MECHANIC AUTO ELECTRICAL & ELECTRONICS

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

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Duration : 1 - Year

Trade : Mechanic Auto Electrical & Electronics - 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 Auto Electrical & Electronics - 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

Addl.Secretary / Director General (Training)
Ministry of Skill Development & Entrepreneurship
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New Delhi - 110 001

PREFACE

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

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

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

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 Auto Electrical & Electronics - 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 Auto Electrical & Electronics 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	Safety Workshop Practice
Module 2	Measuring and Marking Practice
Module 3	Fastening and Fitting
Module 4	Basic Electrical and Electronics
Module 5	Vehicle Specifications and Service Equipments
Module 6	Automotive Electrical and Electronics Components
Module 7	Starting and Charging System
Module 8	Electronic Fuel and Automotive Control System
Module 9	Heating Ventilation Air Conditioning (HVAC)
Module 10	Trouble shooting in Electrical System

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 Auto Electrical & Electronics** 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	Lesson No
1	Use different types of tools and work shop equipment in the Auto work shop following safety precautions.	1.1.01 - 1.2.08
2	Perform precision measurements on the components and compare parameters with specifications used in automotive work shop practices.	1.2.09
3	Use different types of tools and work shop equipment in the Auto work shop following safety precautions.	1.3.10 - 1.3.13
4	Perform basic fitting operations used in the work shop practices and inspection of dimensions.	1.3.14 - 1.3.17
5	Construct electrical circuits and test its parameters by using electrical measuring instruments.	1.4.18 - 1.4.19
6	Perform basic electrical testing in a vehicle.	1.4.20
7	Perform battery testing and charging operations.	1.4.21 - 1.4.24
8	Construct basic electronic circuits and testing.	1.4.25 - 1.4.26
9	Check & Interpret Vehicle Specification data and VIN. Select & operate various Service Station Equipment's.	1.5.27 - 1.5.31
10	Identify the major components of LMV/HMV and dashboard gauges.	1.5.32 - 1.5.34
11	Identify and Check wiring circuits and the electrical components in the vehicle.	1.6.35 - 1.6.36
12	Trace /troubleshoot different wiring circuits in vehicle and prepare different electrical joints.	1.6.36
13	Check and overhaul the ignition system.	1.6.37 - 1.6.41
14	Apply appropriate rule and tools for starting and Charging system and diagnose & rectify faults.	1.7.42 - 1.7.51
15	Understand the constructional features and working principles of EDC/MPFI system.	1.8.52 - 1.8.60
16	Inspect power Steering control module and troubleshooting power steering.	1.9.61 - 1.9.65
17	Diagnosis for all comfort system.	1.9.66 - 1.10.69
18	Demonstrate the skill of automotive lighting system and their troubleshooting.	1.10.70 - 1.10.83
19	Trouble shoots in all electrical circuits.	1.10.84 - 1.10.89

SYLLABUS FOR MECHANIC AUTO ELECTRICAL & ELECTRONICS

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
Professional Skill 112Hrs; Professional Knowledge 25Hrs	Use different types of tools and work shop equipment in the Auto work shop following safety precautions.	1 Familiarization with institute, Job opportunities in the automobile sector, Machinery used in Trade. (10 hrs) 2 Types of work done by the students in the shop floor. (15 hrs) 3 Practical related to Safety and Health, Importance of maintenance and cleanliness of Workshop. (08 hrs) 4 Interaction with health centre and fire service station to provide demo on First aid and Fire safety, Use of fire extinguishers.(07 hrs) 5 Demonstration on safe handling and Periodic testing of lifting equipment, and Safety disposal of used engine oil. (08 hrs) 6 Energy saving Tips of ITI electricity Usage. (02 hrs) 7 Practice using all marking aids, like steel rule with spring calipers, dividers, scriber, punches, Chisel etc., Layout a work piece- for line, circle, arcs and circles.(40hrs) 8 Practice on removing and refitting of Dash Board. Front, Rear bumpers and other electrical components (22 Hrs)	Admission & introduction to the trade: Introduction to the Course duration, course content, study of the syllabus. General rule pertaining to the Institute, facilities available- Hostel, Recreation, Medical and Library working hours and time table. (07 hrs) Occupational Safety & Health Importance of Safety and general Precautions to be observed in the shop. Basic first aid, safety signs - for Danger, Warning, caution & personal safety message. 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. Energy conservation-Definition, Energy Conservation Opportunities (ECOs)-Minor ECOs and Medium ECOs, Major ECOs), Safety disposal of Used engine oil, Electrical safety tips. (07hrs) 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, center punch, pin punch, hollow punch, number and letter punch. Chisel-flat, cross- cut. Hammer- ball pein, lump, mallet. Screw drivers-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 (11 hrs)
Professional Skill 28 Hrs; Professional Knowledge 04 Hrs	Perform precision measurements on the components and compare parameters with specifications used in automotive work shop practices.	9 Practice on measuring the given component using precision measuring equipment like Vernier caliper, Micrometer (28 Hrs)	Systems of measurement, Description, care & use of - Micrometers- Outside and depth micrometer, Micrometer adjustments, Vernier calipers, Dial indicators, ,thread pitch gauge, (04hrs)

