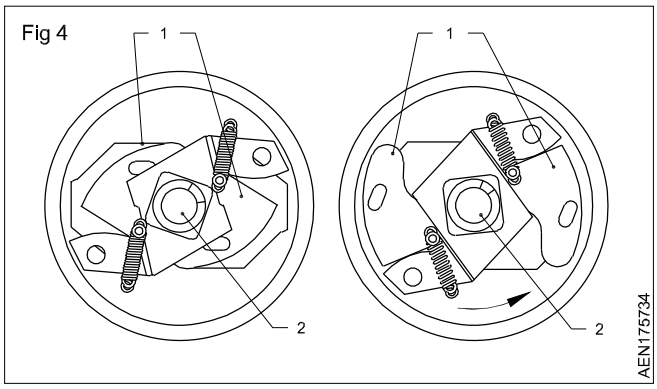
An advance mechanism is provided in the distribution to ensure that under every condition of engine operation, ignition take place at the set time. The advance angle is set in such a way that ignition occurs before the T.D.C of

the piston to have better fuel economy. There are two types of advance mechanism.

i Centrifugal advance mechanism

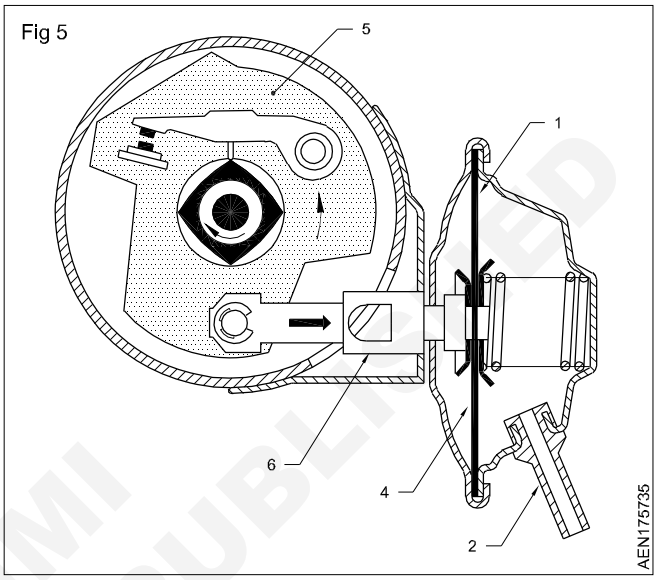
ii Vacuum advance mechanism

Centrifugal advance mechanism (Fig 4): The centrifugal advance mechanism consists of a pair of weighs (1) attached with the distributor shaft (2). As the speed of the shaft increases, the flyweights (1) swing outward and shift the cam in the rotation of the shaft. As a result the cam lobe contact the moveable C.B. points fiber block a little early. Hence, the contact also opens a little early. Thus the ignition point is shifted in the 'early' or 'advance' direction.



Vacuum advance mechanism (Fig 5)

The vacuum advance mechanism consists of a vacuum unit (1) fitted on the distributor. A hose (2) is connected with the carburettor vacuum. The diaphragm (4) of the vacuum unit is moved by the carburettor. An engine which is running under light or moderate load above the idle speed, requires additional spark advance, to increase fuel economy. When vacuum is applied to the diaphragm from the carburettor throat, the breaker plate (5) is pulled with the arm (6) in the direction opposite to the cam rotation. This causes the points to open earlier. When the throttle is in the idle or closed positions there is no vacuum available to pull the diaphragm and ignition takes place at the set time.



Spark plug

Objectives: At the end of this lesson you shall be able to
- **state the purpose of spark plug**
- **explain the cross-section and working of spark plug**
- **state the types of spark plug.**

Purpose of spark plugs: A spark plug (Fig 1) is basically two electrodes positioned to form a gap. The gap is between the insulated centre electrode and the ground electrode. This is the gap that the spark jumps to start the ignition of the compressed air - fuel mixture in the engine cylinder.

Explain the working of spark plug: The number one job of the ignition system is to produce the high - voltage surges that cause the sparks at the spark plug gaps Fig 2 shows in simplified form, how this is done. The ignition coil has two windings: a primary winding of a few hundred turns of relatively heavy wire, and a secondary winding of thousands of turns of very fine wire.

Now see what happens when the ignition switch is turned on, and the trigger has closed the circuit between the ignition coil primary winding and ground (the other battery terminal). Battery current will flow through the primary winding. This causes a magnetic field to form around the winding.

Now, when the trigger opens the circuit between the winding and ground, current stops flowing. The magnetic field collapses.

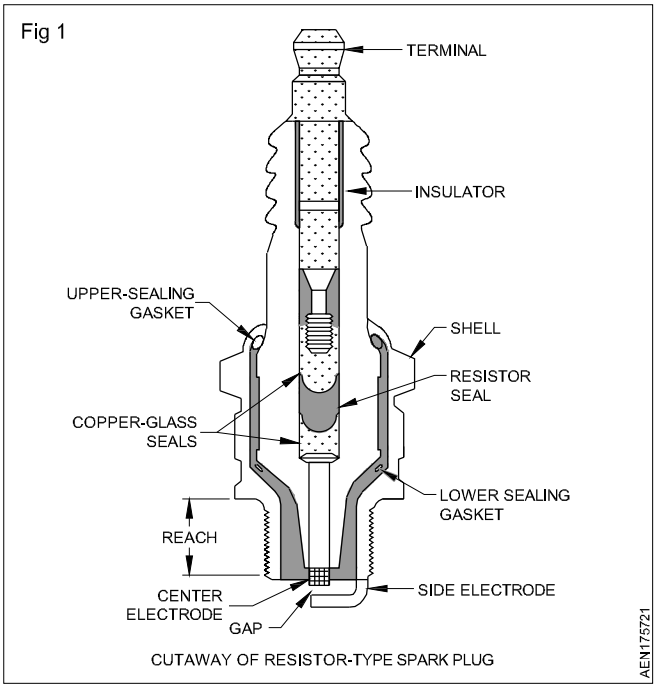
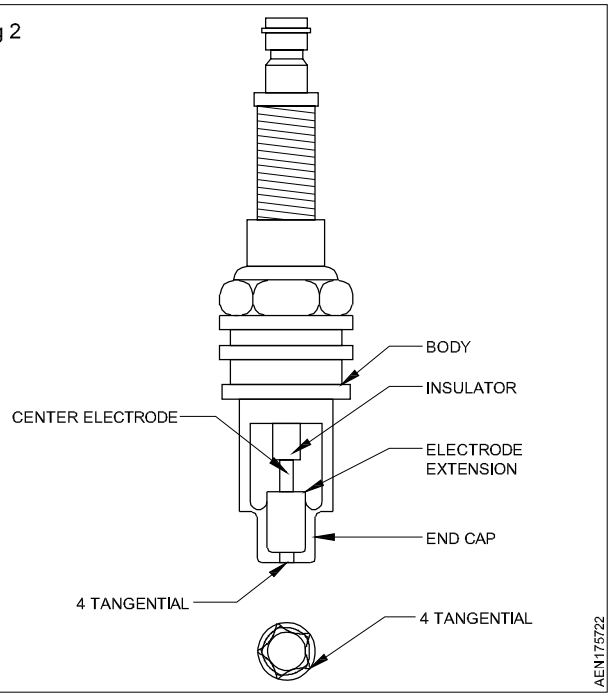


Fig 2



Spark plug with end cap designed to improve combustion swirl. (Fig 2)

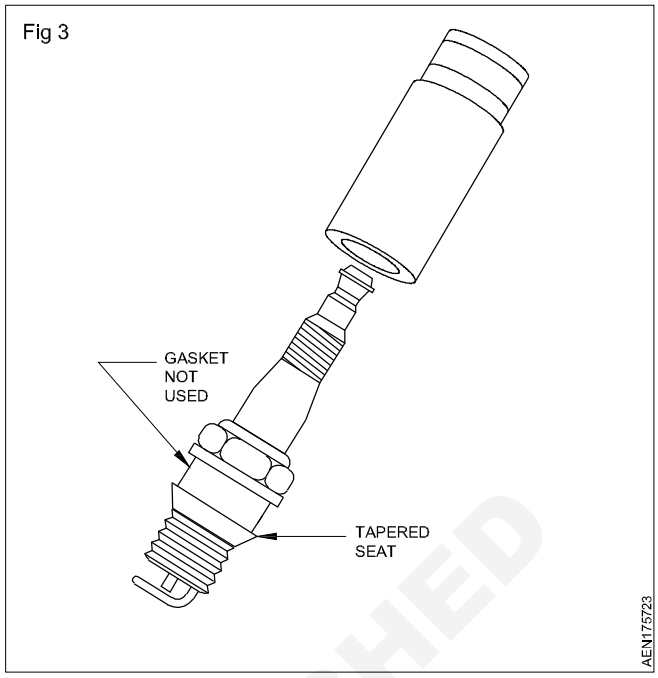
Spark plug has an end cap with a gap to the end cap. When the air fuel mixture is compressed, some of it enters the cap. Then, when the spark occurs, ignition starts in the cap. The burning mixture streams out through the orifices to ignite the rest of the compressed mixture. Note that the tangential orifices are at an angle. As the burning mixture streams out through these orifices, it sets up a swirling motion that speeds the burning of the mixture. This is said to improve engine performance.

Some spark require gaskets when installed in order to assure a leak proof seat. Many engines use plugs with tapered seats (Fig 3) which produce a good seal when installed.

Precautions

Spark plugs for modern engines with electronic ignition systems have gaps of up to 0.080 inch (2.03mm), as previously noted. They are not interchangeable with the plugs used on earlier systems, which used gaps of less than half as much. Use only the specific spark plugs specified for the engine. Attempting to use the earlier type of plug by bending the outer electrode to get the right gap can cause trouble. The plug will not fire right.

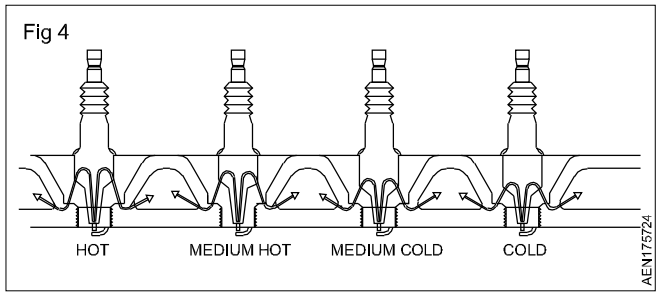
Fig 3



Types of spark plug (Fig 4): Two important characteristics of spark plugs are their heat range and their reach. The heat range of the plug determines the temperature the spark plug will attain in the engine, that is, how hot the plug will get. This controlled by the shape of the plug and the distance heat must travel from the centre electrode of the plug to reach the cooler cylinder head. If the path the heat must travel is long the plug will run hot. If the path is short, the plug will run cooler.

If the plug runs too cold, it will not become hot enough to burn away sooty deposits that collect on the insulator around the centre electrode. It can foul and miss. That is, the high voltage surges will leak across the sooty deposit and not jump the spark gap. If the plug runs too hot, it will wear, or burn the electrodes more rapidly. This also can lead to a miss because the gap becomes too wide for the spark to jump.

Fig 4



Electronic ignition control system

Objective: At the end of this lesson you shall be able to
- **explain ignition control system.**

Ignition control system: This system controls electronically the time of electric current flow to ignition primary coil as well as ignition timing. ECM judges the engine and vehicle conditions by using signals from various sensors, selects the most suitable electric current flow time and ignition timing for that engine and vehicle conditions from among those prestored in its memory and sends an ignition signal to the igniter in ignition coil assembly. Controls of this system include three different types as follows. Ignition timing control as follows. Ignition timing control at engine start, ignition timing control after engine start, electric current flow time control.

Radiator fan control system: This system controls operation (ON/OFF) of the radiator fan motor. Radiator fan motor is turned ON and OFF by its relay when ECM controls. Radiator fan motor turned ON at below 98°C and OFF at below 93°C.

Engine control module (ECM): ECM is installed to the underside of the instrument panel at the passenger's seat side. ECM is a precision unit consisting of microcomputer, analogue / digital converter input/output unit etc. It is an essential part of the electronic control system for its functions include not only such a major function as to control fuel injector, IAC valve, fuel pump relay, etc. But, also onboard diagnostic system (self diagnosis function) and fail - safe function.

Definition: Till in the 90's, a good carburettor was responsible for sending the appropriate amount of fuel into the cylinders. Carburettors atomize mix and supply the proper air fuel mixtures in the petrol / gasoline engines today, the electronic fuel injection replaces the carburettors and they have a injection separately and have a electronic throttle control to ensure good efficiency and exhaust control.

Function of each part

Air supply: The design of the intake system determines how much air can be drawn into a cylinder at any given engine RPM. EFI can achieve uniform distribution of the air delivered to the cylinders.

Air volume: The amount of air entering the engine must be measured, so that the amount of fuel injected into it forms a mixture to suit the engine operating conditions at that time.

MPFI: For any injection duration, if fuel is held at constant pressure, then as manifold pressure varies, so does the amount of fuel delivered through multipoint injectors with the use of computer technology. That means fuel pressure must be held constant above manifold pressure.

Simultaneous in multi point injection: The injectors can all be triggered simultaneously, twice per cycle. In a throttle-body system the central injector is normally triggered on each ignition pulse. With two injectors, alternate triggering may be used injection.

Efficient combustion: Fuel burned into maximum thermal, usable energy.

Fuel pumps: Fuel pumps operate electrically to provide fuel under pressure to the fuel rail and the injectors.

Fuel filters: EFI fuel filters remove contaminants from the fuel, so that clean fuel can be supplied to the injectors.

Tanks and lines: Most fuel tanks are in two parts joined by a weld around the flanges where the parts fit together. Baffles make the tank more rigid, prevent surging of fuel and ensure fuel is available at the pickup tube.

Fuel lines: The fuel tank is connected to the engine by fuel lines. A return line may carry excess fuel back to the tank, to keep fuel system components cool.

Fuel rail: The fuel rail supplies fuel to the injectors under constant pressure.

Fuel pressure regulator: The fuel pressure regulator controls the return of fuel to the fuel tank, to maintain the pressure in the fuel rail at a constant value above intake manifold pressure.

Injectors: Injectors are solenoid - operated valves which deliver fuel in the form of an atomized spray, into the intake manifold, or the intake ports.

Tachometric relay: The tachometer indicates engine RPM

Thermo time switch: The thermo time switch senses engine coolant temperature, to control the operation of the cold start injector, during cranking conditions.

EFI sensors

EFI sensors include: Wide band oxygen sensor twin oxygen sensors, knock sensors, oil deterioration sensor, exhaust gas recirculation sensors and switches.

Potentiometer: A potentiometer is a mechanically variable resistor.

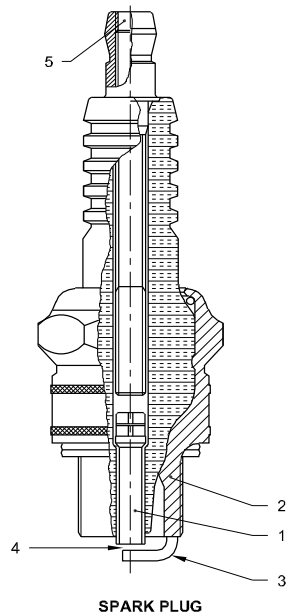
Auxiliary air valves: Auxiliary air valves allow additional air to bypass the throttle plate during cold start, and warm - up conditions.

Idle speed control devices: Idle speed control devices allow the preset idling speed to be maintained automatically when additional loads are placed on the engine, during idling conditions.

Inertia sensors: Inertia sensors shut off the fuel pump in the event of an accident, to minimize the danger of fuel spillage from a leak in the system.

Spark plug (Fig 1): It is fitted on the cylinder head or cylinder block. The purpose of a spark plug is to provide a gap across which a high voltage of the ignition system can jump.

Fig 1

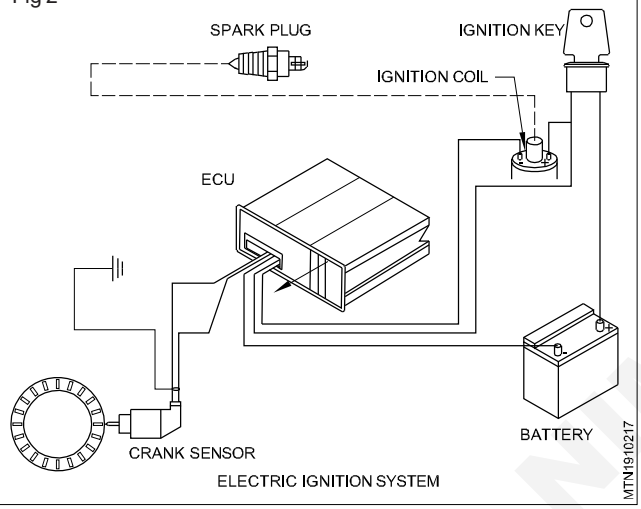


SPARK PLUG

The spark plug consists of a central electrode (1) fitted in the porcelain insulator (2) and sealed within a steel shell, which also holds the side electrode (3). The electrode (3) is set with the lower end of the central electrode (1) to form the spark gap (4). The steel shell has external threads which fit into the cylinder head to make an earthling contact. A high tension lead from the distributor is connected at the terminal (5) of the spark plug.

Electronic Ignition System (CDI System) (Fig 2): The present day two wheelers attain greater speed and more reliability because of electronic ignition system. The traditional mechanically operated contact breaker points is replaced with a pulse generator and C.D.I unit called capacitor discharge ignition system.

Fig 2



The new system equipped with a pulse generator which mainly consists of a trigger (1) and a pulsar coil or pick-up coil (2).

The trigger is toothed rotor, which is mounted on the crank shaft, the trigger is placed on the periphery of the flywheel and the pulsar coil is mounted on a non-rotating part and very close to the fly-wheel. The gap between the trigger and pulsar coil is very small 0.4 - 1.0 mm. The timing of the engine is determined by the location of the pulsar coil with respect to trigger.

This system eliminates contact breaker and in additional it is equipped with

1 C.D.I unit 2 Trigger 3 Pulsar coil

1 Capacitor Discharge Ignition Unit: This is a unit to provide the greater output voltage. It is more reliable and does not deteriorate in performance. It helps in instant starting, smoother engine and faster pick-up.

It stores the charged energy for the spark in a capacitor with in the module that is released to the spark plug. This also allows greater timing flexibility.

2 Trigger: It is a toothed rotor (1) which is mounted on the crank shaft (2), In some engines the trigger is placed on the periphery of the fly-wheel.

3 Pulsar coil: The pulsar coil is placed on a non-rotating part and very close to the fly-wheel. It is the heart of the engine. It gives timing signal to the ignition control box (CDI box). As the ridge on the fly wheel spins part the pulsar coil the timing signal is generated. The ignition box then uses the signal. It is also called pick-up coil.