Professional Skill 56 Hrs; Profssional knowledge 10 Hrs	Use different types of tools and work shop equipment in the Auto work shop following safety precautions. Use of different type of fastening and locking devices in a vehicle.	10 Practice on General cleaning, checking and use of nut, bolts, & studs etc.(16 hrs) 11 Removal of stud/bolt from blind hole. (06 hrs) 12 Practice on cutting tools like Hacksaw, file, chisel, Sharpening of Chisels, center punch, safety precautions while grinding. (20 hrs) 13 Practice on Hacksawing and filing to given dimensions. (14 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. 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. (10 hrs)
Professional Skill 56 Hrs; Professional Knowledge 12 Hrs	Perform basic fitting operations used in the work shop practices and inspection of dimensions.	14 Practice on Marking and Drilling clear and Blind Holes, Sharpening of Twist Drills Safety precautions to be observed while using a drilling machine.(18 hrs) 15 Practice on Tapping a Clear and Blind Hole, Selection of tape drill Size, use of Lubrication, Use of stud extractor. (16 hrs) 16 Cutting Threads on a Bolt/ Stud. (10 hrs) 17 Adjustment of two piece Die, Reaming a hole/ Bush to suit the given pin/ shaft, scraping a given machined surface. (12 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, type of Laps. (12 hrs)
Professional Skill 28 Hrs; Professional Knowledge 07 Hrs	Construct electrical circuits and test its parameters by using electrical measuring instruments.	18 Practice in joining wires using soldering Iron, Construction of simple electrical circuits.(16hrs) 19 Measuring of current, voltage and resistance using digital multimeter, practice continuity test for fuses, jumper wires, fusible links, circuit breakers.(12 hrs)	Basic electricity, Ground connections, Voltmeter, ammeter, Ohmmeter, Multimeter, Conductors & insulators, Wires, Shielding, Length vs. resistance, Resistor ratings. (07 hrs)
Professional Skill 28 Hrs; Professional Knowledge 05 Hrs	Perform basic electrical testing in a vehicle.	20 Diagnose series, parallel, series -parallel circuits using Ohm's law, 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. (28 hrs)	Fuses & circuit breakers, Ballast resistor, Stripping wire insulation, cable colour codes and sizes, Resistors in Series circuits , Parallel circuits and Series-parallel circuits, Capacitors and its applications, Capacitors in series and parallel.(05 hrs)
Professional Skill 28 Hrs; Professional Knowledge 04 Hrs	Perform battery testing and charging operations.	21 Cleaning and topping up of a lead acid battery, testing battery with hydrometer. (08 hrs) 22 Connecting battery to a charger for battery charging, Inspecting & testing a battery after charging.(08 hrs) 23 Measure and Diagnose the cause(s) of excessive Key-off battery drain	Batteries & cells, Lead acid batteries & Stay Maintenance Free (SMF) batteries, Thermisters, Thermo couples, Relays, Solenoids, Charging system circuit (04 hrs)

		(parasitic draw) and do corrective action. (07 hrs) 24 Testing of relay and solenoids and its circuit. (05 hrs)	
Professional Skill 28 Hrs; Professional Knowledge 07 Hrs	Construct basic electronic circuits and testing.	25 Identify and test power and signal connectors for continuity, Identify and test different type of Diodes, NPN & PNP Transistors for its functionality.(16 hrs) 26 Construct and test simple logic circuits OR, AND & NOT and Logic gates using switches. (12 hrs)	Basic electronics: Description of Semi-conductors, 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 28Hrs; Professional Knowledge 04 Hrs	Check & Interpret Vehicle Specification data and VIN. Select & operate various Service Station Equipment's.	27 Identification of different type of Vehicle. (04 hrs) 28 Demonstration of vehicle specification data.(06 hrs) 29 Identification of vehicle information Number (VIN). (04 hrs) 30 Demonstration of Garage, Service station equipments. (07 hrs) 31 Vehicle hoists - Two post and four post hoist, Engine hoists, Jacks, Stands.(07 hrs)	Auto Industry - History, leading manufacturers, development in automobile industry, trends, new product. Brief about Ministry of Road transport & Highways, 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 -Two post and four post hoist, Engine hoists, Jacks, Stands. (04 hrs)
Professional Skill 28Hrs; Professional Knowledge 07 Hrs	Identify the major components of LMV/ HMV and dashboard gauges.	32 Identification of parts in a diesel/ petrol engine of LMV/ HMV.(08 hrs) 33 Practice on starting and stopping of diesel/petrol engines. (12 hrs) 34 Observe and report the reading of Tachometer, Odometer, temp and Fuel gauge under ideal and on load condition. (08 hrs)	Introduction to Engine: Principle & working of 4-stroke diesel engine (Compression ignition Engine (C.I), Principle of Spark Ignition Engine (SI), difference between C.I. engine and S.I Engine, 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 gear shift position, Seat belt warning light, Parking-brake-engagement warning light and an Engine-malfunction light. Different type of starting and Stopping method of Petrol/Diesel Engine. (07 hrs)
Professional Skill 28Hrs; Professional Knowledge 07 Hrs	Identify and Check wiring circuits and the electrical components in the vehicle.	35 Practice to identify components and their locations indicated on the wiring diagram. (12 hrs) 36 Practice to identify the power source, ground connection, and controls for electrical circuits using a wiring diagram.(16 hrs)	Electrical and Electronic Components:- Switches-Description of Normally open, Normally closed, single pole single throw switch (SPST), ganged, and mercury switches used in Automobile circuit. Description of Relay, ISO Relays, Solenoids, Buzzers. Resistors- Description of different type of resistors and their color codes - Fixed, stepped, and variable resistors-Rheostat, Potentiometer. Description of Diodes, Diode identification and ratings, zener diodes, Avalanche diodes, Light emitting diodes, photo diodes and clamping diodes.

			Transistors- Description of NPN, PNP, field-effect transistor (FET), phototransistors. Description of Integrated circuits. Circuit protection devices- Description of fuses, different type of fuses- glass or ceramic, blade and bullet or cartridge fuses. Fusible links, maxi fuses, circuit breaker, Positive Temperature coefficient (PTC) resistor device. (07 hrs)
Professional Skill 28Hrs; Professional Knowledge 05 Hrs	Trace /troubleshoot different wiring circuits in vehicle and prepare different electrical joints.	36 A Diagnosis and remedy for- Speedometer shows no operation, fuel level meter shows no operation, coolant temp meter shows no operation, Oil pressure light shows no lighting. (28 hrs)	Wiring and circuit diagrams- Automotive wiring. Comparison between solid and stranded primary wire. Description of wire size- Metric and American wire gauge (AWG), Importance of ground straps used in automotive wiring. Description of different type of terminals and connectors- Molded, multiple-wire hard shell, bulkhead, weather-pack, metri-pack, heat-shrink covered butt connectors. Importance of printed circuit boards, wiring harnesses, wiring diagrams and color codes and circuit numbering. Study of common electrical and electronic symbols used in wiring diagrams. (05 hrs)
Professional Skill 28 Hrs; Professional Knowledge 04 Hrs	Check and overhaul the ignition system.	37 Check and replace ignition coil, Check ignition timing, Checking & changing a spark plug (04 hrs) 38 Diagnosis- Possible causes and remedy for Engine cranks, but will not or hard to start, Poor fuel economy or engine performance. (06 hrs) 39 Identification and testing of Hall effect sensor, Optical sensor. (08 hrs) 40 Tracing and testing of sensor circuits.(05 hrs) 41 Tracing of Distributor less ignition systems circuit. (05 hrs)	Ignition principles and Primary and secondary winding of Ignition components, Spark plugs, Spark plug components, ballast resistor coil, Dwell angle, Spark timing. Battery power source, Description and function of Capacitor/condenser, High-tension leads, Induction wiring, Hall effect sensors, Hall effect operation, Optical type sensors Distributor less ignition systems, Insulated coils, Distributor less ignition system timing. (14 hrs)
Professional Skill 56Hrs; Professional Knowledge 10Hrs	Apply appropriate rule and tools for starting and Charging system and diagnose & rectify faults.	42 Removing starter motor from vehicle, and Performance test for pull-in test, Hold-in test, pinion (plunger) return test, No- load performance test. (08 hrs) 43 Solenoid test for Hold in coil open circuit, Armature test - Ground test, Open circuit test, pull-in coil open circuit test, field coil test. (04hrs) 44 Inspections of brush length wear as per service manual. (02 hrs) 45 Trouble shooting, possible causes and remedy for starter motor not running, Starting motor running but too slow (small torque), staring motor running, but not cranking engine. Noise, starting motor does not stop	Starting system- purpose of starting system, Staring system components, Starter motor principles, study of starter control circuits. Starter motor construction, Starter magnet types, Starter motor engagement, Commutation, Switching, solenoid

		running. Growler testing for rotors.(08hrs) 46 Checking a starting system, Jump-starting a vehicle. (06 hrs)	
		47 Checking a charging system for the Cause of undercharge, No charge, and over charge conditions. (04 hrs) 48 Removing & replacing an alternator, Inspection of rotor for ground, open circuit - field coil resistance, slip ring surface, Fan, bearing. (06 hrs) 49 Inspection of stator for ground, open circuit, Inspection of Drive end bearing rotation, Rectifier, brush length compare with service manual. (06 hrs) 50 Slip ring surface. Inspecting & adjusting an engine drive belt, replacing an engine drive belt / pulleys / Tesnionsers and their alignments. (06 hrs) 51 Trouble shooting, possible causes and remedy for warning lamp does not glow when ignition switch is on, Warning lamp glows dim when ignition switch is on, warning lamp 'on' while the alternator is running, Warning lamp glows 'dim' while the alternator is running, warning lamp flickers considerably. (06 hrs)	construction. (05 hrs) Charging system- The purpose of Charging system, charging system components, charging system circuit, Alternator principles, Alternating current, Alternator components, Rectification, Phase winding connections, Rotor circuit, Voltage regulation, System operating voltage, High voltage charging systems, Rotor, Stator, Alternator end frames, Slip ring & brush assembly, Rectifier assembly, Alternator cooling fan. (05 hrs)
Professional Skill 84 Hrs; Professional Knowledge 12 Hrs	Understand the constructional features and working principles of EDC/MPFI system.	52 Identification of EDC components, sensors, testing of sensors and actuators. (14 hrs) 53 Identification of various components of MPFI system.(06hrs) 54 Testing of MPFI components and replacement if necessary. (04 hrs) 55 Check delivery from fuel Pump. Replacing a fuel filter. (02 hrs) 56 Identification of Electronic control Unit. (07hrs) 57 Set up for testing, Testing of Electronic Control Circuit. (08 hrs) 58 Fault finding in Electronic circuit and remedies using scan tool. (18hrs) 59 Identification of various sensors installed in engine & its mounting. (10 hrs) 60 Testing of Temperature sensor, Pressure senor, potentiometer, magnetic induction sensor, cam shaft sensor, crankshaft position sensor. (15 hrs)	Electronic Diesel control- Electronic Diesel control systems, Common Rail Diesel Injection (CRDI) system, Hydraulically actuated electronically controlled unit injector (HEUI) diesel injection system. Sensors, actuators and ECU (Electronic Control Unit) used in Diesel Engines. Introduction to Electronic fuel injection (EFI) fuel supply system, Multi-point injection systems (MPI/MPFI), EFI air cleaners, Electronic mufflers, EFI fuel supply system components- Description of Fuel pumps, EFI sensors, Potentiometer, Auxiliary air valves, Idle speed control devices, Inertia sensors. Introduction to EFI Engine Management - EFI operation Modes of EFI, Idle speed control systems, Feedback & looping, Cold start systems, Air measurement, Air-flow monitoring, Variable intake manifold system, Electrical functions, EFI wiring diagram, Electronic control unit - ECU, EFI system ECU, Electronic control unit settings, Engine speed limiting, Malfunction indicator lamp. Importance of Diagnostic Trouble Code (DTC) & its general format. Use of scan tool and retrievals of codes. (07hrs)