Advantages of electronic ignition system

1 It provides greatest output voltage and good on engines performance and less maintenance required.

2 Elimination of common cause of ignition misfire.

3 No wear and tear & increased available time for coil saturation.

4 No points get burned or misadjusted.

5 This sealed unit provides a water and moisture proof ignition system.

6 Ignition timing once set does not change.

7 Increase in mileage and lower pollution levels.

8 Instant engine starting and faster pick-up.

9 Increasing time between firing, which allows the coil to cool more.

Starter motor

Objectives: At the end of this lesson you shall be able to
- **state function of starter motor**
- **state working principle of starter motor**
- **state type of stater motor**
- **state the function of fuse.**

Starter motor: The engine crankshaft must be rotated at a speed of a minimum 100 r.p.m. to start the engine. This action is called engine cranking. As it is hard to rotate the engine at that speed by hand or with a lever, a starter motor is used to crank the engine.

Location of the starter motor: The starter motor is fixed in the rear side of the engine, when the starter is switched on the starter motor's pinion engages with the flywheel ring gear and rotates the flywheel.

Principle: When a current is passed through an armature coil which is placed between two stationary magnets an e.m.f is induced and the armature coil starts rotating.

Construction (Fig 1&2): Three kinds of DC starter motors are used;

1 Series 2 Shunt 3 Compound

In automobiles the series wound type is generally used. In this the field and armature coils are connected in series.

This enables the motor to produce a high starting torque. The armature windings (1) are fixed in slots and their ends are soldered to the commutator segments (2). The pole shoes (3), two or four in number, are screwed to the yoke (4) and they have field windings (5). These windings help to produce the magnetic field. The insulation pieces are placed between the pole shoes (3) and metal yoke (4). Copper segments are provided with mica insulation in between the commutator brushes (6).

Fig 1

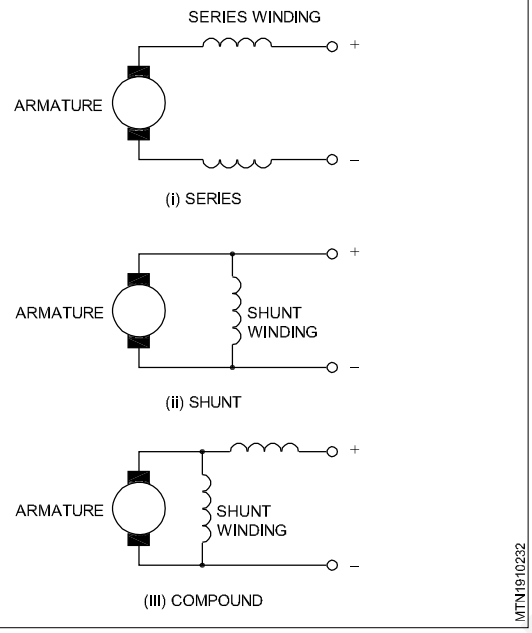
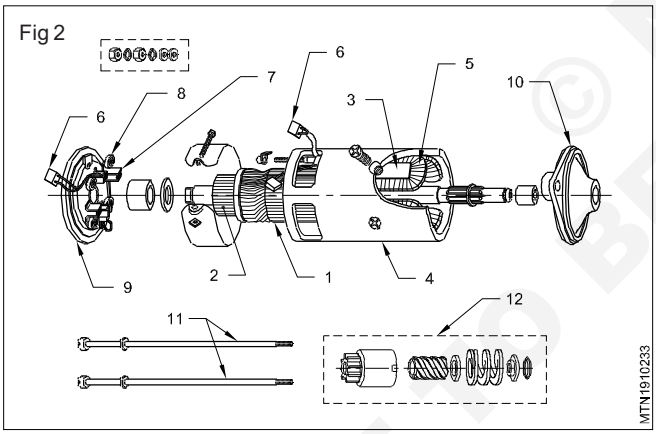


Fig 2



These brushes (6) slide in the brush holders and are kept in contact with the commutator with the help of small springs (8). The brushes (6) are given a curvature at the bottom to have more contact with the commutator (2). The armature is supported either on bushes or coil.

The commutator end is covered by a bracket called commutator end bracket (9). At the drive end, it is covered by the drive end bracket (10). Both the brackets are connected by through bolts (11). At the drive end in the armature shaft, a drive mechanism (12) is fitted.

Operation of starter motor (Fig 2): Current from the battery is supplied to the armature's (1) coil by two or four stationary brushes (6). These brushes (6) are in contact with the commutator's (2) segments. The same current is also supplied to the field coils (5). Both the field coil (5) and the armature's (1) magnetic field attract and refuse each other and cause the armature to rotate. Each coil of armature (1) is connected to one pair of copper segments of the commutator (2). The brushes come in contact with each coil of the armature (1) by turn, and in the process the armature's speed increases further.

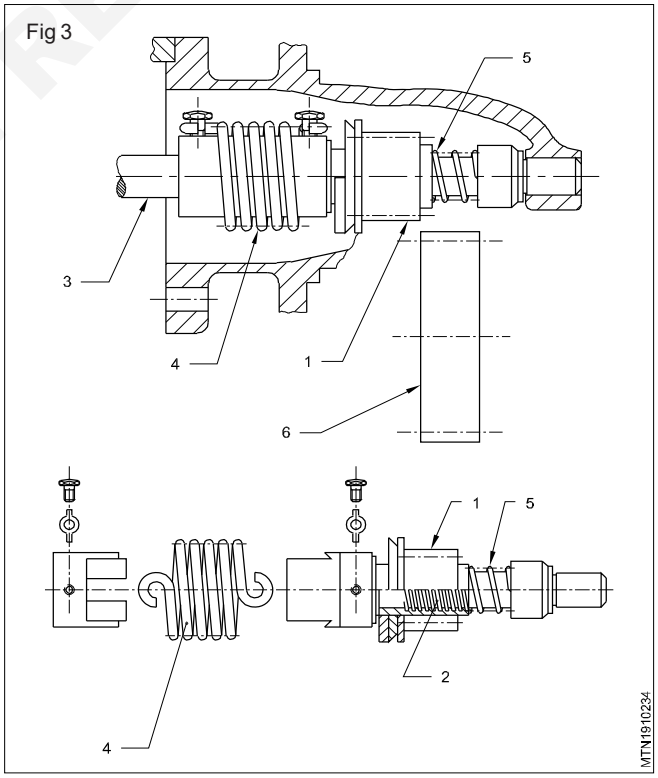
Once the engine starts running under its own power it attains a speed up to 4000 r.p.m (depending upon the design). Since the flywheel ring to starter pinion ratio is very high, the starter pinion will rotate at a much higher speed than the engine. This speed will damage the starting motor by throwing the windings out of the armature slots and also the commutator segments due to centrifugal force. In order to prevent this it is necessary to disengage the starter pinion from the flywheel ring gear once the engine has started. To achieve this three types of drive mechanisms are used.

- Bendix drive
- Over-running clutch drive
- Axial or sliding armature type and non-coaxial type

Bendix drive (Fig 3)

This is a most commonly used mechanism. It consists of a pinion (1) which is mounted on a hollow sleeve. The pinion (1) has internal screw threads and is loose fitted on the sleeve (2). The armature shaft (3) is supported by bearings at both the ends. A bendix drive spring (4) is provided to limit the turning of the sleeve on the armature shaft. An anti-drift spring (5) is provided to prevent the pinion from striking the flywheel (6).

Fig 3

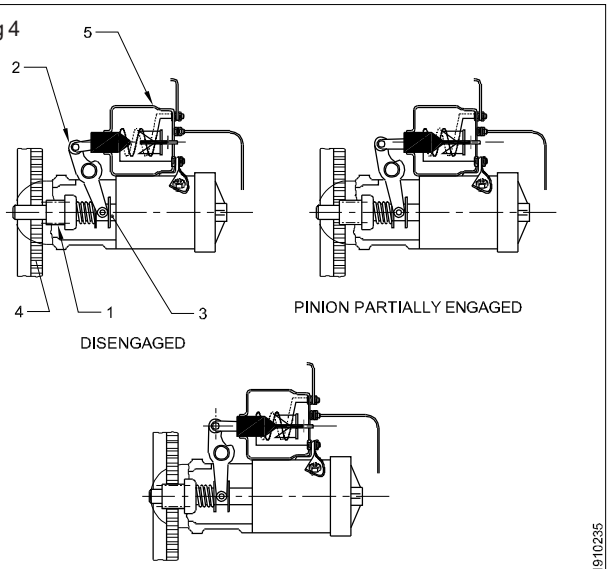


When the motor is switched on, the drive head rotates with the armature shaft (3). This motion is transmitted to the sleeve. The pinion (1) rotates along with the sleeve and travels forward to come in mesh with the flywheel ring gear

(6). Now the engine's crankshaft rotates and the engine is started. When the engine speed increases the pinion (1) is thrown back to its original position due to inertia.

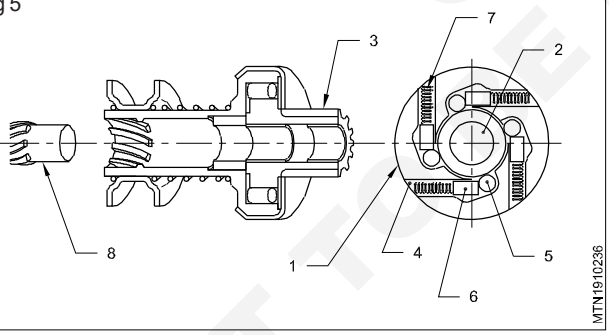
Over running clutch drive: The shift lever (2) is used by the over-running clutch to slide the pinion along the armature shaft (3) for meshing into or out of the flywheel teeth (4). The shift lever (2) is operated either by a solenoid (5) or by manual linkage. (Fig 4)

Fig 4



The over- running clutch permits the drive pinion (1) to run faster than the armature for a brief period during which the pinion (1) remains in mesh with the ring gear (4) once the engine has started. This protects the armature from damage due to over-speeding. (Fig 5)

Fig 5



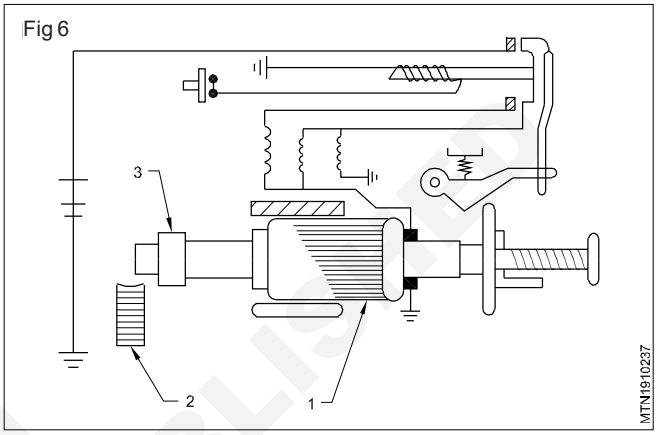
The over-running clutch, which consists of a shell and a sleeve (1) assembly, is splined to the armature shaft (8), so that the shell is driven by the shaft.

The pinion gear (3) is fastened to a collar (9) which is fitted inside the clutch shell. Four tapered notches (4) cut in the shell contain steel rollers (5). These are held in the small ends of the notches by spring (7) and plunger assemblies so that the rollers contact the collar.

The pinion (3) is forced to rotate with the armature shaft and cranks the engine. When the engine starts its attempts to drive the armature shaft (8) cause the rollers (5) to rotate out of the small ends of the notches. This will release the collar (3) from the shaft. This allows the pinion (3) to rotate at high speed without driving the armature.

Axial or sliding armature drive (Fig 6): This type of drive allows its armature (1) to slide in order to enable its pinion to come in mesh with the flywheel ring gear (2). When the starter switch is operated, the solenoid coil is energised. This completes the circuit of the shunt winding and also of an axillary series field winding. The armature is pulled due to the magnetic field and the pinion (3) engages with the flywheel ring gear (2). A clutch is provided between the armature (1) and pinion (1). When the starter switch is released, the armature returns to its original position by the return spring. Since the pinion (1) is still in mesh with the flywheel (2).

Fig 6

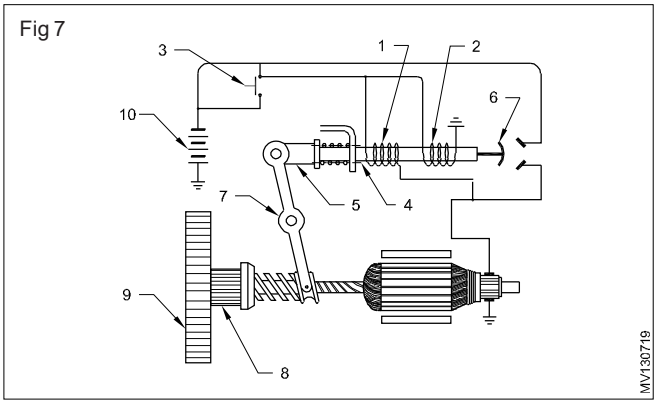


It rotates at very high speed but the clutch prevents the rotation of the armature at the pinion's speed and prevents damage to the armature. The pinion is held in mesh until the starter switch is released by the auxiliary shunt winding. When the engine starts, the current falls down and the magnetic field is reduced. Now the pinion is pulled back to its position by the spring.

Need of solenoid switch: The solenoid switch is a strong electromagnetic switch. It is used to operate the over-running clutch drive pinion to engage with the flywheel ring gear. It also acts as a relay to close the contacts between the battery and the starting motor.

Construction of solenoid switch (Fig 7): In a solenoid there are two windings, a pull-in winding (1) and a hold-in winding (2). The pull-in winding (1) is wound with thick wires (series winding) and the hold-in winding (2) is of thin wires (shunt winding). The pull-in winding (1) is connected to the starter switch (3) in the solenoid.

Fig 7



The hold in winding (2) is connected across the switch terminal and ground. The two windings are wound around

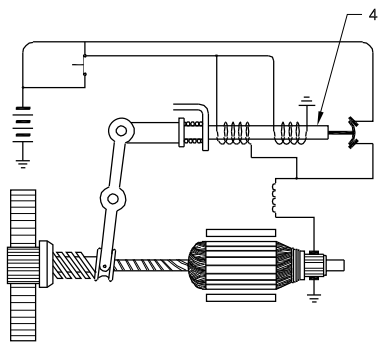
a hollow core (4). An iron plunger (5) is placed inside the core (4). The other end of the plunger moves a shift lever (7) to engage the pinion (8) with the flywheel ring gear (9).

Function of solenoid switch (Fig 8)

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 the 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.

Note: Refer the exercise 1.3.23 to 1.3.28 for fuse.

Fig 8



Switch

Objectives: At the end of this lesson you shall be able to
- **state the function of source coil**
- **state the function of pulsar coil**
- **state the function of power relay source coil**
- **state the function of SCR.**

When the ignition key is turned on a low voltage current from the battery flows through the primary windings of the ignition coil through the breaker points & back to the batter.

Pulsar coil: The pulsar coil is an important component in an engines timing & ignition system. The pulsar coil, (often called pickup coil or timing coil) is responsible for providing the timing signal to the ignition control box on modern motor cycles with solid - state ignition system.

Power relay: A power relay is a device that uses an electromagnet to open or close a circuit when the input (coil) is correctly excited. They provide a high level of isolation between the control signal (coil) and the output (Contracts) - typically with a rated impulse voltage of 4 or 6kv.

Silicon Rectifier (SCR): An SCR or Silicon controlled Rectifier is a semiconductor, or integrated circuit(TC) that allows the control of current using a small current. Basically, it is a simple direct current (DC) light switches.

Charging System

Objectives: At the end of this lesson you shall be able to
- **explain charging system**
- **explain need of fly wheel magneto (alternator)**
- **explain the need of stator coil and plate assembly**
- **explain the function of rectifier/regulator assy (RR Unit)**
- **explain need of battery.**

Charging Circuit: The charging system is the basic electrical system used in automobiles to generate electric power. The generated power is used in many ways in like charging battery, ignition system, lighting system etc., through various wiring circuit. (Fig 2)

Basically the charging circuit (Fig 1) consists of

1 Alternator (with rotor fly wheel magneto and stator)

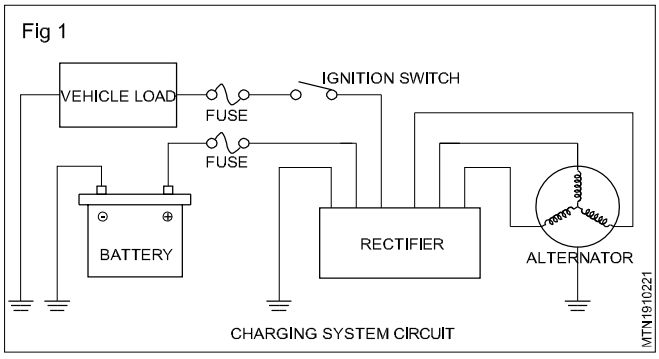
2 Rectifier regulator assembly 3 Battery

1 Alternator (Fig 3): It is a device used to generate electrical power, which is also called dynamo. In two wheeler this device is split into two main parts called

i Rotor fly wheel with magneto and

ii Stator coil

Fig 1

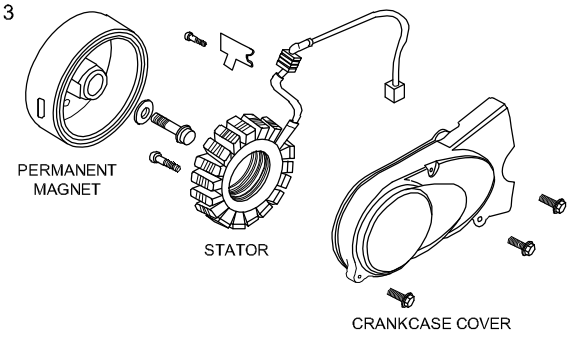


Rotor fly-wheel magneto: This is a wheel rotor consists of number magneto fixed on its inner surface. This is designed to rotate along with the crank shaft over stator plate unit which is stable at centre. This rotation creates magnetic flux in the stator coil.

Stator Coil with a plate (Fig 3): The stator coils with winding (3) which are two or more in two wheelers which are stationary at the end of crank shaft. The rotation of flywheel magneto induce magnetic flux in the coil by generating alternating current in the field circuit. The current developed in each coil is supplied to each unit according to the no of coils.