			EFI sensors- Description, location and function of Intake Temperature sensor, Mass airflow sensor, Manifold absolute pressure sensor, Air vortex sensor, Fuel system sensor, Throttle position sensor, Exhaust gas oxygen sensor, Crank angle sensor, Hall effect voltage sensor. (05 hrs)
Professional Skill 28 Hrs; Professional Knowledge 07 Hrs	Inspect power Steering control module and trouble shooting power steering.	61 Inspection of power steering control module circuit. (04 hrs) 62 Trouble shooting and remedy for steering wheel feels heavy at low speed, poor recovery from turns, Vehicle pulls to one side during straight driving. (06 hrs) 63 Identification of ABS components, checking of ABS warning lamp. (04 hrs) 64 Identification of Automatic transmission components. (04 hrs) 65 Inspection of shift lever switch, throttle position sensor, speed sensor and automatic transmission wiring harness coupler.(10 hrs)	Steering, suspension and Brakes:- Description of Electric power assisted steering and it's wiring circuit. Basic electric power steering operation, Electronic adjustable-rate shock absorbers, Electric brakes, Electro hydraulic braking (EHB), ABS brake system, Antilock braking system operation, Principles of ABS braking, ABS master cylinder, Hydraulic control unit, Wheel speed sensors, ABS with Electronic Brake force Distribution (EBD) control unit. Electronic control transmission- Electronic control Unit, Fully hydraulically controlled transmission, Electronic shift programs, Manual selection. (07 hrs)
Professional Skill 56 Hrs; Professional Knowledge 10 Hrs	Diagnosis for all comfort system.	66 Identification of Air conditioning components, Performance test on A/c unit, Checking Charged state of refrigerant, Inspecting & adjusting an engine drive belt, replacing an engine drive belt. 67 Checking a heating system, Compressor rotation test, air Gap check, Refrigerant recovery - evacuating -charging of A/c system. 68 Replenishing compressor oil level Trouble diagnose and remedy for No cooling or warm air, Cool air comes out only intermittently, cool air comes out only at high, Insufficient cooling, Abnormal noise from compressor Magnetic clutch, condenser, evaporator, blower motor. 69 Diagnosis test for high pressure gauge pressure high low, pressure	Heating Ventilation Air Conditioning (HVAC) legislation, Vehicle heating, ventilation & cooling systems, Basic air-conditioning principles, Air-conditioning capacity, Air-conditioning refrigerant, Humidity, Description and function of Fixed orifice, Control devices, Thermostatic expansion valve system, Thermal expansion valves, Air-conditioning compressors, Condensers & evaporators, Receiver drier, Lines & hoses, TX valve construction, Temperature monitoring thermostat, Refrigerants, Pressure switches, Heating elements. Air-conditioning ECU, Ambient air temperature sensor, Servo motors, Electric servo motors, Automatic climate control sensors, Evaporator temperature sensor, Blower speed control, Ventilation systems. (10 hrs)
Professional Skill 56 Hrs; Professional Knowledge 10 Hrs	Demonstrate the skill of automotive lighting system and their trouble shooting.	gauge for pressure high low.(56 hrs) 70. Trace the light circuit - test bulbs, align head lamps, aiming headlights. (02 hrs) 71 Changing a headlight bulb, checking of a head light switch and to replace if faulty. (02 hrs) 72 Trouble shooting and remedy for Headlight - headlight do not light up, only one headlight does not light up, Only one beam ("Hi" or "Lo") does not light.(04 hrs) 73 Trouble shooting and remedy for	Discharge (HID) headlights. Headlight & dimmer circuits, Park & tail light circuits, Brake light circuits, turn signal circuit, Cornering lights, Fog lights circuit, interior lights- courtesy, reading and instrument panel lights, Smart lighting , Reverse lights. (10 hrs)

		turn signal and hazard warning lights -Flash rate high or one side only flashes, No Flashing, flash rate low.(04 hrs) 74 Trouble shooting and remedy for clearance, tail and license plate lights -All lights do not light up, some lights do not light up.(02hrs) 75 Trouble shooting and remedy for Back-up light - Back-up lights do not light up. (03 hrs) 76 Trouble shooting and remedy for Brake lights - Brake lights do not light up, Brake light stay on.(03 hrs) 77 Trouble shooting and remedy for fuel meter and fuel gauge unit - Fuel meter shows no operation or incorrect operation. (03hrs) 78 Trouble shooting and remedy for Engine coolant Temp (ECT) meter and ECT Sensor - Engine coolant temp meter shows no operation or incorrect operation.(04 hrs) 79 Lighting system, Lamps/light bulbs, Lamp/light bulb information, LED lighting, Headlights-description of standard sealed beam, halogen sealed beam, composite and high intensity discharge (HID) headlights. (08 hrs) 80 Headlight & dimmer circuits, Park & tail light circuits, Brake light circuits, turn signal circuit, Cornering lights, Fog lights circuit, interior lights- courtesy, reading and Trouble shooting and remedy for oil pressure light - Oil pressure warning light does not light up when ignition switch is on at engine off.(08 hrs) 81 Trouble shooting and remedy for brake and parking brake warning light- Brake warning light does not light up when fluid flow level, Brake warning light does not light up when parking brake pull up, Brake warning lights stay on.(09 hrs) 82 Trouble shooting and remedy for interior light- Interior light do not light up.(02hrs) 83 Trace the wiring circuit of traffic signal flashers light circuit-tracing defects in the flasher circuits, replacing fuse bulb.(02hrs)	
Professional Skill 56 Hrs; Professional Knowledge 10 Hrs	Trouble shoots in all electrical circuits.	84 Trouble shooting and remedy for Horn- No horn operation, poor sound quality, horn sounds continuously and to replace the horn if faulty. (12 hrs)	Accessories: Horn circuit, wiper circuit, power window components and circuit. Power door lock circuit, automatic door lock circuit, remote keyless entry system circuit, antitheft system, immobilizer system.

		85 Remove and install wiper motors and wiper switches.(08 hrs) 86 Checking & replacing wiper blades.(08 hrs) 87 Trouble shooting and remedy for windshield wiper and washer - no operation, intermittent operation, continuous operation, and wipers will not park. (08 hrs) 88 Diagnose causes for improper operation of the windshield washer system and to replace the pump if faulty. (10 hrs) 89 Diagnose the power window system for - all power window motors do not operate, some switches do not operate. (10 hrs)	Navigation system, Car radio and cassette player, car videos. Description and function of Airbags, Seatbelt, Vehicle safety systems, Crash sensors, Seat belt pre-tensioners, Tire pressure monitoring systems Integrated communications, Proximity sensors, Reflective displays, Global positioning satellites, Triangulation/ trilateration, Telematics. Application of Automotive bus system-currently used in cars: CAN (Control Area Network) , LIN (Local Interconnect Network), FlexRay™ and MOST (Media Oriented Systems Transport)., Importance of E/E Architecture. (10 hrs)

Organization of ITIs and scope of the Mechanic Auto Electrical & Electronics

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

Brief Introduction of Industrial Training Institute (ITIs)

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

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

They are giving training about 132 trades including Engineering and Non-engineering trades with the duration of 1 or 2 years. The minimum eligibility for admission in ITIs 8th, 10th and 12th pass with respect to the trades and admission process will be held in every year in July.

From 2018 annual pattern was introduced with implemented revised syllabus.

At the end of each year, All India Trade Test (AITT) will be conducted in every July with multiple choice type questions. After passing, National trade certificates (NTC), will be issued by DGT which is authorized and recognized internationally.