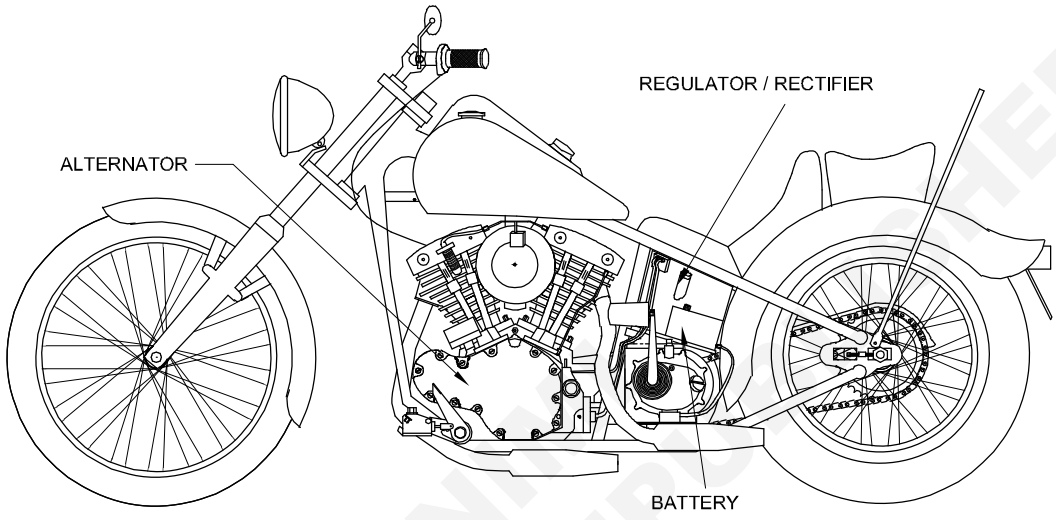
Rectifier/Regulator assembly: The generated alternating current A/C in the field coil is been rectified and converted into direct current with the help of rectifier. And the voltage is been regulated to maximum up to 12 volts in two wheelers by the voltage regulator for the function of various electrical devices.

Fig 3



ALTERNATOR ASSEMBLY

Fig 2



ACTUAL LOCATIONS OF CHARGING SYSTEM

Starting system

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

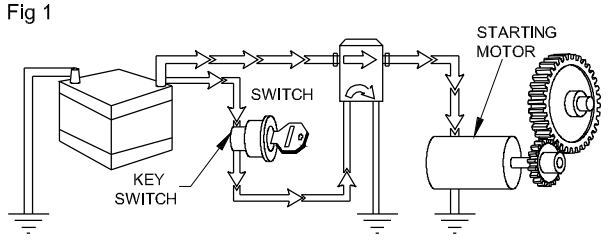
- **state purpose of the starting system**
- **describe the starting circuit**
- **state the principle of starting motor**
- **explain construction of starting motor**
- **explain operation of starting motor.**

Purpose of the starting system

The starting system is used to start the engine when the starter switch is pressed / turned current flows to the starter motor from the battery and the starter motor's shaft rotates. A drive pinion is connected to the starter motor shaft. The drive pinion turn the engine fly wheel till the engine starts

The starting system, which includes the starting motor, switch, battery and cables, does the cranking. Fig 1 is a simplified drawing of the starting system. When the key switch is closed, it connects the main switch to the battery. The main switch then magnetically closes the main contacts between the battery and the starting motor. The starting motor shaft begins to turn. A small pinion gear on this shaft is meshed with a large gear on the engine flywheel. When the small pinion gear turns, it rotates the flywheel. The crankshaft is attached to the flywheel, and so the crankshaft rotates and the engine starts.

Fig 1



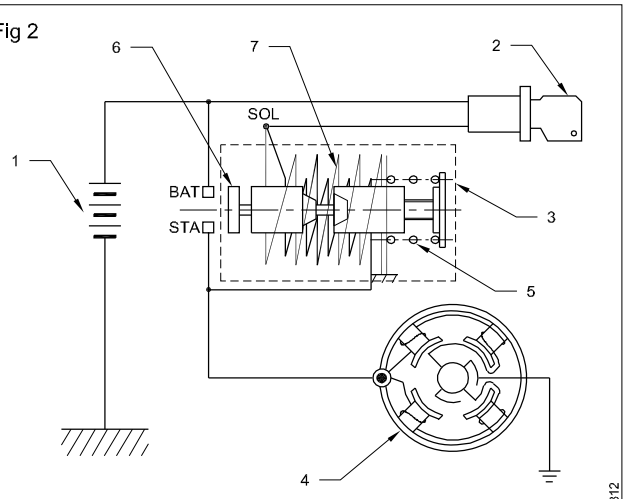
SIMPLIFIED DRAWING OF A STARTING SYSTEM
(CHEVROLET MOTOR DIVISION OF GENERALM MOTORS CORPORATION)

Description of a starting circuit (Fig 2)

The -ve terminal of the battery (1) is connected to earth. The +ve terminal of the battery (1) is connected to the solenoid switch's (3) battery terminal. From there a wire is connected to the starter switch's (2) input terminal. From the input terminal of the starter switch (2), a wire is connected to the solenoid winding's (7) input terminal.

The other end of the winding is connected to earth. From the starter terminal of the solenoid switch a connection is given to the starter motor's (4) input terminal. In a starter motor an internal connection is given to connect the field windings as well as the armature through the brushes and the other end is connected to earth.

Fig 2



SIMPLIFIED DRAWING OF A STARTING SYSTEM
(CHEVROLET MOTOR DIVISION OF GENERALM MOTORS CORPORATION)

When the key switch is turned, a small amount of current flows from the battery (1) to the starter solenoid (3). This current energies the solenoid windings and the plunger (6) moves to connect the battery's and starter motor's terminal in the solenoid switch (3). Current now flows directly to the motor (4). When the switch is released the current flow stops and the return spring (5) pulls the plunger (6) back, disconnecting the starter motor from the battery.

Starter motor function

The engine crankshaft must be rotated at a speed of a minimum 100 r.p.m. to start the engine. This action is called engine cranking. As it is hard to rotate the engine at that speed by hand or with a lever, a starter motor is used to crank the engine.

Location of the starter motor

The starter motor is fixed in the rear side of the engine, when the starter is switched on the starter motor's pinion engages with the flywheel ring gear and rotates the flywheel.

Principle

When a current is passed through an armature coil which is placed between two stationary magnets an e.m.f. is induced and the armature coil starts rotating.

Construction

Three kinds of DC starter motors are used. (Fig 3)

- Series
- Shunt
- Compound

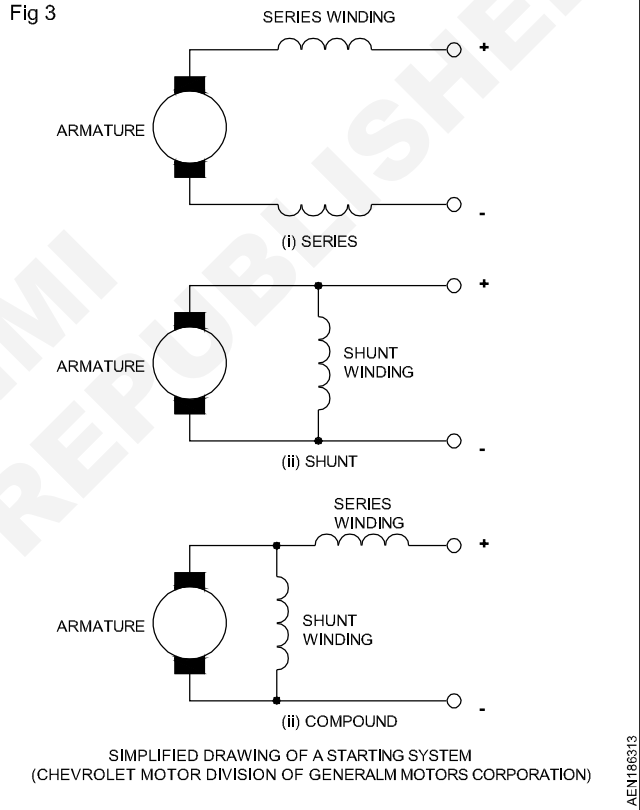
In automobiles the series wound type is generally used. In this the field and armature coils are connected in series. This enables the motor to produce a high starting torque. The armature windings (1), (Fig 4) are fixed in slots and their ends are soldered to the commutator segments (2).

The pole shoes (3), two or four in number, are screwed to the yoke (4) and they have field windings (5). These windings help to produce the magnetic field. The insulation pieces are placed between the pole shoes (3) and metal yoke (4). Copper segments are provided with mica insulation in between the commutator brushes (6).

These brushes (6) slide in the brush holders and are kept in contact with the commutator with the help of small springs (8). The brushes (6) are given a curvature at the bottom to have more contact with the commutator (2). The armature is supported either on bushes or coil.

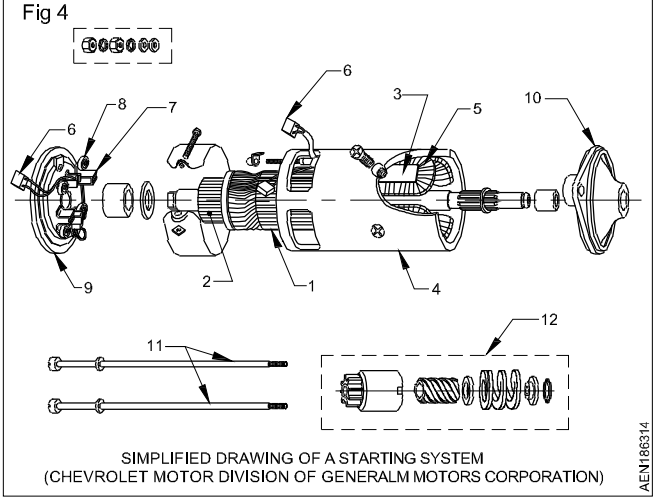
The commutator end is covered by a bracket called commutator end bracket (9). At the drive end, it is covered by the drive end bracket (10). Both the brackets are connected by through bolts (11). At the drive end in the armature shaft, a drive mechanism (12) is fitted.

Fig 3



SIMPLIFIED DRAWING OF A STARTING SYSTEM
(CHEVROLET MOTOR DIVISION OF GENERALM MOTORS CORPORATION)

Fig 4



SIMPLIFIED DRAWING OF A STARTING SYSTEM
(CHEVROLET MOTOR DIVISION OF GENERALM MOTORS CORPORATION)

Starting system drives

Objectives: At the end of this lesson you shall be able to
- **explain operation of Bendix drive**
- **explain operation of over running clutch drive**
- **explain operation of sliding armature drive.**

Starting system drives: They are three types;

1 Bendix drive

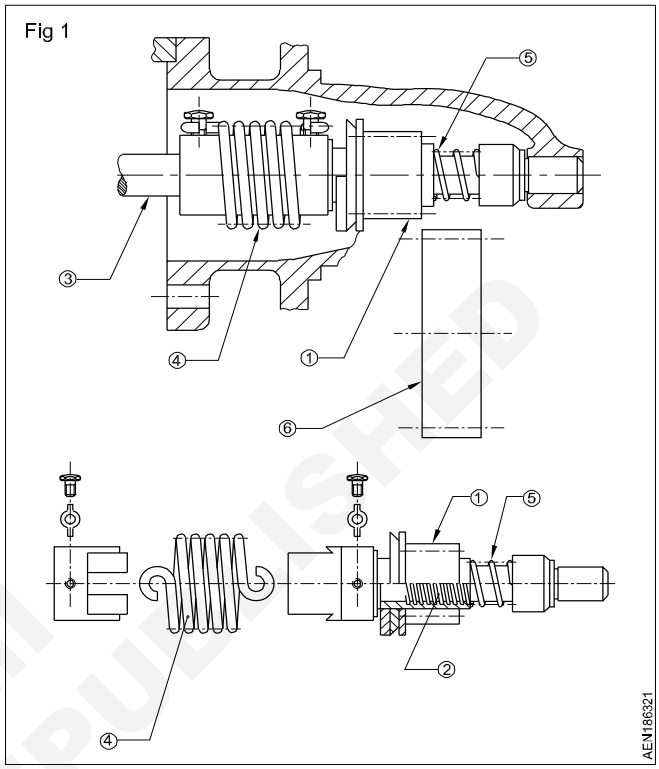
2 Over-running clutch drive

3 Axial or sliding armature type and non coaxial type

Bendix drive (Fig 1)

This is a most commonly used mechanism. It consists of a pinion (1) which is mounted on a hollow sleeve. The pinion (1) has internal screw threads and is loose fitted on the sleeve (2). The armature shaft (3) is supported by bearings at both the ends. A bendix drive spring (4) is provided to limit the turning of the sleeve on the armature shaft. An anti-drift spring (5) is provided to prevent the pinion from striking the flywheel (6).

Fig 1



Lighting system - Lamp and sealed beam

Objectives: At the end of this lesson you shall be able to
- **describe sealed beam headlights**
- **describe halogen head cornering, interior smart light system.**

Lamps (Fig 1 & 2): An automotive light bulb usually contains one or two filaments. In a single filament bulb, the terminal is connected to one side of the filament and the opposite end of the filament is usually connected to the bulb case (Fig 1).

Voltage is supplied to the bulb terminal and current flows through the filament to the bulb case. The circuit is completed from the bulb case through the vehicle ground back to the battery. The indexing pins on the sides of the case retain the bulb in the socket. Many automotive bulbs have two filaments and two terminals that supply voltage to the filaments.

Fig 1

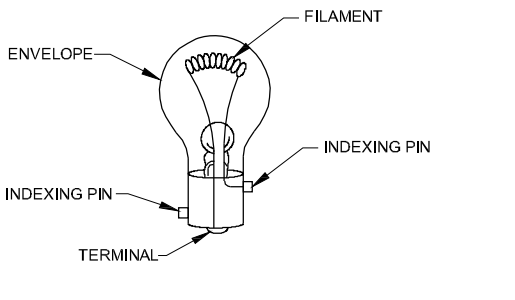
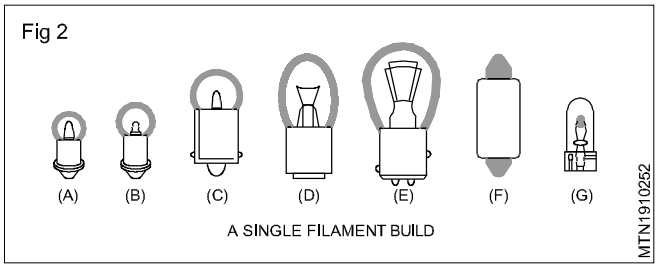


Fig 2



These dual filament bulbs serve two purposes such as stop and tail lights. The indexing pins position the bulb terminals properly in the socket. A verity of different bulbs are used in a typical vehicle.

When current flows through a bulb filament, it becomes very hot. The electrical energy in the filament is changed to heat energy and this action is so intense that the filament glows and gives off light. This process of changing electrical energy to heat energy that produces light is called incandescence.

The filament is surrounded by a vacuum that prevents overheating and destruction of the filament. When a bulb is manufactured, a vacuum is sealed inside the glass envelope surrounding the bulb.

When replacing automotive bulbs, be sure the replacement bulb is the same as the original bulb, including the position of the indexing pins. Most bulbs have the part number stamped on the bulb case.

A, B - Miniature bayonet for indicator and instrument lights

C - Single contact bayonet for license

D - Double contact bayonet for trunk

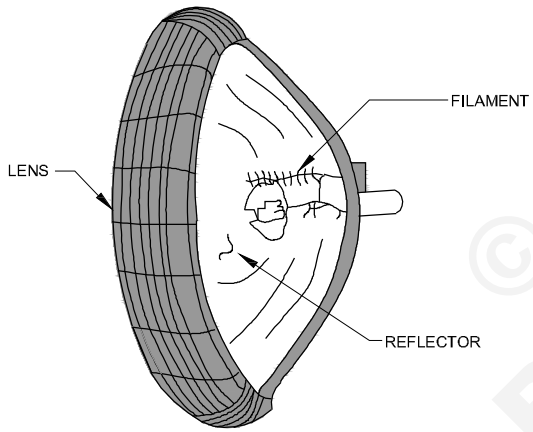
E - Double contact bayonet with staggered indexing lugs for stop, turn signals, and brake light.

F - Cartridge type for dome lights

G - Wedge base for instrument lights

Sealed beam headlights (Fig 3): Sealed beam headlights may be round or rectangular shaped. Sealed beam headlights have a parabolic reflector sprayed with vaporized aluminum in the rear of the sealed beam. This reflector is fused to a glass lens in the manufacturing process. All the oxygen is removed from the sealed beam and then it is filled with argon gas.

Fig 3



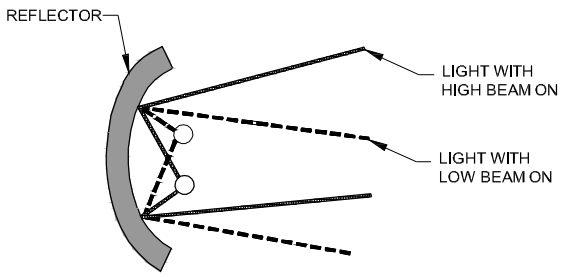
SEALED BEAM HEADLIGHT DESIGN

If oxygen were allowed to remain in the sealed beam, the filament would become oxidized and burn out quickly. Sealed beams may contain one or two filaments. If the sealed beam operates on both high and low beam, it has two filaments and three terminals. Some sealed beams that operate only on high beam contain a single filament and two terminals.

The light from the filament in a sealed beam is reflected from the reflector through concave prisms in the lens. The prisms in the lens direct the light beam downward in a flat, horizontal pattern (Fig 4). The filaments are precisely located in the reflector to properly direct the light. If a sealed beam has two filaments, the lower filament is for high beam and the upper filament is for low beam (Fig 5)

Light emitting diodes (LED). A certain number of diodes are interconnected with a physical unit according to the bringhtness required and the desired light colour. The multiple allocation reduces the probability of failure of the overall function. Light emitting diodes have a service life of approximately 10,000 hours. They are used in particular for brake lights, as they achieve their maximum bright less in a significantly shorter time than filament lamps or halogen lamps (approximately 2mm)

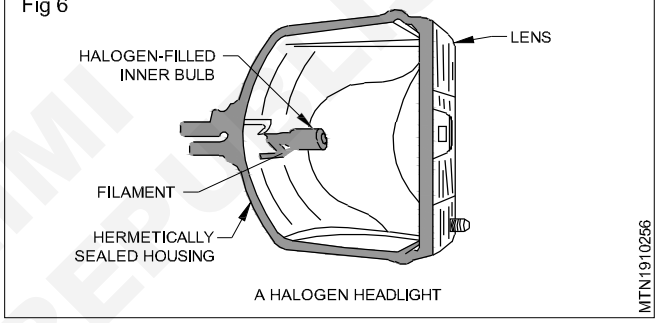
Fig 5



FILAMENT LOCATION IN A SEALED BEAM CONTROLS THE LIGHT BEAM PROJECTION

Halogen headlights (Fig 6): Many newer vehicles have halogen headlights. This type of headlight contains a small bulb filled with iodine vapor. The bulb has a glass or plastic envelope surrounding a tungsten filament. The bulb is installed in a sealed glass housing.