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

Scope of the Mechanic Auto Electrical & Electronics trade

Objective: At the end of this lesson you shall be able to
- **state the importance and scope of the mechanic auto electrical & electronics trade training.**

Scope of the Mechanic auto electrical & electronics training : Mechanic auto electrical & electronics trade under Craftsmen Training Scheme (CTS) is one of the most popular trade delivered nation wide through the network of ITI. This trade training duration is one year.

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

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

Job Opportunities

- Mechanic auto electrical & electronic can join in central and state government establishments, like railway, airport, marine, military and automobile industry.
- employment opportunities in overseas.

Self - employment opportunities

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

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

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

Do not interfere in other's activities.

Attentive 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 and 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.

Prepare well before writing a test/examination.

Avoid any malpractice during the test/examination.

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

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

Time-table

Practical and theory class hours are schedulated in advance and working hours as generally 8 hrs included lunch hours

Course Content in the syllabus: Introduction to the auto industry engine, charging and starting systems. Electronics fuel system, stearing, suspension, brake and HVAC system.

- Identify the various types of tools equipment, raw materials, spares used in mechanic Motor vehicle 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 Auto Electrical & Electronics circuits.

Facilities in I.T.I: Hostel, first aid provision, visiting doctor's and facility 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 the types of occupational hazards.**

Safety

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

Occupational health and safety

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

Need of occupational health and safety

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

Occupational (Industrial) Hygiene

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

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

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

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

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

Occupational Hazards

"Source or situation with a potential for harm in terms of

injury or ill health, damage to property, damage to the workplace environment, or a combination of these"

Types of occupational health hazards;

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 (ionising & Nonionising)
- Illumination etc.,

2 Chemical Hazards

- Inflammable
- Explosive
- Toxic
- Corrosive
- Radioactive

3 Biological Hazards

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

4 Physiological

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

5 Psychological

- Wrong attitude
- Smoking
- Alcoholism
- Unskilled
- Poor discipline
  - 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 have to 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 planning and organising work, by training the people, and engaging the 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, in the working conditions, which employees are asked to do, and the training given to them.

Employee's responsibilities: You will be responsible for use the equipment, with safety precaution and the experience of your training, and your general attitude to safety work and follow the organisation standing orders.

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.

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

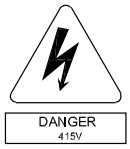
Prohibition signs (Fig 1)

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

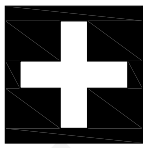
Shape	Circular.
Colour	White symbol on blue background.
Meaning	Shows what must be done.
Example	Wear hand protection.

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

WARNING SIGNS

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.

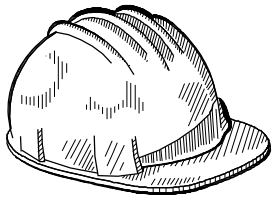
They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

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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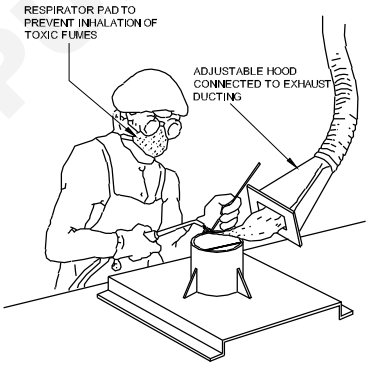
Fig 3



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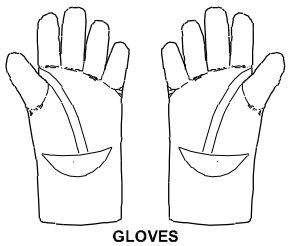
Common type of personal protective equipments and their uses and hazards are as follows

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

Types of protection	Hazards	PPE to be used
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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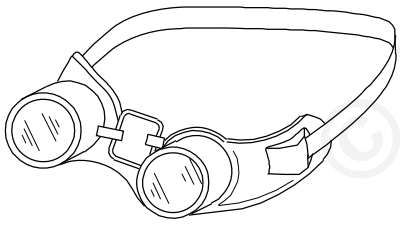
Fig 5



GOGGLES

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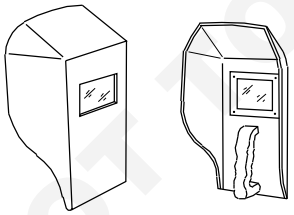
Fig 6



HAND SCREEN

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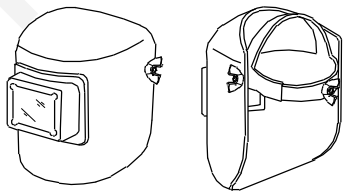
Fig 7



WELDING HELMET

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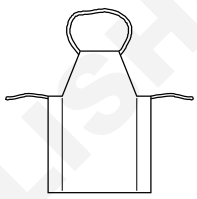
Fig 8



APRON

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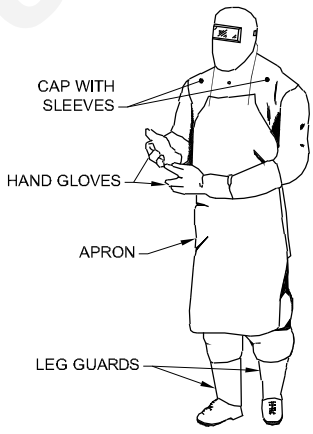
Fig 9



LEG GUARDS

AEN110129

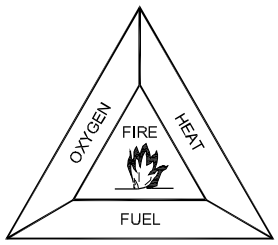
Safety practice - fire extinguishers

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.