Fig 6



A HALOGEN HEADLIGHT

Halogen is a term for a group of chemically related nonmetallic elements including chlorine, fluorine and iodine.

The tungsten filament can withstand higher temperatures and burn brighter because of the halogen added to the bulb. Halogen headlights produce approximately 25 percent more light compared to sealed beam headlights.

Because the bulb in halogen headlight is self contained, a cracked lens does not prevent headlight operation. However a cracked lens should be replaced because it results in poor light quality.

Many vehicles are presently equipped with composite headlights and replaceable halogen bulbs (Fig 6). The composite headlights allow the vehicle manufacturers to design the headlights in various shapes to conform to more aerodynamic body styling. For example, some composite headlights wrap around the front corner of the vehicle.

Handlebar controls (Fig 7): Handlebar is provided with various control switches on both ends. The front brake lever is attached with right side handle grip while the clutch lever is attached with left side handle grip. Various switches given on handle grips are used to operate various electrical components and circuits

Fig 4

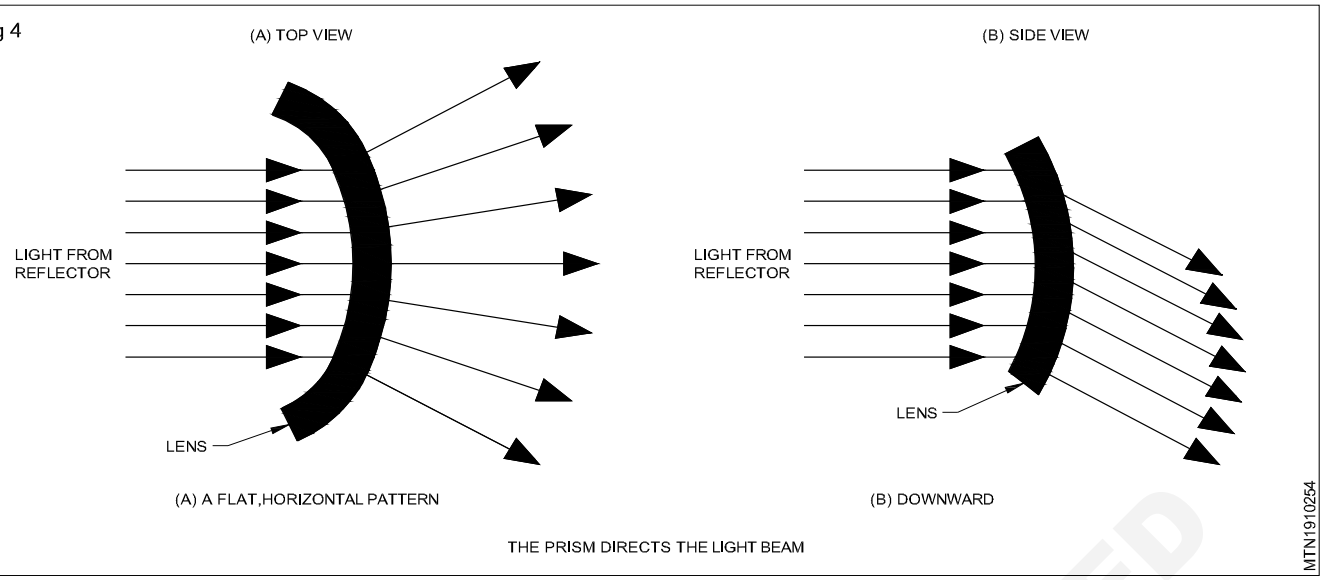
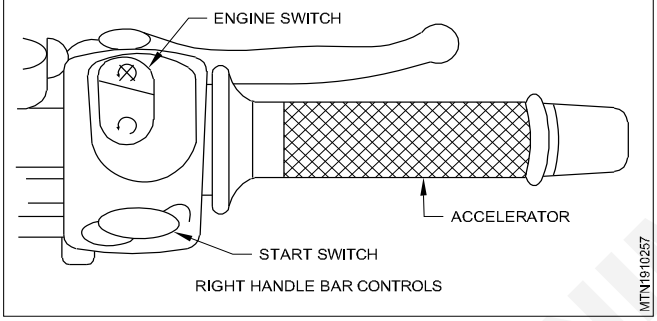


Fig 7

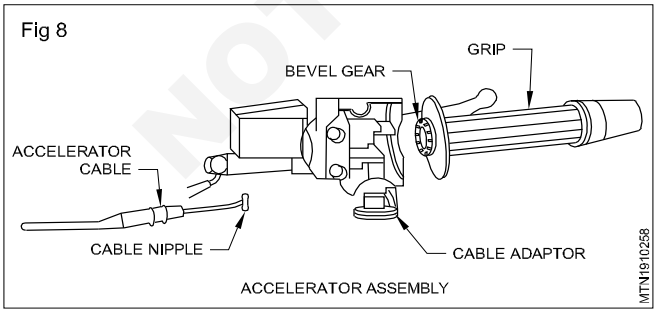


Right handlebar controls: Right handlebar controls includes engine stop switch, start switch, accelerator and front brake lever. (Fig 7)

Engine Stop Switch is kept nearer to the throttle grip. When the switch is turned to the (RUN) position, the engine can be cranked. When the switch is turned to the (OFF) position, the engine cannot to cranked.

Start Switch is generally located below the engine stop switch. The start switch is used for starting engine. The accelerator cable is used to connect the butterfly valve(s) of the carburettor or the throttle body with the grip. It opens the butterfly valve(s) in accordance with the handle grip by transmitted the rotational motion of the grip. (Fig 8)

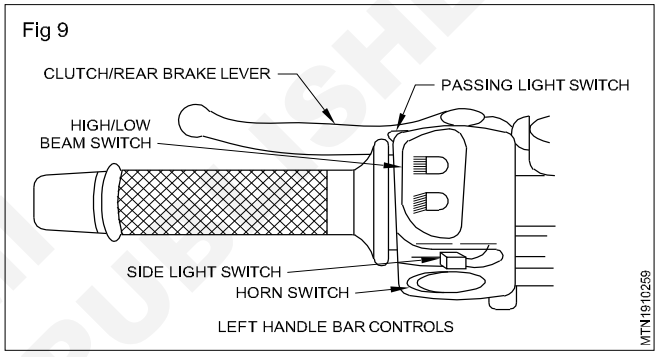
Fig 8



Left handlerbar controls: It includes headlight dimmer switch, passing light switch, side light switch, horn switch and rear brake lever or clutch lever. (Fig 9)

Headlight dimmer switch is used to select high beam or to low beam.

Fig 9

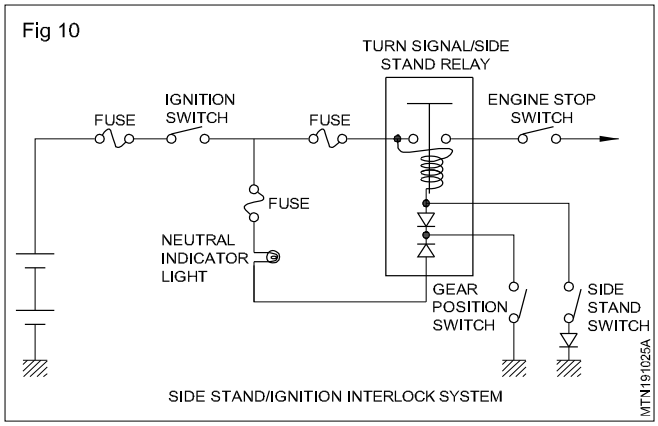


Passing Light Control Switch is used to flash the headlight momentarily to signal approaching cars or when passing.

Turn Signal Switch is used to signal a left turn or to signal a right turn. It is simply pressed to turn the signal off.

Side stand/ignition interlock system (Fig 10)

Fig 10



The side stand/ignition interlock system prevents the vehicle from being started with the side stand down. The system is operated through electric circuit provided between the battery and the ignition coil. Figure shows circuit of side stand/ignition interlock system.

Transmission Gear Display: This display shows the selected gear. The neutral position is indicated by N and by the neutral indicator light.

Head lamp assembly

Objective: At the end of this lesson you shall be able to
- **describe head lamp assembly.**

Head lamp assembly: The head light illuminate the road ahead. The quartz halogen bulb has twice the brightness of ordinary bulbs.

1 It gives about three to four times longer life than ordinary bulbs.

2 It does not show fade throughout its life.

3 Ensure a constant brightness always.

Head lamp relay

1 It is used to meet the heavy load requirements of halogen bulbs.

2 It control the both low and high beans at minimum voltage drop and minimum current consumption.

Reflector project the light in proper direction

1 Head lights provided with dipper.

2 It produces two ways of beams.

3 Main beam for use when the road if clear

4 Dip bean for use during traffic.

The top head of the halogen bulb has a black quarts coating.

1 It should be kept free from water and grease etc.,

2 The bulb should always be held by it's metal base to avoid cracking due to uneven surface temperature

3 Increasing the side illumination and redirecting the light rays on to the road ahead, and also act as a protective cover.

4 An improperly adjusted head light may fail to light the road for a safe distance. So head light adjustment must be done.

Purpose of head light: Head light is to provide suitable light for the driver during night and helps to prevent the road accident during night drive.

Trouble shooting in ignition system

Trouble	Causes	Remedies
No sparks at spark plug	- Ignition coil defective	Replace
	- Defective spark plug	Replace
	- HT lead short circuited	Replace
	- Battery or magneto output too low	Rectify
	- Ignition switch defective	Replace
	- Hal effective sensor or defective	Replace
Engine starts but runs poorly	- Ignition coil defective	Replace
	- Condener weak	Replace
	- Spark plug defective	Replace
	- Insufficient fuel supply	Rectify
	- Dirty air filter	Replace
	- Improper valve and ignition timing	Adjust
No light comes on when ignition switch ON	- Warning light bulb fuse	Replace
	- Ignition switch defective	Replace
	- Loose wire connection	Rectify
Head light beams do not shift	- Dipper switch defective	Replace
when Hi - Lo switch is operated	- Head light bulb one filament damaged	Replace
	- Wiring short circuited	Rectify
Misfiring	- Defective spark plug	Replace
	- Ignition short circuit	Rectify
	- Water mix with fuel	Replace
	- Insufficient current supply to the spark plug	Rectify
	- HT lead loose contact	Tighten
All light come on but dimly when ignition switch is turned ON	- Low watt bulbs used	Replace
	- Low voltage supply	Rectify
	- Wire loose connection	Rectify
	- Bulb contact points dirty	Clean
	- Improper switch contact	Replace the switch

LPG supply system in three wheeler engine

Objectives: At the end of this lesson you shall be able to
- **draw the L.P.G supply system**
- **state the construction of L.P.G system parts**
- **explain the each part**
- **explain the starting procedure**
- **explain the important tips for "Cold starting".**

The optimization of LPG system on gasoline engine was carried out on similar lines to that of CNG. The LPG system is an optimization such as over speed controller and market, were implemented from the beginning.

The optimization variables

1 Compression ratio 2 ECU

3 Air gas valve 4 Ignition timing

The engine was optimized with cylinder head having compression ratio of 9.5:1 against 9:1.

The head was also fitted with valves having stepped valve seat profile. This results performance improvement for basic petrol engine.

Compression ratio: The compression ratio of LP gas engine is limited by know resistance of the fuel. The max compression ratio depends on number of other parameters like air - fuel ratio. Combustion chamber design, charge density.

Fig 1

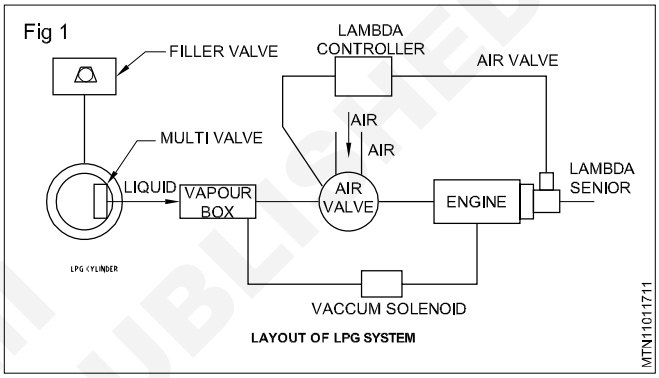
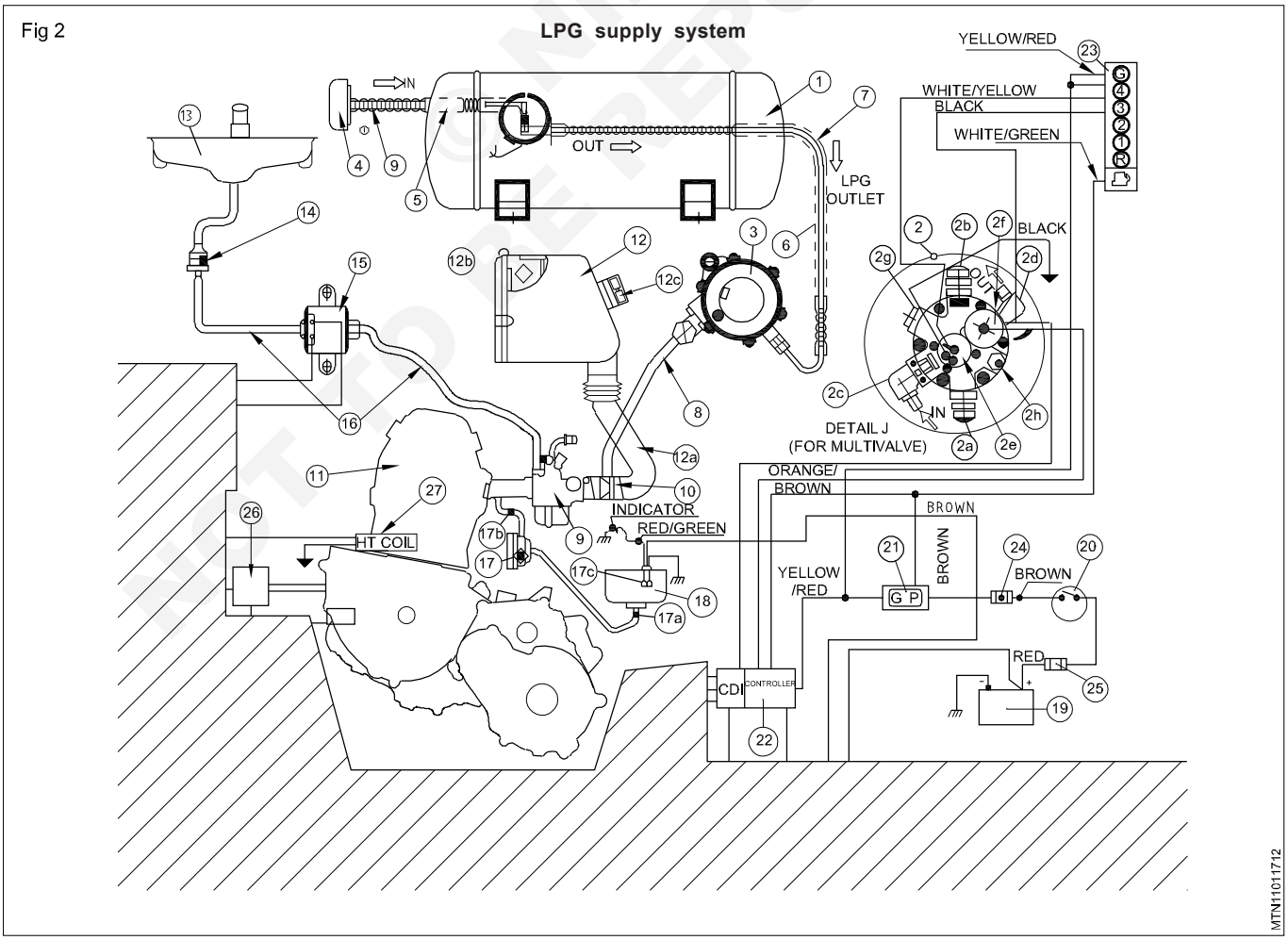


Fig 2 **LPG supply system**



ECU: The vehicle performance was evaluated for acceleration and drivability and especially for declaration stalling with CPP. OZ ECU. The mixture was getting excessively lean during sudden acceleration because of limitation ECU.

Air gas valve: Gas flow to engine was optimized by varying shims opening path by position of power screw. Mass emission and FTP test results indicate that emission was minimum in case of power screw position at approx. 65 - 70 % and diaphragm having two shims.

Ignition system: The requirements of stoichiometric LPG engine with respect to ignition Systemax moderate. The existing gasoline engine user the conventional distributor type ignition system with spark advance. The engine was evaluated for different spark advance setting and it was observed that ignition advance has very little effect on engine performance. Hence spark advance for gasoline was kept same as that for LPG mode.

Location of parts

LPG cylinder (A)

LPG cylinder is mounted below driver's seat. The cylinder has capacity of 20.6 liter of water (16.5 kg of LPG when filled 80%). With this capacity the vehicle can over approximately 250 - 300km).

Multifunction valve (B)

Multi function valve is mounted on the LPG cylinder. It is an assembly for mounting on LPG tank for filling and withdrawal of LPG along with safety devices. It consist of the following components.

Components of multifunction valve

Shut off valve (C)

Manual shut off valve (Yellow colour knob) is to be closed whenever servicing / maintenance is carried out. This shut off valve is to be closed when vehicle is parked for long time or overnight. Also in case of any leakage observed this valve is to be closed immediately.

Excess flow valve

It is a safety valve provided in the multifunction valve which closes automatically when a predetermined flow limit exceeds.

Gas level indicator (D)

A dial type level indicator is mounted on multifunction valve which gives indication of the level of the LPG contained in LPG tank.

Automatic fill limiter

This valve is provided in the multi function valve which closes automatically when a predetermined level of gas i.e. 80% the full capacity of cylinder is filled in the cylinder.

LPG solenoid valve (E)

It is provided to switch off the gas flow when the ignition key is OFF position or the selector switch is on petrol/off position.

Refilling unit (F)

It is provided for filling gas into the cylinder.

Vapour box (G)

Multi valve is covered with vapour box for venting the gas, in case of leakage (if any), the ventilation hoses are routed such that any gas escaping due to leakage from tank fittings will not enter the vehicle passenger compartment or driver space.

Petrol solenoid valve

It is mounted on the chassis member. It will start the petrol flow when the selector switch is on petrol mode.

Pipe assembly I

This is high-pressure pipe connecting LPG filling unit to multifunction valve.

Pipe assembly II

This is high-pressure pipe connecting multifunction valve to LPG regulator.

Flexible hose assembly

It supplies low-pressure gas from LPG regulator to mixer.