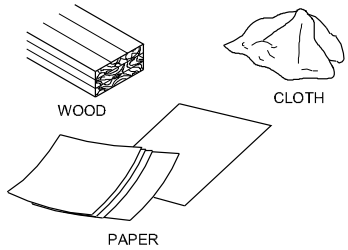
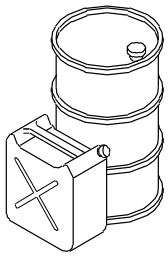
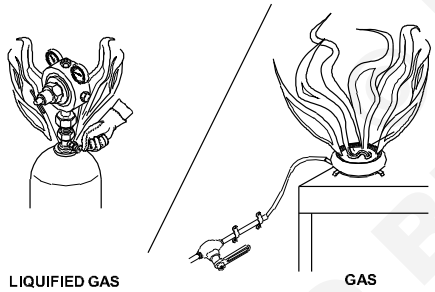
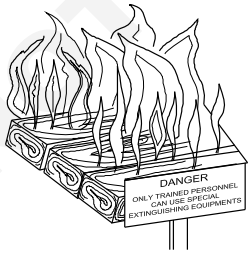
Blowlamps and torches must not be left burning when they are not in use.

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

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.

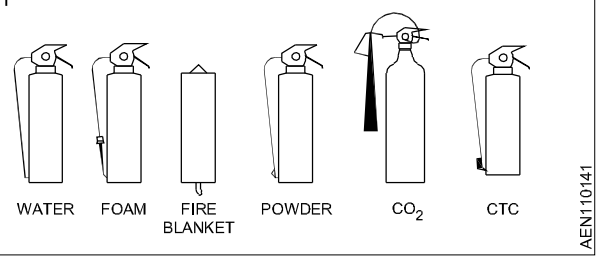
Fuel	Extinguishing
Fig 2 CLASS 'A' FIRE  AEN110132	Most effective ie. cooling with water. Jets of water should be sprayed on the base of the fire and then gradually upwards.
Fig 3 CLASS 'B' FIRE  FLAMMABLE LIQUIDS AND LIQUIFIABLE SOLIDS AEN110133	Should be smothered. The aim is to cover the entire surface 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  LIQUIFIED GAS GAS AEN110134	Extreme caution is necessary in dealing with liquefied gases. There is a risk of explosion and sudden outbreak of fire in the entire vicinity. If an appliance fed from a cylinder catches fire - shut off the supply of gas. The safest course is to raise an alarm and leave the fire to be dealt with by trained personnel. Dry powder extinguishers are used on this type of fire. Special powders have now been developed which are capable of controlling and/or extinguishing this type of fire.
Fig 5 CLASS 'D' FIRE  METALS AEN110135	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.**

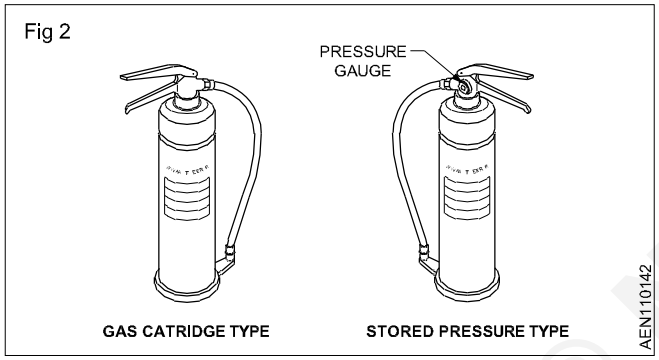
Many types of fire extinguishers are available with different extinguishing 'agents' to deal with different classes of fires. (Fig 1)

Fig 1



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

Fig 2

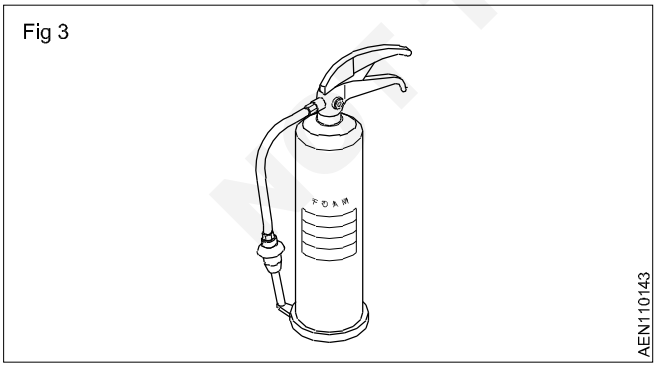


– Gas cartridge type
– Stored pressure type

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

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

Fig 3



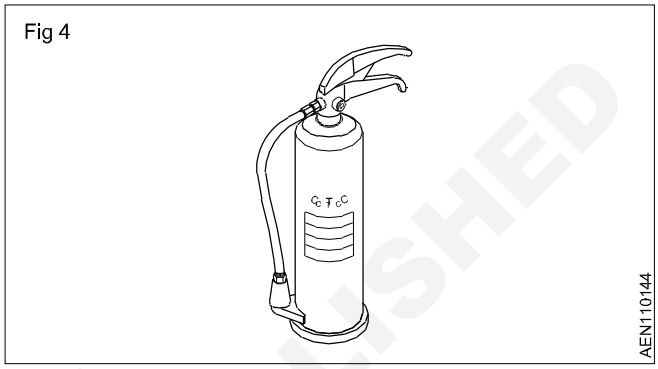
Most suitable for

– flammable liquid fires
– running liquid fires.

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

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

Fig 4

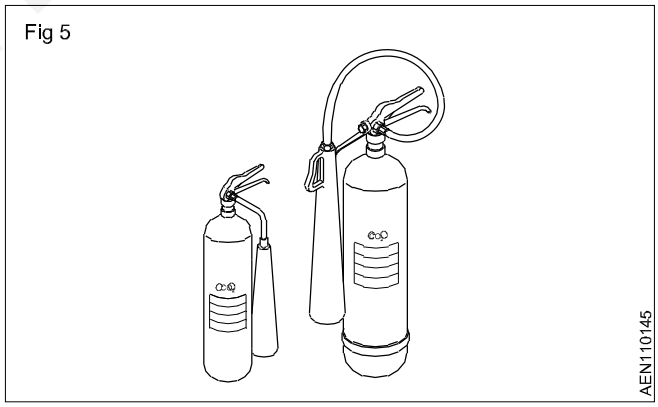


Carbon dioxide (CO_2): This type is easily distinguished by the distinctively shaped discharge horn. (Fig 5).

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.

Fig 5

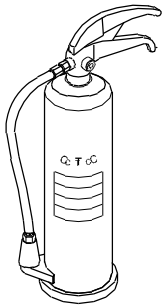


Halon extinguishers (Fig 6): These extinguishers may be filled with carbon-tetrachloride and Bromochlorodifluoro methane (BCF). They may be either gas cartridge or stored pressure type.

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 procedure

- 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 unburn 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.
- Always support the 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.
- Check the Hydraulic lift (or) cranes oil level and top up the oil level periodically.
- Check the function of the lifting equipments.
- The Hydraulic oil used in the lifts or cranes should be replaced periodically.
- The lifting equipment should be over hauled once (or) twice a year.
- Check the electrical connections of the lifting equipment periodically.
- Calibration of the lifting equipment should be done once in a year and calibration certificate must be obtained from the authorized testing center.

Energy conservation process

Objectives: At the end of this lesson you shall be able to
- **state the electrical safety tips**
- **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 ¼th 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.

Electrical safety precautions

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 Donot 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 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

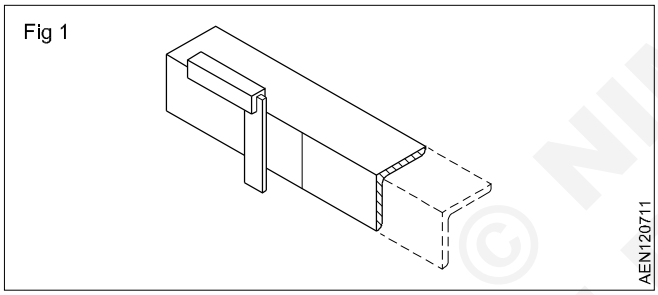
Chalk mixed with methylated spirit

White lead powder mixed with turpentine

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

Whitewash is not recommended for workpieces of high accuracy.

Fig 1



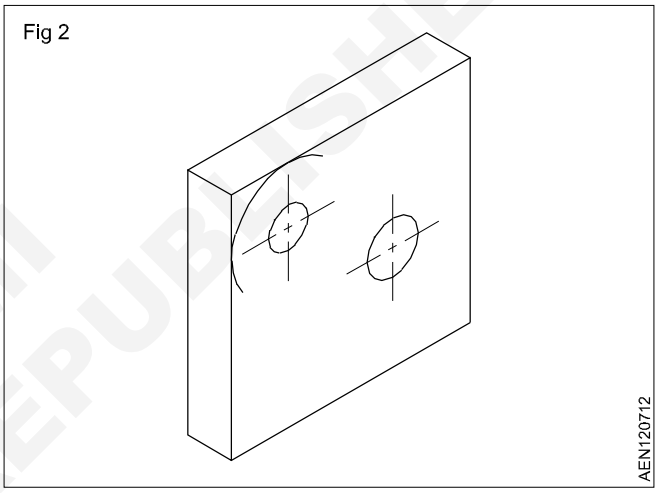
Cellulose lacquer

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



Cleaning tools

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

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

The general cleaning tools are

1 Wire brushes

2 Emery sheets.

Wire brushes

Wire brushes are generally used for cleaning the work surfaces.

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

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

Applications

1 Wire brushes can be used for cleaning uneven surfaces

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

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

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

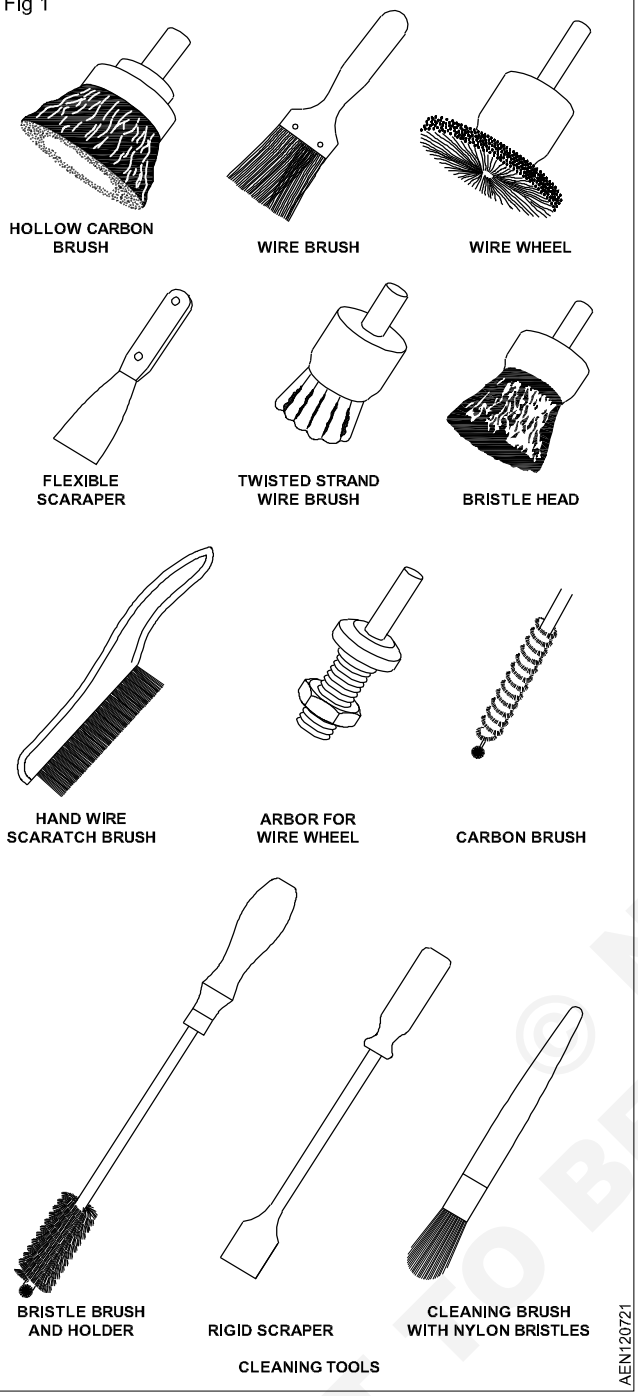
5 Nylon bristles with impregnated abrasive brush can be used for engine boring

6 A washing brush can be used to clean the cylinders by using soap and water.

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

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

Fig 1



CLEANING TOOLS

Safety precautions

Steel wire brushes should be used carefully on soft metals.