Inline regulator (I)

High - pressure gas from cylinder enters the inline regulator where the pressure is reduced to a level appropriate for delivery to the gas control unit.

Control (selector) Switch (k)

It is mounted on the dashboard. It has three positions.

Gas

The vehicle will run on LPG, G LED will glow. The gas solenoid will open & petrol solenoid will close.

OFF

Both gas & petrol solenoids will be off. This position is useful for switching to either mode.

Petrol

The vehicle will run on petrol. Petrol solenoid will open & gas solenoid will close.

Mixer unit

Introducing gaseous fuel to the induction air of the engine. It is provided in the inlet system just before the Carburettor.

Starting procedure (Fig 3)

i To run vehicle on gas mode

1. Ensure shut off valve on (Cylinder colour knob) multifunction valve is open.
2. Put Selector switch (B) on Gas mode.
3. Put Ignition switch (A) on.
4. Crank the engine. While cranking the engine do not open or raise throttle, more than 10% of throttle opening.

5 Repeat the procedure if vehicle does not start.

6 We have provided the limp home facility to run the vehicle on petrol in case the LPG is exhausted.

ii To run vehicle on Petrol mode

1 Put the ignition switch ON.

2 Put selector switch (B) on Petrol mode.

3 Wait for some time for filling of the Carburettor bowl.

4 Crank the engine.

The idling speed adjustment is higher when the engine is on LPG than the adjustment required for engine running in petrol. Therefore if vehicle is required to run on petrol mode for considerable time, then it is advisable to reduce idling speed by adjusting carburettor idling screw for smoother run of engine.

Caution: While switching from petrol to gas mode, put the Selector switch in OFF position. Run the vehicle till the petrol in Carburettor is consumed. Then switch over to gas position. Also adjust the idling speed if required.

Important Tips for Cold starting

For easy 'Cold Starting' i.e. first time in the morning or after ¾ hours parking when the engine becomes cold, it is recommended to start the engine only on 'PETROL' and then switch over to LPG (GAS) as follows :

1 With On/Off switch 'ON' put the selector switch (Controller Unit) on 'P' (Petrol) mode position.

2 Use choke and start engine by turning ignition key to 'START'. On starting the engine release the choke immediately.

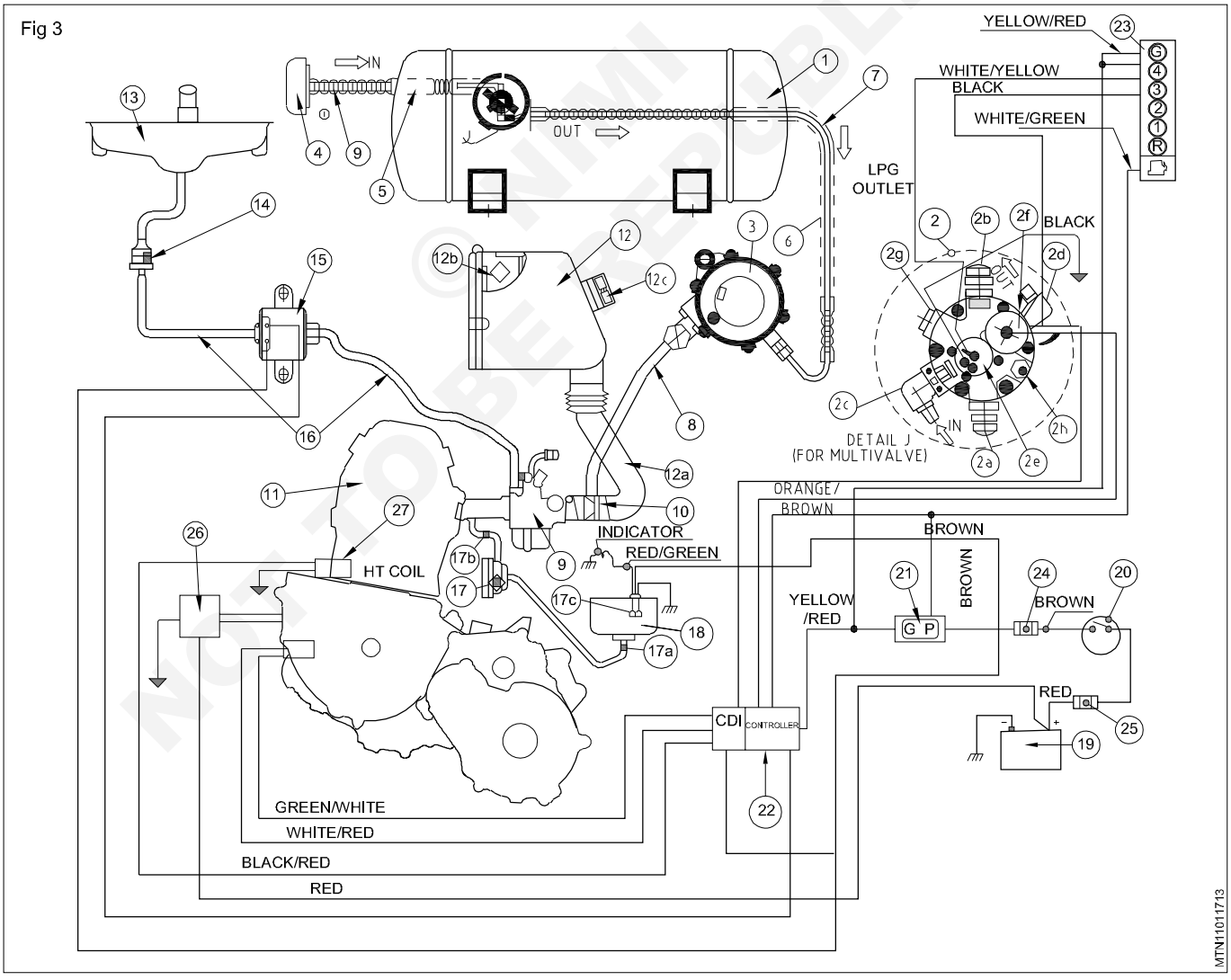
3 Warm-up the engine and run the vehicle on petrol for 2/ 3 minutes i.e. For 3/5 kms.

4 To switch over engine to LPG (GAS) put the selector switch on 'O' (OFF) mode position while engine is running. On feeling slight jerk at engine put selector switch to 'G' (GAS) mode position.

5 Ensure engine gives proper response to throttle. If engine fails to respond, repeat the procedure as mentioned at point no. 4.

This will reduce repeated cranking during 'Cold starting'.

Fig 3



Alternate fuels (CNG)

Objectives: At the end of this lesson you shall be able to
- **alternate fuel for three wheelers**
- **function of CNG**
- **explain about alternate fuels and four stroke CNG engine**
- **state the classification of three wheelers**
- **state the drive train of three wheelers.**

Alternate fuels: The regular liquid fuels permanently used are petrol and diesel. Because of the crisis in three energy sources and to reduce the pollution levels in recent years, considerable research efforts are being made to find out alternative fuels for automobile engines.

Out of research findings, they liquefied petroleum gas (LPG) which is a mixture of propane and butane, as well as compressed Natural gases (CNG) are found to be successful for use in automobiles engine as alternate fuels.

Use of compressed natural gas (CNG) (Fig 1&2)

The engine fitted with CNG is considered to be more environmental friendly. There are considerably less pollutants associated with compressed natural gas being ignited, which gives off 40% less green house gas. In addition the CNG is marginally cheaper than ordinary gasoline or diesel.

Function of parts are similar as in LPG system

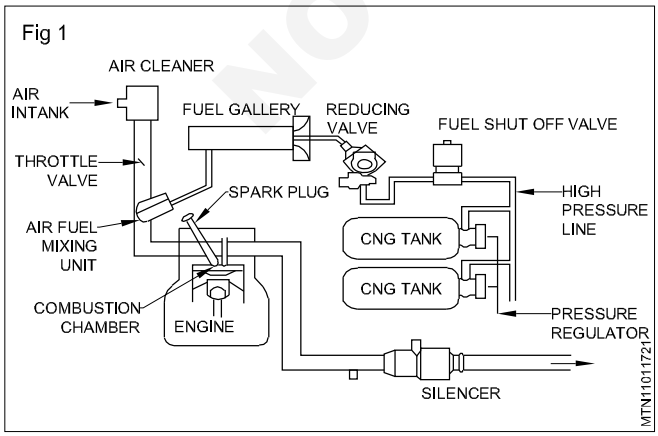
Main parts are;

1 CNG storage tank
2 Pressure regulator
3 Fuel shutoff valve
4 High pressure line
5 Reducing valve
6 Fuel gallery
7 Throttle body
8 Air-fuel mixing unit
9 Spark plug
10 Combustion chamber

Function of CNG (Fig 2)

When the ignition switch is turned on position then the gas from the CNG tank (1) thorogh a pressure regulator valve (2) is been pulled to the fuel shut off valve (3) operated by ignition solenoid.

Fig 1



This highly pressurised gas through a series of high pressure lines (4) to the reducing valve (5) where the pressure of the gas is lessened until it matches the amount needed by the fuel injection system of the vehicle.

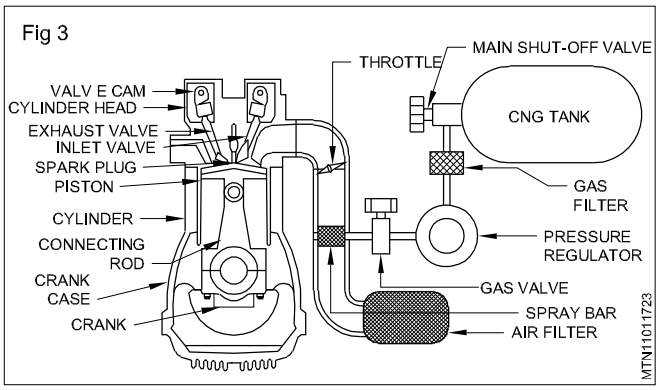
Once the gas reached to an acceptable pressure the solenoid valve (3) allows the gas to move into the fuel gallery (6) and the throttle body (7) of the system.

Just as with gasoline once the engine has received the gas through the mixing unit (8) is ignited by the spark plug (9) in the combustion chamber (10) by producing energy to power the vehicle.

Engines for three wheelers: Three wheelers work with three varieties of engine which include four-stroke petrol engines, four-stroke CNG engines and four-stroke diesel.

Four-stroke CNG Engine (Fig 3): Normally, passenger auto rickshaws use CNG engine which also works on Otto Cycle similar as four-stroke petrol engine. However, instead of petrol and air, the mixture of air and gas is supplied inside the cylinder during suction stroke. Other arrangements and components also remain same like four-stroke petrol engine. The pressurized CNG is stored in the tank located at rear side of the vehicle. The main shut-off valve is used to refill the reservoir as well as to cut the flow of CNG as and when required. The gas filter blocks the suspended impurities of CNG gas and avoids damage to the engine components. The pressure regulator plays vital role in this system.

Fig 3



The pressure regulator is primarily used to reduce the pressure of CNG flowing from reserboir to the cylinder. this is achieved by expanding the CNG. As CNG expands it gets very cold due to Joule-Thomson effect. Moisture in CNG can form ice and hydrate deposits, resulting in chocking of flow. Therefore, the pressure regulator quickly manages the varying gas composition and supplies appropriate amount of CNG. CNG is injected in the flowing air stream through the spray bar. The pressure difference between flowing air and pressure regulator helps to achieve

spontaneous injection of CNG. A conventional throttle is used to manage the flow of air+gas mixture.

Classification of three wheelers: Different types of three wheelers on the basis of fuel, weight and use are classified in the following ways:

1 With respect to use
   a Passenger Auto Rickshaw
   b Commercial Loading Auto Rickshaw
   c Special Purpose Three Wheeler
2 With respect to make
   a Passenger Auto Rickshaw: Bajaj, TVS, Piaggio, Mahindra etc.
   b Loading Auto Rickshaw: Bajaj, TVS, Piaggio, Mahindra etc.
   c Special Purpose: Harley Davidson motorbikes, ATVs etc.
3 With respect to fuel used
   a Petrol vehicle
   b CNG vehicle
   c Diesel vehicle
4 With respect to wheel configuration
   a Single front, dual rear wheel (Tadpole)
   b Dual front, single rear wheels (Delta)
5 With respect to steering configuration
   a Front wheel(s) steering vehicles
   b Rear wheel(s) steering vehicles

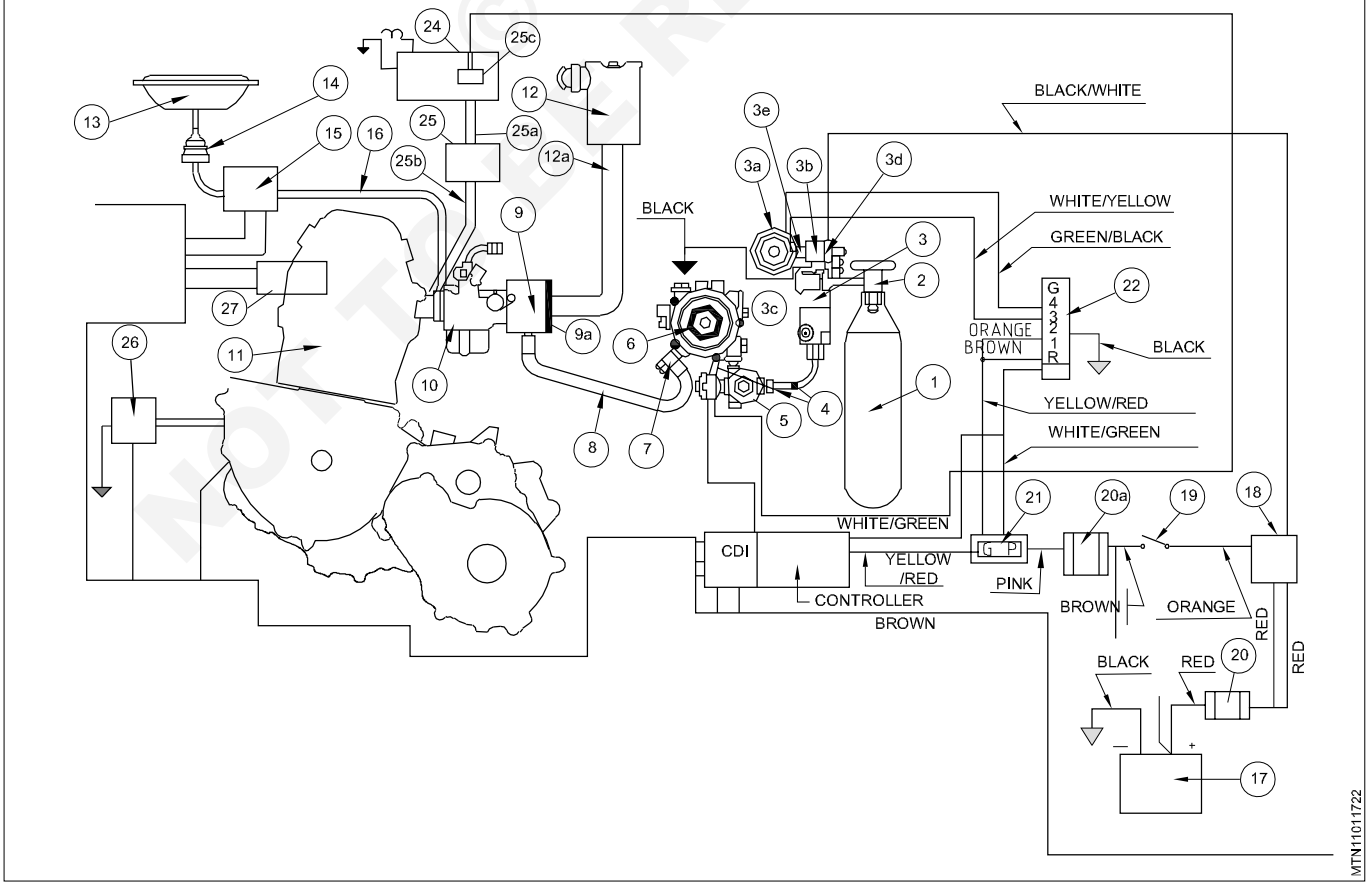
Three wheeled vehicles are mostly used either as passenger auto rickshaws or as loading auto rickshaws.

Layout of passenger rickshaw (Fig 4): Figure shows a layout of a passenger auto rickshaw. It consists of frameless structure. The vehicle body provides a strong, rigid structure on which to attach the components necessary.

To make up the vehicle. 80% of body is made up of pressed steel and rest of the body is made up of canvas, rooftop is made from flexible canvas. Transmission is provided to the rear wheels through multiplate clutch and 3-4 or 5 speed constant-mesh gear box, and sometimes through the chain drive or by using differential gear box in the rear axle. The engine is started by means of a hand lever (kick) start or electric start provided. The front steel body partly gives protection to the driver, passengers and the vehicle. It also consists a glass wind shield in front of vehicle. A wiper assembly is necessarily attached for the front wind shield. The steering mechanism, handlebar controls and brake controls are similar like scooter, as explained in respective chapters. The rear brake lever is mounted on the floor.

Rear wheel is mounted on swinging arm which is connected with frame through rear suspension. Generally the front suspensions are leading link or trailing link type.

Fig 2



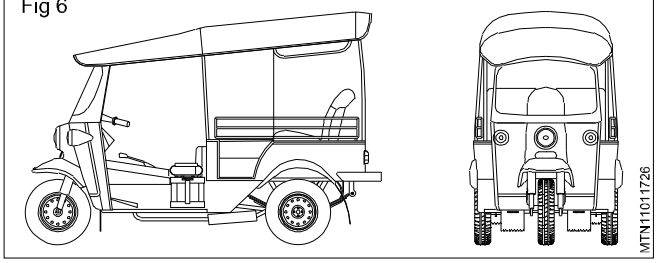
These vehicles use hydraulically operated drum brakes on all three wheels. Handbrake is also provided to park the vehicle on ascent.

Layout of loading auto rickshaw (Fig 5): Figure shows a layout of a loading auto rickshaw. As they are used as loading vehicles, they necessarily use conventional type frame and body construction. The frame endures all the load during dynamic condition.

Rear wheel is mounted either on swinging arm or on solid axle with leaf springs. Generally the front suspensions are leading link or trailing link type. These vehicles use hydraulically operated drum brakes on all three wheels. Handbrake is also provided to park the vehicle on ascent.

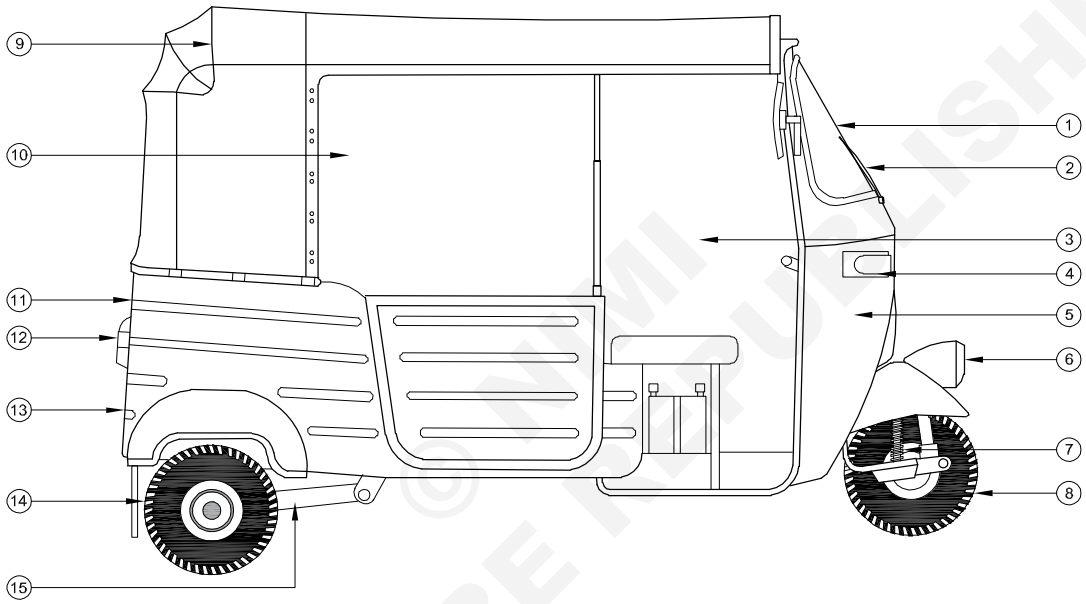
Passenger Vehicle (Fig 6): These vehicles are used for public transport. Load carrying capacity of these vehicle is much higher than normal auto rickshaws. These vehicle also incorporate flexible roof.

Fig 6



Overall dimensions and seating capacity of these vehicle are also more than normal auto rickshaws. Therefore, they are normally used for mass transportation. Figure shows a passenger vehicle.

Fig 4



1. FRONT GLASS SHIELD
2. WIPER
3. DRIVER COMPARTMENT
4. SIDE LIGHTS
5. FRONT BODY
6. HEAD LIGHT
7. FRONT SUSPENSION
8. FRONT WHEEL
9. CANVAS ROOF
10. PASSENGER COMPARTMENT
11. ENGINE COMPARTMENT
12. TAIL LIGHT
13. REAR BODY
14. REAR WHEELS
15. SWING ARMS

LAYOUT OF PASSENGER AUTO RICKSAW

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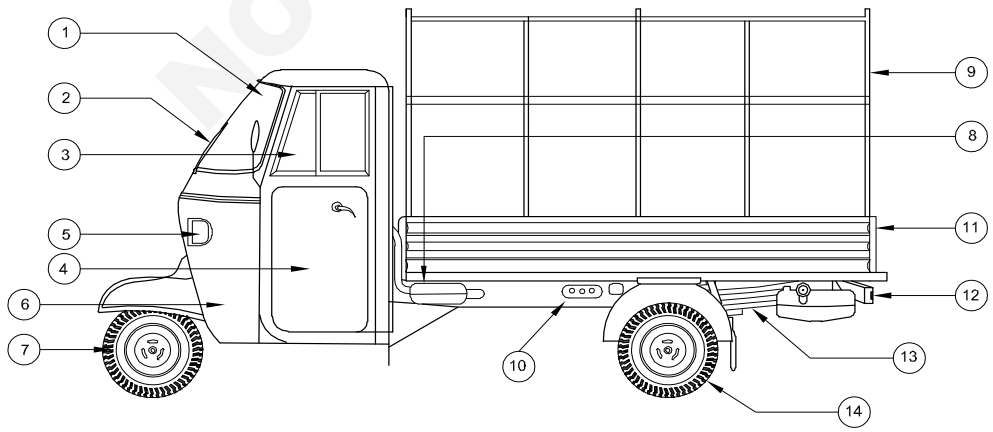
Fig 5



1. FRONT GLASS SHIELD
2. WIPER
3. DRIVER COMPARTMENT
4. DOOR
5. HEAD LIGHT
6. FRONT BODY
7. FRONT SUSPENSION
8. ENGINE COMPARTMENT
9. CARRIAGE UNIT
10. FRAME
11. CARRIAGE DOOR
12. TAIL LIGHT
13. REAR SUSPENSION
14. REAR WHEELS

LAYOUT OF LOADING AUTO RICKSAW

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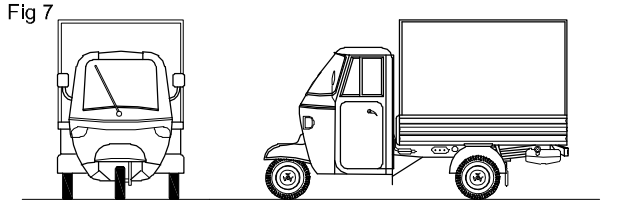
Delivery Vehicle (Fig 7): These vehicles are used to transfer lightweight goods. The rear carriage unit is fully enclosed with one or two doors at rear.

Fig 7



DELIVERY VEHICLE

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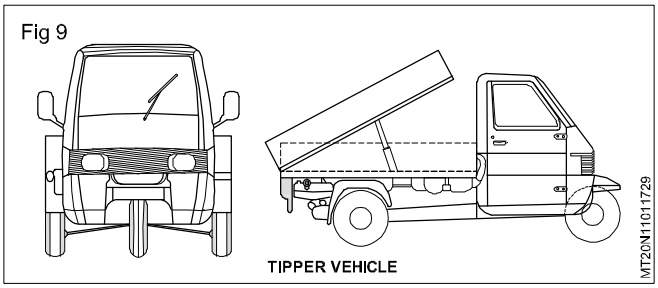
Pick Up Vehicle (Fig 8): Pick up vehicles are normally used to carry heavy goods.

Tipper Vehicle (Fig 9): The rear carriage unit of tipper vehicles is equipped with hydraulic mechanisms. This carriage unit can be lifted and set downed by these hydraulic circuits.

Drive train three wheelers (Fig 10): Both passenger and loading auto rickshaws use different drive train layout depending upon engine location. The passenger auto rickshaws use rear located engine outline with which a compact transmission unit is attached which transmit the power and torque to the drive axles. The loading auto rickshaws use centrally located engine outline which essentially needed propeller shaft to transmit power and torque.

Fig 9



TIPPER VEHICLE

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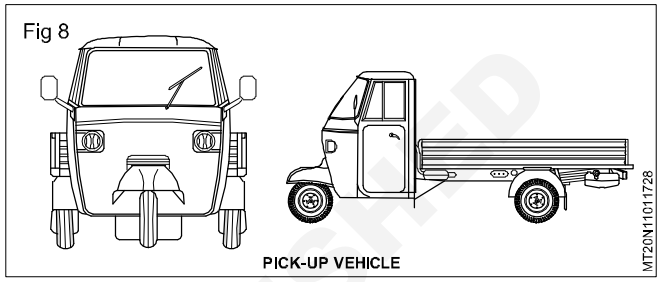
Fig 8



PICK-UP VEHICLE

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Sources of emission

Objectives : At the end of this lesson you shall be able to
- **state sources of emission**
- **state different type of emission.**

The power to move a motor vehicle comes from burning fuel in an engine. Emissions from vehicles are the by-products of this combustion process. Emissions from a motor vehicle generally come from four sources

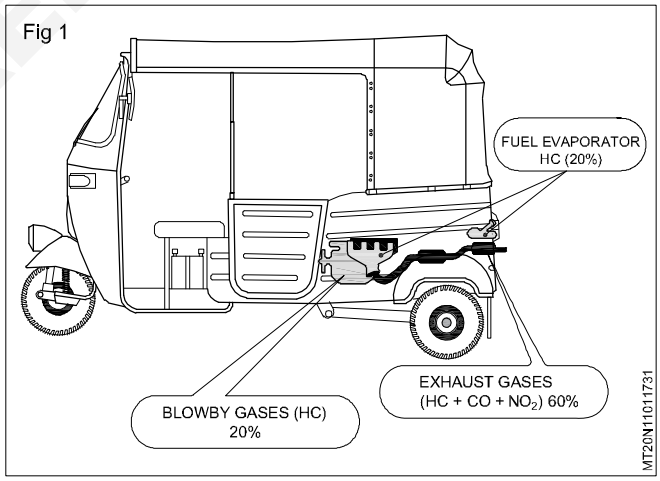
1 The fuel tank
2 The carburettor
3 The crankcase
4 The exhaust system

Evaporative Emissions: The fuel tank and carburetor allow fuel to evaporate and escape to the atmosphere. These are called evaporative emissions

Exhaust Emissions: The crankcase and exhaust system (Fig 1) emit pollutants directly from the engine into the atmosphere. They are caused when hydrocarbons, lead compounds, and oxygen and nitrogen from the air, are burned in the combustion chamber.

In a compression-ignition engine, emissions originate from the engine, and escape to the atmosphere from the exhaust, and the crankcase breather.

Fig 1



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Combustion process

Objectives : At the end of this lesson you shall be able to
- **state combustion process**
- **define perfect combustion**
- **define typical real-world engine combustion process.**

Most vehicle fuels (gasoline, diesel, natural gas, ethanol, etc.) are mixtures of hydrocarbons, compounds that contain hydrogen and carbon atoms.

In a "perfect" engine, oxygen in the air would convert all of the hydrogen in fuel to water and all of the carbon in the fuel to carbon dioxide (carbon mixed with oxygen). Nitrogen in the air would remain unaffected.

In reality, the combustion process is not "perfect," and automotive engines emit several types of pollutants:

a "Perfect" Combustion Process:

FUEL (hydrocarbons) + AIR (oxygen and nitrogen) = CARBON DIOXIDE (CO_2) + Water (H_2O) + Nitrogen

b Typical Real-World Engine Combustion Process:

FUEL (hydrocarbons) + AIR (oxygen and nitrogen) = UNBURNED or PARTIALLY BURNED HYDROCARBONS (VOCs) + NITROGEN OXIDES (NO_x) + CARBON MONOXIDE (CO) + CARBON DIOXIDE (CO_2) + Water (H_2O)

"Perfect" Combustion process is achieved by Ideal compression pressure is reached within the cylinder, condition of spark plug and timing accurate, Temperatures at correct value for engine, fuel, air, amount of fuel correct according to engines requirement.

Precise valve timing that the engine receives the correct amount of air, Electronically managed fuel injection systems use sensors and catalytic converters to control the combustion process and the air-fuel ratio supplied to the engine at all times.

Hydrocarbons

Objectives : At the end of this lesson you shall be able to
- **state the of different type Hydrocarbon compounds**
- **state the Characteristics of Hydrocarbons**
- **state the Effect of Hydrocarbons.**

- Hydrocarbons are a major source of motor vehicle emissions.
- Gasoline, diesel, LP and natural gas are all hydro carbon compounds.
- Hydrocarbon emissions react with other compounds in the atmosphere to produce photo-chemical smog.
- Gasoline needs to evaporate easily to burn properly in an internal combustion engine.

But this property also means it evaporates easily into the atmosphere at ordinary temperatures and pressures.

- When a vehicle is being refueled, hydrocarbon vapors can escape from the filler neck into the atmosphere.
- When the vehicle is left in the sun, its temperature increases, and fuel evaporates from the tank

Hydrocarbons in exhaust gases

Objective : At the end of this lesson you shall be able to
- **state the release of Hydrocarbon compounds in produced during combustion.**

In a 4-stroke gasoline engine, during valve overlap at top dead centre (TDC), some intake charge is drawn out of the combustion chamber into the exhaust port. Raw fuel, a mixture of hydrocarbons and air, is released into the atmosphere.

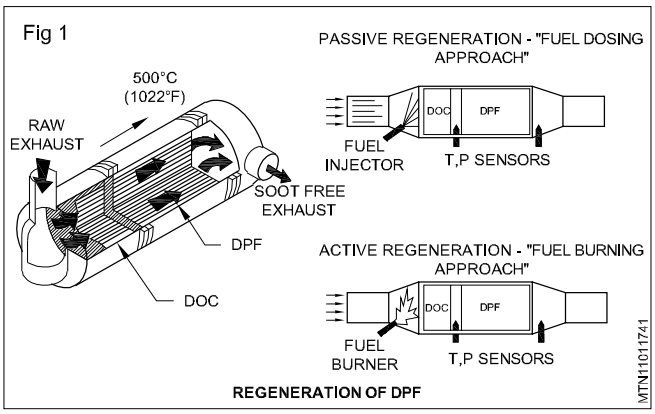
When combustion occurs in the cylinder, the walls, piston and piston rings are slightly cooler than points closer to the burning mixture. Some of the air and fuel molecules come in contact with these cooler parts, and they cool down, until their temperature becomes too low for combustion to occur. They are left unburned, and when the exhaust port opens, they leave the cylinder.

Misfiring of the ignition can result in unburned fuel leaving the cylinder when the exhaust port opens.

If an excessively rich air-fuel mixture is used, there is too much fuel for the quantity of air. Combustion will be incomplete, and any unburned fuel will leave the cylinder through the exhaust port.

If an excessively lean mixture is used, then combustion takes longer, and the flame may extinguish before it is complete. When the exhaust port opens, unburned hydrocarbons will be exhausted from the cylinder.

enters the cells that are open at the upstream end and flows through the porous walls to the adjacent cells. The adjacent cells are open at the downstream end from where the filtered gas exits to the atmosphere. Flow path of gas through walls of the filter is also shown on Fig 1.



Regeneration of DPF: It is relatively easy to filter and collect the particulate matter in the trap but the soot is to be burned in-suitable i.e., 'regenerate' the trap so that pressure drop across the filter is kept always at an acceptable level.

Burning of soot particles begins at about 540º C. Such high exhaust gas temperatures do not occur during engine operation for sufficiently long periods of .time. The diesel exhaust gas temperatures in the exhaust pipe typically reach to about 300ºC only.

Two types of regeneration systems have been investigated and a few developed for employment on production vehicles

1 Active regeneration 2 Passive regeneration

Active DPF Regeneration: In the active regeneration systems, sensors are used to monitor pressure drop across the trap. On receiving the signal from the sensor, the exhaust gas temperature is increased above

500º C by any one of the following techniques

Engine throttling: Throttling of air reduces airflow that results in decrease of overall air-fuel ratio, which increases the combustion and exhaust temperatures.

Use of electric heater upstream of filter: power to the electric heater is supplied by the engine alternator. A typical truck DPF regeneration system may require a 3 kw heater.

Use of burner upstream of filter: A diesel fuel burner is placed in the exhaust in front of the filter to regenerate the diesel particulate filter.

Passive regeneration: The passive regeneration systems (Fig) employ catalysts to reduce soot oxidation temperatures to the levels that lie within the normal exhaust gas temperature range. The catalyst is either added to diesel added to diesel fuel in the form of additives or is impregnated on the surface of the filter substrate. Another approach for passive regeneration uses a special oxidation catalyst in the front of the ceramic wall flow particulate filter to promote soot oxidation. This system is known as the continuously regeneration trap (CRT).

Sulfur content in fuels

Gasoline and diesel fuels contain sulfur as part of their chemical composition.

Sulfuric acid is produced when sulfur combines with water vapor formed during the combustion process, and some of this corrosive compound is emitted into the atmosphere through the exhaust.

High sulfur levels in fuel, when combined with water vapor, can also cause corrosive wear on valve guides and cylinder liners, which can lead to premature engine failure.

The use of proper lubricants and correct oil drain intervals helps combat this effect and reduces the degree of corrosive damage.

Although regulations have reduced the permissible levels of sulfur in fuel, there are some side effects from using low sulfur diesel fuel.

The refining process used to reduce the sulfur level can reduce the natural lubricating properties of the diesel fuel, which is essential for the lubrication and operation of fuel system components such as fuel pumps and injectors.

Crankcase emission control

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

- **state the purpose of crankcase ventilation**
- **describe the working principle of positive crank case ventilation (PCV) system**
- **explain different stages of PCV valve operation**
- **describe the working principle of crankcase depression regulator valve (CDRV) for diesel engine.**

Purpose of crankcase ventilation: The first controlled emission was crankcase vapors. While the engine is running during combustion some unburned fuel and other products of combustion leak between the piston rings and the cylinder walls, down into the crankcase. This leakage is called blow-by. Blow by gases are largely HC gases

Unburned fuel, and water from condensation, also find their way into the crankcase, and sump. When the engine reaches its full operating temperature , the water and fuel evaporate. To prevent pressure build - up, the crankcase must be ventilated.

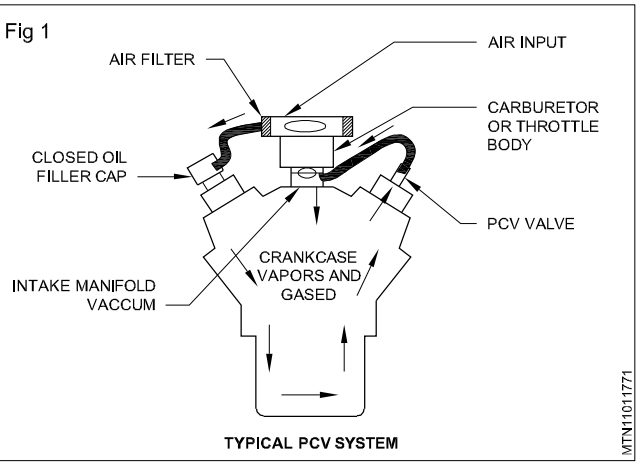
In earlier vehicles, crackcase vapors were vented directly to the atmosphere through a breather tube, or road draught tube. It was shaped to help draw the vapors from the vapors from the crankcase, as the vehicle was being driven.

Modern vehicles are required to direct crankcase breather gases and vapors back into the inlet system to be burned.

A general method of doing this is called positive crankcase ventilation, or PCV.

PCV working principle: The PCV vacuum circuit works as follows (Fig 1). Air for the system enters the air cleaner area. The air then goes through the air filter, through a tube, and through the closed oil filler cap.

Fig 1



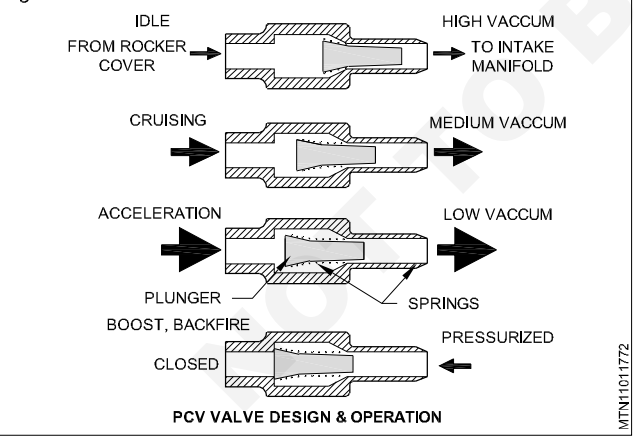
TYPICAL PCV SYSTEM

The intake mainfold vaccum the draws the crankcase vapors and gases back to the PCV valve. From the PCV valve, the vapors and gases are drawn into the intake of the engine to be burned by combustion.

If too many vapors and gases get into the intake mainfold, it may upset the air-fuel ratio. The PVC valve helps to control the amount of vapors and gases going back into the intake mainfold.

As shown in the diagram (Fig 2), the PCV valve consists of a tapered plunger and two springs, and limits the air flow based on intake mainfold vacuum.

Fig 2



PCV VALVE DESIGN & OPERATION

During idle and deceleration when blow-by gases are minimal, the low pressure (or " high" vacuum) in the intake mainfold pulls the plunger against the springs and restricts the airflow through the valve.

During acceleration and heavy-load operations when blow-by gases are at their maximum, low vacuum in the intake mainfold allows the springs to keep the plunger " back" for maximum airflow through the PCV valve.

In the case when the intake mainfold becomes pressurized, such as during boost on turbocharged engines or during backfire, the plunger's seat is forced against the valve case preventing air from entering the crankcase.

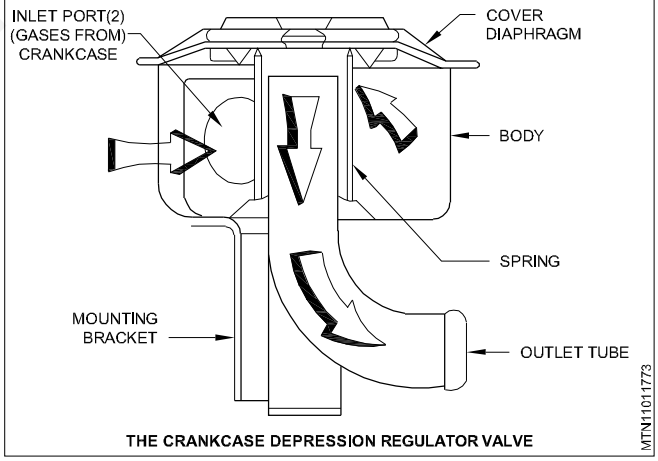
Crankcase depression regulator valve (CDRV) for diesel engine: A crankcase depression regulator valve (CDRV) is used to regulate the flow of crankcase gases back into the engine. This valve is designed to limit vacuum in the crankcase. The gases are drawn from the valve cover through the CDRV and into the intake mainfold.

Fresh air enters (Fig 3) the engine through the combination filter, check valve, and oil fill cap. This air mixes with blow-by gases and enters the opposite valve cover. These gases pass through a filter on the valve cover and are drawn into the connected tubing.

Intake mainfold vacuum acts against a spring loaded diaphragm to control the flow of crankcase gases. Higher vacuum levels pull the diaphragm close to the top of the outlet tube.

This reduces the amount of gases being drawn from the crankcase and decreases vaccum in tne crankcase. As intake vacuum decreases, the spring pushes the diaphragm away from the top of the outlet tube allowing more gases into the mainfold. The diesel crankcase ventilation system should be cleaned and inspected every 15,000 miles (24,000 km) or at 12 month intervals.

Fig 3



THE CRANKCASE DEPRESSION REGULATOR VALVE

Evaporation emission control

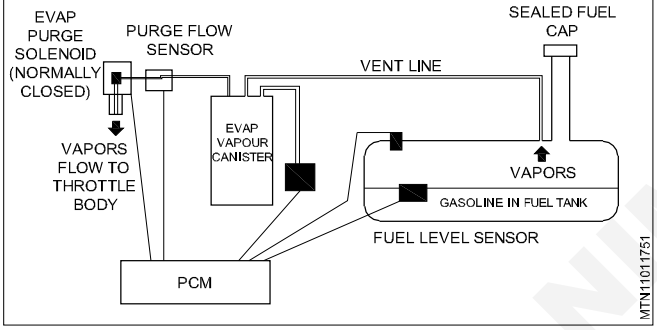
Objectives : At the end of this lesson you shall be able to
- **state the purpose of evaporation emission control (EVAP) systems.**
- **explain the working principle of evaporation emission control (EVAP) systems**
- **describe the EVAP system components.**

Purpose of Evaporation emission control (EVAP) systems: The Evaporation emission control (EVAP) systems totally eliminate fuel vapours going into the atmosphere.

Vent lines from the fuel tank and carburetor bowl route vapors to the EVAP storage canister, where they are trapped and stored until the engine is started.

When the engine is warm and the vehicle is going down the road, the PCM/ECU then opens a purge valve allowing the vapors to be drain off from the storage canister into the intake manifold. The fuel vapors are then burned in the engine (Fig 1)

Fig 1



EVAP system components: The major components of the evaporative emission control system include:

Fuel tank- This has some expansion space at the top so fuel can expand on a hot day without overflowing or forcing the EVAP system to leak.

Gas cap - This contains pressure/vacuum relief valve for venting on older vehicles (pre-OBD II), but is sealed completely (no vents) on newer vehicles (1996 & newer).

Liquid-Vapor Separator - This is located on top of the fuel tank or part of the expansion overflow tank. This device prevents liquid gasoline from entering the vent line to the EVAP canister.

Some liquid-vapor separators use a slightly different approach to keeping liquid fuel out of the canister vent line. A float and needle assembly is mounted inside the separator. If liquid enters the unit, the float rises and seats the needle valve to close the tank vent (Fig 2).

EVAP Canister - This is a small round or rectangular plastic or steel container mounted somewhere in the vehicle. It is usually hidden from view and may be located in a corner of the engine compartment or inside a rear quarter panel (Fig 3).

Fig 2

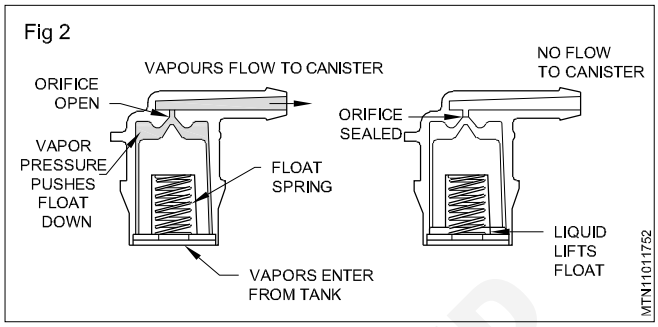
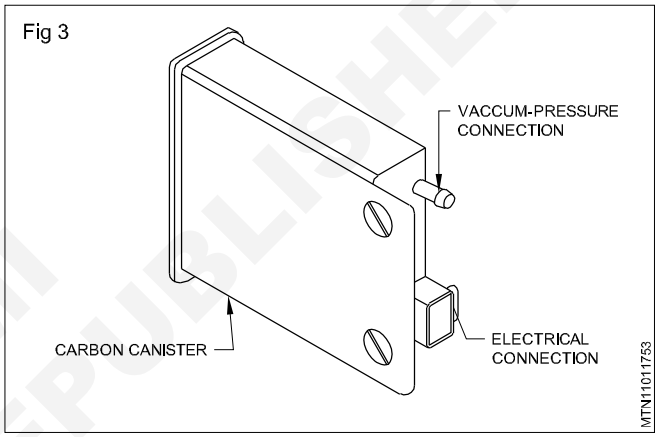
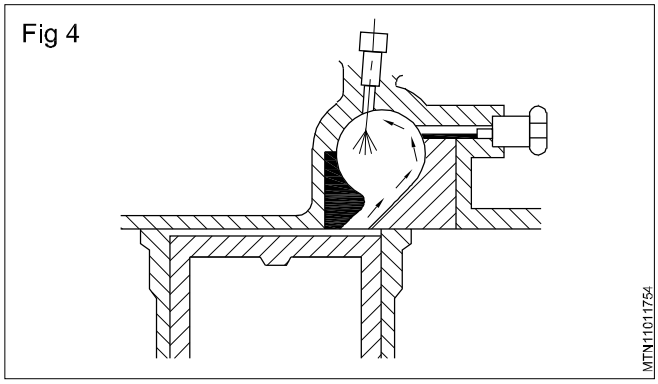


Fig 3



The canister is filled with about a kg of activated charcoal. The charcoal acts like a sponge and absorbs and stores fuel vapors. The vapors are stored in the canister until the engine is started, is warm and is being driven. The PCM then opens the canister purge valve, which allows intake vacuum to drain off the fuel vapors into the engine. The charcoal canister is connected to the fuel tank via the tank vent line.

Fig 4

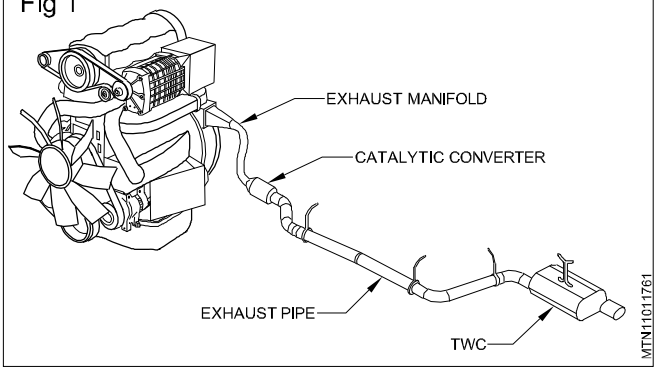


Catalytic converter

Objectives : At the end of this lesson you shall be able to
- **state the purpose of catalytic converter**
- **explain the conversion principle of catalytic converter**
- **describe the EVAP system components.**

Passenger cars and light trucks have been equipped with catalytic converters. A Catalytic converter is located (Fig 1) within the exhaust system and converts to convert harmful emissions as HC, CO, NOx, produced by an internal combustion engine, to less-harmful elements: H2O (Water), CO2 (Carbon Dioxide), and N2 (Nitrogen).

Fig 1



Block Diagram of three-way catalytic converters (TWC) (Fig 3)

Modern vehicles are fitted with three-way catalytic converters (TWC). The term 'three-way' is in relation to the three regulated emissions the converter is designed to reduce:

- Unburnt Hydrocarbons are oxidized into water/steam.
- Carbon monoxide is oxidized into carbon Dioxide
- Oxides are converted into Nitrogen and Oxygen

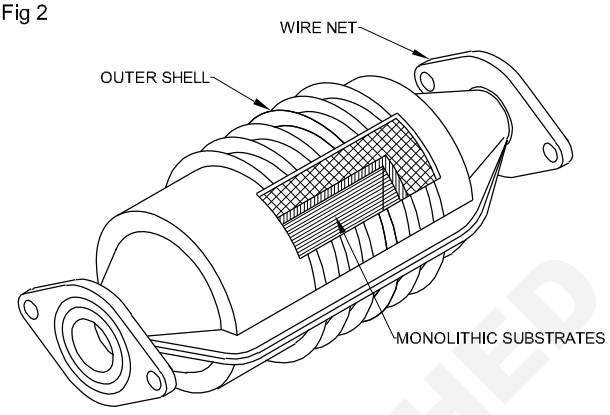
The converter uses two different types of catalysts to reduce the pollutants a reduction catalyst and an oxidation catalyst.

A honeycomb structure (Fig 2) as either ceramic or metallic is treated with a wash-coat of precious metals usually platinum, palladium and rhodium through which the exhaust gasses flow. The Surface of the honeycomb material has a rough finish such that it allows the maximum contacts are available to the exhaust gasses.

The exhaust gases first pass over the reduction catalyst in the converter. The platinum and rhodium coating helps to reduce the oxides of nitrogen, together known as 'NOX' emissions

The Three-way Catalyst, which is responsible for performing the actual feed gas conversion, formed by coating the internal substrate with the following type materials.

Fig 2



TWC - HONEYCOMB CATALYST ELEMENT

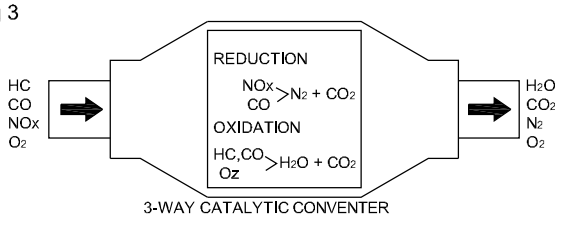
Material	Conversion for
Platinum/palladium	Oxidizing catalysts for HC and CO
Rhodium	Reducing catalyst for NOx
Cerium	Promotes oxygen storage to improve oxidation efficiency

The diagram (Fig 3) below shows the chemical reaction that takes place inside the converter.

The electronic control unit, or ECU, monitors the air-fuel ratio by using an exhaust gas oxygen, or EGO, sensor, also known as a lambda sensor. This sensor tells the engine computer how much oxygen is in the exhaust and uses this information via the ECU to control the fuel injection system.

The ECU can increase or decrease the amount of oxygen in the exhaust by adjusting the air-to-fuel ratio. The system ensures that the engine runs at close to the stoichiometric point in normal driving conditions. It also ensures that there is always sufficient oxygen in the exhaust system to allow the oxidization catalyst to deal with unburned hydrocarbons and carbon monoxide.

Fig 3



OXIDATION AND REDUCTION PROCESS

Vehicle emissions standards - Euro and Bharat

Objectives : At the end of this lesson you shall be able to
- **follow the bharat emission standards for gasoline passenger two and three wheelers**
- **follow the bharat emission standards for diesel passenger two and three wheelers.**

Emission requirements for light road vehicles have exited in the European emission standards (EU) since the early 1970s. While the first requirements for heavy came in at the end of the 1980s. Today, vehicle emissions are controlled under two basic frameworks: the "Euro Standards" and the regulation on carbon dioxide emissions.

Currently, emissions of nitrogen oxides (NO_x), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), Carbon monoxide (CO) and particulate matter (PM) are regulated for most vehicle types, including cars, lorries, trains, tractors.

While the norms help in bringing down pollution levels, it invariably results in increased vehicle cost due to the improved technology & higher fuel prices. However, this increase in private cost is offset by savings in health costs for the public, as there is lesser amount of disease causing particulate matter and pollution in the air.

Exposure to air pollution can lead to respiratory and cardiovascular diseases, which caused 620,000 easily deaths in 2010, and the health cost of air pollution in India has been assessed at 3 per cent of its GDP.

European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in Eu member states. Emission standards for passenger two and three wheelers are summarised in the following tables.

Gasoline vehicles must also meet an evaporative (SHED) limit of 2g/test (effective 2000) 3-and-2 wheel vehicles. Emission standards for 3-and-2 wheel gasoline vehicles are listed in the following tables.

Table 1 Emission Standards for 3 wheel gasoline vehicles, g/km

Year	CO	HC	$HC+NO_x$
1991	12-30	8-12	-
1996	6.75	-	5.40
2000	4.00	-	2.00
2005 (BS II)	2.25	-	2.00
2010 (BS III)	1.25	-	1.25

Table 2 Emission Standards for 2 wheel gasoline vehicles, g/km

Year	CO	HC	$HC+NO_x$
1991	12-30	8-12	-
1996	5.50	-	3.60
2000	2.00	-	2.00
2005 (BS II)	1.5	-	1.5
2010 (BS III)	1.0	-	1.0

Table 3 Emission Standards for 2&3 wheel diesel vehicles, g/km

Year	CO	$HC+NO_x$	PM
2005	1.00	0.85	0.10
2010	0.50	0.50	0.05

Architecture of electrical vehicle

Objectives: At the end of this lesson you shall be able to
- **state the architecture of electrical vehicle design**
- **state the electric drive and controller**
- **state the electric energy storage solutions**
- **state the battery management system**
- **state the control unit function**
- **state the development process of electric vehicle.**

Architecture of electrical vehicle: The internal combustion engine have a carbon based combustion process that creates heat and pollution. However the internal combustion engine is toxic and it is still one of the least efficient mechanical devices on the planet. The internal combustion engines destroy all life on the earth.

While an internal combustion engine has hundreds of moving parts, an electric motor vehicle has only one moving parts. This is the main reasons for electric two & three wheelers are so efficient.

An electric vehicle consists of battery that provides energy to electric motor that drives the wheels and a controller regulates the energy flow to the motor. An electric two wheelers are simple, highly reliable, have life time measured in millions of kilometers no need to periodic maintenance. The cost efficiently less per kilometer to operate thet vehicle. Electric vehicle are highly, flexible as well using electrical energy readily available anywhere as input fuel energy.

Electric drive and controller: The electric motor replace the internal combustion engine and provides mechanical output by working on the principle of mutual induction. The electric motor is directly installed and drive the wheels through the conventional drive train and direct layout. The electric motors are available in all types, shapes and sizes. In comparison with the internal combustion engine, electric motor produce zero pollutants.

The electric motors are equipped with only one moving part. Electric motor can develop its full power just the start. Electric motor for a small friction of time can capable to generate a power output of two to four times their continuous rating for defining acceleration and hill climbing ability, the 5 minute power rating generally used. A large part of this power rating is spoiled due to heat generated under load and high current consumption.

Therefore it becomes essential to keep the motor running with cool operation. Operating the electric motor with high current and overload conditions easily damage its various components like the field coils, armature and carbon brushes. Available horse power from electric motor increases with the amount of voltage supplied to the wheel drive motor.

DC motor consists of a coil of were that can rotate in a magnetic field. The current is supplied through two carbon brushes. These brushes create a moving contact with a split ring known as a commutator, permanent magnets are used to generate a steady magnetic field in which the coil lies. In modern DC motors the permanent magnets are substituted by another coil of were which produces its own magnetic field when current is supplied. A magnetic field creating north and south magnetism is generated due to the forces exerted on the current caring wires. The magnetism generates a force on the coil which is known as an armature. The rotational movement is created attraction of an opposite north and south poles created when current is supplied to the armature. Types of DC motors used in an electric are as follows;

- Series
- Shunt
- Compound
- Permanent magnet
- Brushless
- Universal

In electric vehicle DC drive systems are now being replaced by the AC drive systems because of their improvements in new technology. The conventional three phase source new of voltage stators is used in which winding is placed at 120°. AC motor rotor consists of aluminium conductors are connected together at both ends of the rotor through aluminium end rings. The air gap flux generating the rotor current is produced when three currents are supplied through the three symmetrically placed windings. The interface of the sinusoid ally distributed air gap flux and induced rotor currents creates a torque on the rotor. When used for adjustable speed applications, like road vehicles. AC motors are powered by inverters. The inverter helps to convert the DC power to the AC power a desired amplitude and frequency.

Components of motor

- Armature
- Commutator
- Field poles
- Carbon brushes

Motor controller

The controller plays an important role on every electric vehicle. The controller on an electric vehicle acts like a carburettor which controls the speed and power output of the drive motor. The controller is usually interfaced with the accelerator. The controller provides many other features. Such as safety interlocks and protection for electric motor.

Multiswitching control: This type of motor controller is the simplest and most basic form. Multiswitching controller makes use of different rows of batteries. These batteries are separated to form a pack that supplies various voltages as required. To provide initial driving torque, one row of batteries is engaged in the circuit. The circuit thus gets limited voltage and current on the start. As the vehicle gains some momentum, another row of batteries is switched on. Likewise, a vehicle can have four different speeds with a battery pack with four rows. Each speed is resulted by switching a row of batteries on and increasing the voltage.

Solid - state controllers: These controller use electronics to provide rapid ON/OFF switching of power to vary the motor speed. The voltage is regulated by controlling the duration of on-off pulses of power. Older controllers were operated at low switching frequency. This low operational frequency was a source of audible sound.

Pulse - width modulated controller: The PWM controller is typically used on most electric vehicles. It switches the power on and off at very high frequencies to control the vehicle speed. PWM controller is a solid-state device that uses a pulse-width modulator to send short surges of current to the motor. Most controllers are capable to regulate themselves for over current and over heating conditions. They are also capable of cutting back on power or even shutting down temporarily if required.

AC controllers: With the help of modern microprocessors and power switching devices, it is possible to manufacture highly efficient AC induction motor controller for modern electric vehicles. AC controllers offer many advantages like increased consistency, wider vehicle speed range, improved efficiency, and combination of programmable

features. AC controller also provide more accurate control and full regeneration capability. Compared with DC controllers, AC controllers can provide natural regenerative braking without extra components. AC controllers provide a constant torque for a wide range of RPM. Which results as constant acceleration irrespective of speed. This would often facilitate the vehicle to be used on one gear ratio.

Energy storage solutions: The battery charger is the one component of electric vehicle. The charger plays a major part in keeping efficient working of vehicle. Faulty charging techniques also cause of battery damage. The charger has three functions.

- To charge the battery in a safe manner and in specific time.
- To monitor and optimize the charging rate.
- To terminate the charging process of the battery to avoid over or under charging.

During battery charging process, it is very essential to supply more energy into the battery which should be faster then the chemical process.

As the chemical reaction in the battery cannot take place immediately this larger energy supply can have harmful results in many ways. Extremely high rates of charging generate heat, gassing and internal pressure in the battery. Therefore it is essential to set the charging times and charging rate at optimum value accurating to the capacity of the battery.

The most important function of the battery charger is to notice and control when to stop and finish the charging cycle. The battery life mainly depends upon the efficiency of charger sensing the cut off point and terminating the charging process. The good charger has the capacity to sense and stop the charging process before any damage occurs. The efficiency of a charger refers to the actual energy supplied as an input to charging energy delivered as an output. Electric vehicle charger are solid state and much more efficiency attaining the 95%.

Battery management systems/ Energy management system (BMS/EMS): When charging the row of batteries connected in a series, it is significant to confirm that the weaker battery receives extra charging. The cells progressively loose the chemical balance when batteries are linked in series and used as one group. As a results lower capacity cells endure quicker charging and discharging cycle.

Therefore their terminal voltage also remains higher or lower than the average charging voltage. Therefore, battery balancer is used to adjust the charge current. Battery balancer are connected to each pair of batteries to balance the charging current flowing into the batteries continuously. The power balancing system balances and maintains the batteries during charging, discharging and even during idle period battery balancing system is its easiness in adjusting to all battery system can be easily installed in new and existing electrical vehicle battery system.

The battery management system is a one step advance than a battery balancing system and controls more activities as follows;

- Monitors every cell voltage
- Field programmable and upgradable
- Intelligent cell balancing
- Enforces minimum and maximum voltages
- Enforces maximum current limits
- Monitors state of charge
- Retain data about batter history
- Integration with 3rd party smart phone apps (torque, engine link)
- Compatible with almost all lithium - iron cells
- One-click setup for many common battery types
- Support battery cells in series per BMS module.

BMS may also be combined with other systems of vehicle that converse with the MBS via CAN bus.Such systems comprise a temperature management system an antitheft device that disables the battery or side stand indicator system of the vehicle. In addition a MBS can fulfill all functions of battery balancers like protection of battery during charging, discharging protection, monitoring during charging process. The batteries are more sensitive to overcharging and discharging. When the batteries are used in a series they are generally protected with the help of BMS.

Function of electric vehicle control unit: Electric control units have facilitating the two wheelers to become smart as well. These features include engine immobilizers, ABS, antitheft alarm. Two wheeler ECU is a small computer in themselves which are essential in supporting various product features. There are different type of control systems are used in a vehicle single and multiple control units.

Single ECU central body control is directly connected to various sensors and can bus, does the processing and implements necessary action. This works best when there are not two many sensors are integrated in the vehicle design, body control module is connected to sensors through the wire harness. Functions like DC to DC conversion, drivetrain, lamp load are handled by the unit.

Multiple ECU are tasked to manage different functions. However each of them is interfaced with main control unit called the body control module. The ECU making electric two wheeler, a power house of amazing feature at the same time safe and efficient.

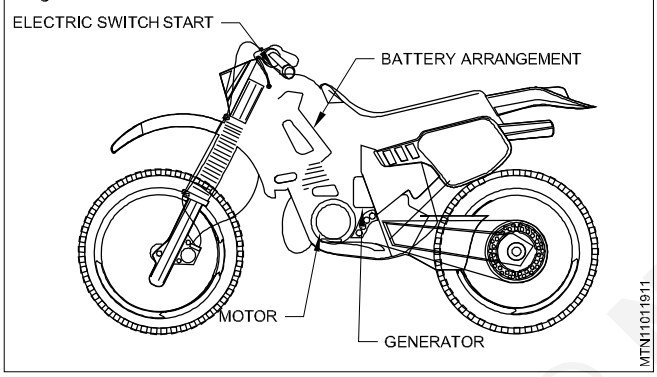
Development process of electric two wheeler: The electric two and three wheeler set up appears a lot more promissing in the form of research, financial acquisitions or investments that makes the electric vehicle segment hirelings. The innovation of internal combustion engine produce the pollution and their fuel cost is also swelling day by day. To compensate zero tail pipe emission

technologies have been held up as the last solution to transportation rated pollution problems. Electric two wheelers have been offered for several decades. Electric two wheelers with their zero tail pipe emissions, can significating improve urban air quality.

Working components of electric two wheeler (Fig 1)

- Battery
- Electric motor
- Frame
- Swing arm
- Wire harness
- Horn
- Throttle cable
- Chain
- Control unit
- Handle bar
- Fork
- Carriers
- Lights
- Display unit
- Clutch
- Wheels

Fig 1



The all above parts/components are being tested in the lab for reliability test for all electrical components, endurance test for tyre fatigue test for handlebar, water dip test for motors salt spray testing for steel parts brake wire testing, UV/Weather test for plastic painted parts and brake shoe performance testing on a dynamometer testing machine, the two wheeler electric vehicles are tested in house on the parameters of electrical performance 100% two wheelers are tested on a specially developed E-bike test track constructed for uneven bumps, rain showers, bad road conditions, water logging on roads and stop gradients on fly over.

Drive train layout of electric two wheeler (Fig 2)

There are two types of drive systems are used in electric two wheeler;

1 Direct drive system 2 Indirect drive system

The drive train layout shown in Fig 2 is known as direct drive, which is used most widely to small electric scooters. In this system two electric motors, battery controller are used (front and rear wheel motor) (Fig 2)

Fig 3 shown the indirect drive mostly used on electric motor cycles and three wheelers. Transmission, a chain or belt drive or may be a shaft drive units are conventionally used on capacity electric vehicles. The function of each components of drive train is as follow;

Fig 2

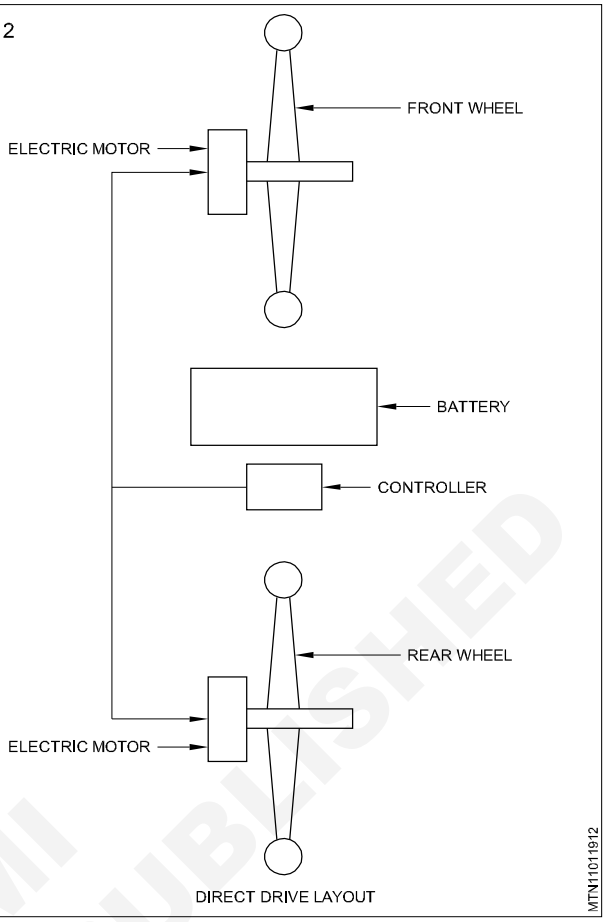
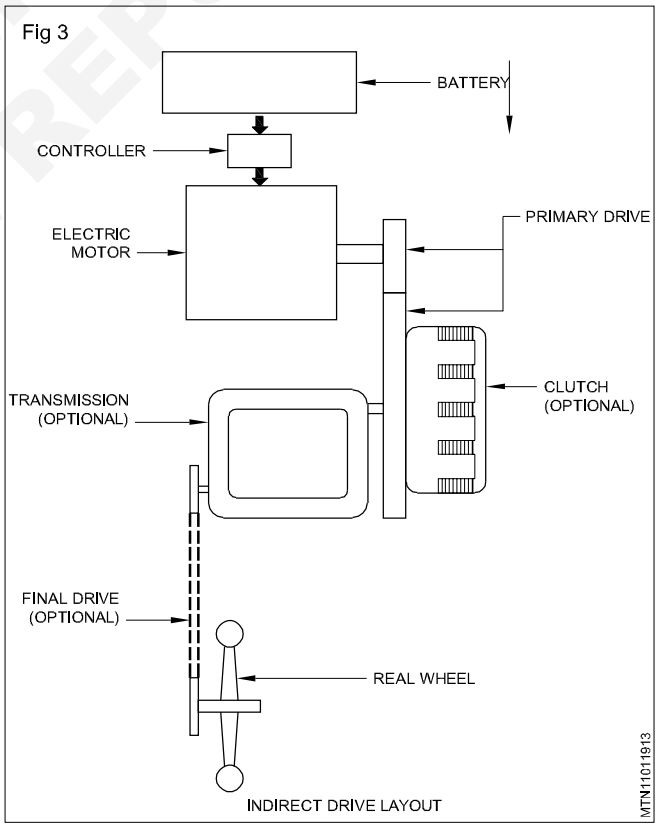


Fig 3



Battery: The main function of the battery is to deliver direct current to the electric motor and other electronics or electrical items fitted with electric vehicle. Here battery is work as a fuel for the electric vehicle. There two types of batteries are used in electric vehicle;

1 Lead acid battery 2 Lithium iron battery

Electric motor: The electric motor replace the engine and provides mechanical out by working on the principle of mutual induction. The electric motor directly installed inside driving wheel through the conventional drive train on indirect drive layout.

Controller: The controller is controlled the vehicle speed power output of the electric motor. The controller is interlinked with acceleration. The controller provides safety interlocks and protection for electric motor.

Clutch (optional): Just like an ordinary two wheeler. It disengages the power flow the motor so that transmission gears can be shifted and once engaged the vehicle can be drive from stand still to top speed.

Manual transmission (optional): It provides a number of alternative gear ratios to the motor to meet vehicle needs maximum torque for hill climbing speed or minimum speed to economical cruising at maximum speed.

Claim or belt drive: Motor is conventionally connects to drive the wheels by chain or 'V' belt.

The stability control system (SCS): It has multiple functions for which it exchanges information with the vehicle control system. The main function is to control the braking system and to provide accurate vehicle speed information to the other system. It also send out the braking torque request to the VCS.

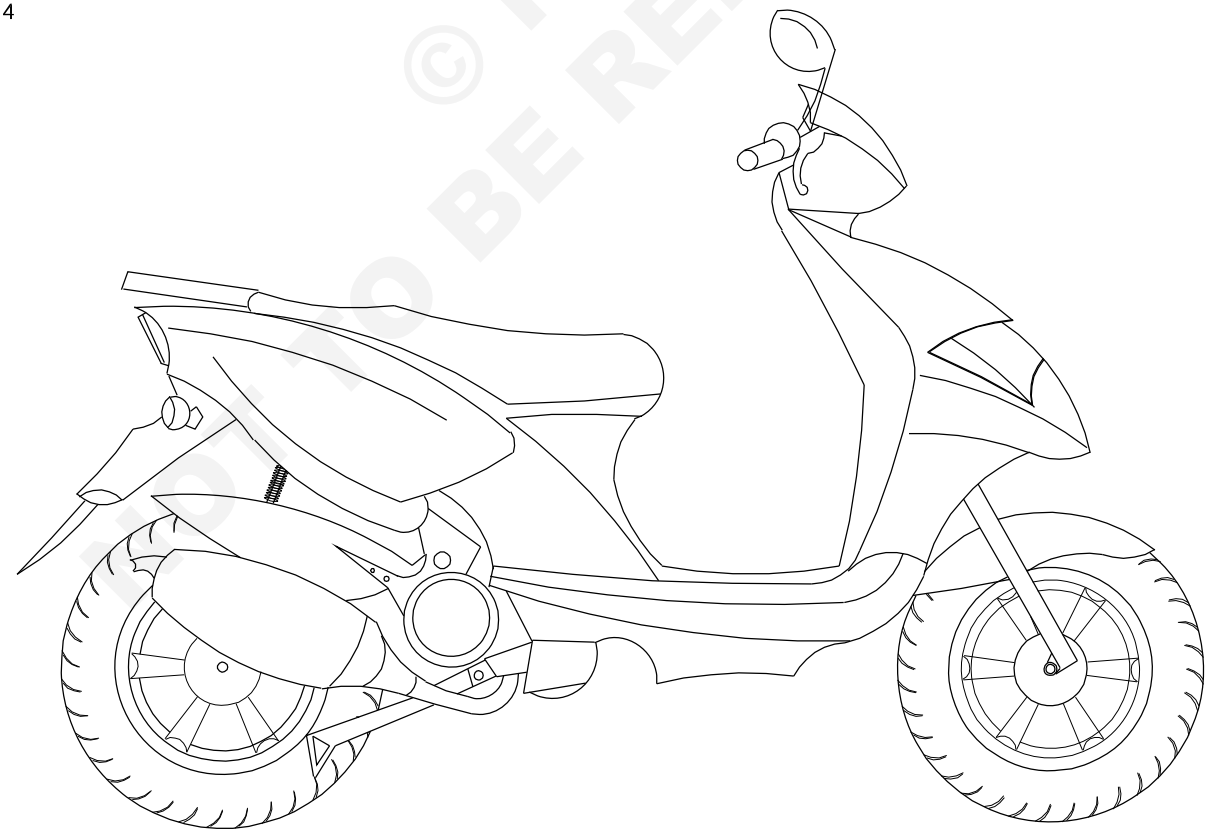
Which will apply it to the electric machine via EMCS. The idea is that the braking request from the driver need through the braking pedal/hand lever position does not translate automatically into foundation brake (hydraulic) activations. Instead the electric machines are going into generator mode providing negative torque and the vehicle is slowed down recuperating electrical energy in the same time.

For vehicle stability purposes the SCS calculates the maximum torque limits for both electric machines. Vehicle control system (VCS) makes decisions regarding the value of the electric machine torque and direction of rotation. The electric machine torque is feed back to the driver mode system and can be used to display the power train mode and level or energy recuperation. (Fig 4)

Working principle: The working starts with a battery connection. The battery consists of two terminals one is positive and another one is the negative terminal. The positive terminal is linked to the stator body of the motor on the other hand, the negative is linked to the edge of the vehicle. The battery and the motor are connected into series.

The wire connections were made for the flow of electrons starting with one section then onto the next part. At the point when the engine empowers through the current, the stator field coil gets magnetized and induces the rotor shaft to rotate in the counter clockwise direction. Towards the finish of the engine shaft significant conditions were made for the seating of clutch assembly.

Fig 4



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SCOOTER

Clutch is a power transmission gadget, which offers drive to the back wheel. The clutch get together is situated with the rotor shaft through needle orientation. On the other end of the rotor shaft an alternator is settled for the reviving framework, as it is an electrical gadget which changes over the rotational power into the electromotive power. This alternator is connected to revive the battery while vehicle is in movement. This course of action is done through V-belt pulley.

The current flows the battery with a guide of control framework to the stator body. This current makes the field coil temporarily magnetized with the goal that the rotor shaft tends to pivot in its virtual speed. As there is a V-belt drive between the pedal shaft and the grasp gathering, the movement of the vehicle is sufficiently attained.

The speed in the pedal shaft is constantly lessened with the utilization of sprockets. Here the speed decrease is in the proportion of 1:4. This game plan lessens the speed of the engine repeatedly. To the correct side of the vehicle there lies a chain drive for the pedal shaft. A free wheel is mounted on the back wheel to limit the turn of the pedal under running condition.

Principle parts of electric two wheelers framework (Fig 4)

Basically, a two wheeler gets in electricity from two sources - **a battery and an alternator.** The function of the battery is to store charge, it maintains a stated voltage and keeps the electrical system working when the engine is switched off.

On the other hand, the alternator, produces electricity when the engine is switched on. It takes care of spreading electricity to numerous electrical devices and charges the battery.

Merits and demerits of electric two wheelers

An electric vehicle greatly reduces cost expended on the fuel. However, there are other reasons also to promote the technology of electric vehicles.

Merits

- It does not require fuel
- Charging can be harnessed from any source of electricity.
- It reduces hydrocarbon and carbon monoxide, responsible for many environmental problems, by 98%.
- Electricity can be generated by renewable energy.
- Operating cost is very low as it hardly requires any maintenance.
- It also reduces noise pollutions.

Demerits

- Limited distance can be driven.
- Vehicle becomes heavier due to the electric motors, batteries, chargers and controllers.
- Battery charging takes time.
- Limited access to charging location.