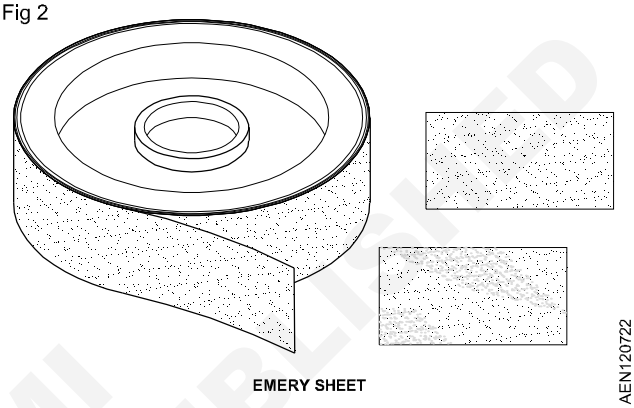
It should not make any scratches on the finished surface.

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



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.

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 use the 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 crank shaft and cylinder liners.

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

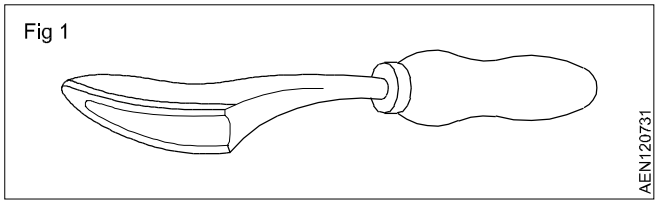
Special Scraper

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

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

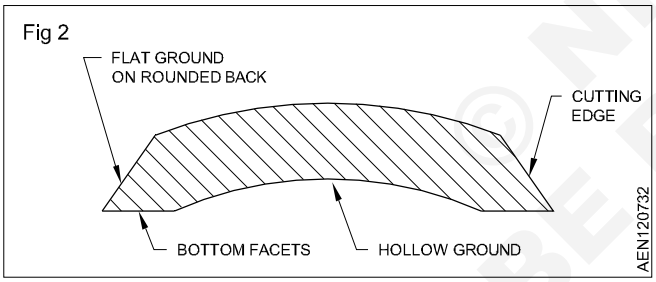
Half round scraper

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



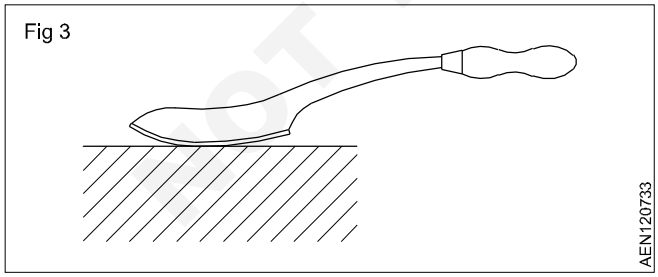
The round bottom face is curved and is hollow in the middle.

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



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

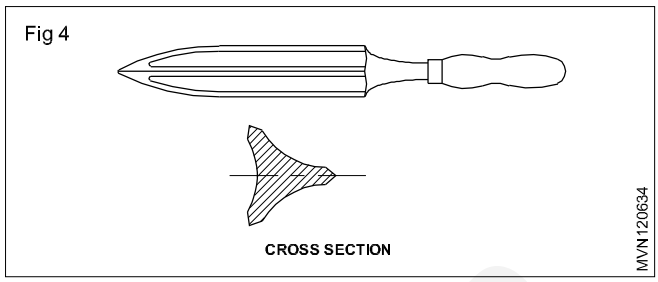
The curvature at the cutting edge helps to make point contact while scraping, and also helps to remove small spots. (Fig 3)



Three- square scraper (Fig 4)

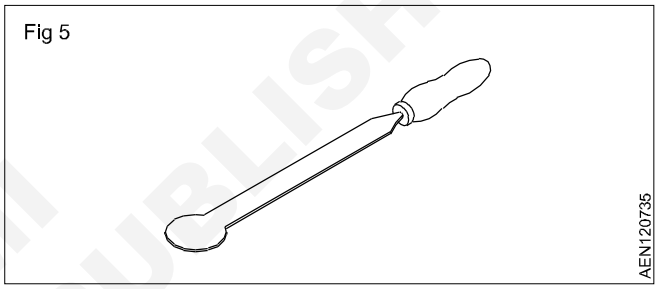
This scraper is used for scraping small diameter holes and deburring the edges of holes.

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.

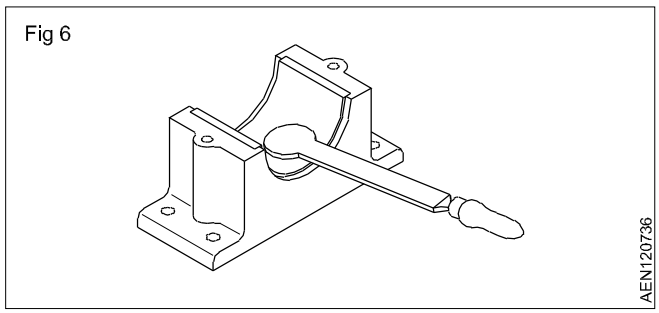


It is useful for scraping large bearings. (Fig 6) This scraper can be used in a longitudinal direction like a flat scraper or with a circumferential movement like a half round scraper. This dual action helps to prevent ridges on the scraped surfaces.

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 it is stored.

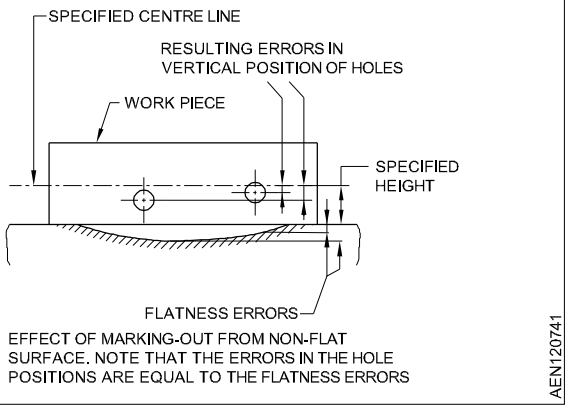


Surface plates

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**
- **state the uses of marking off tables.**

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

Fig 1

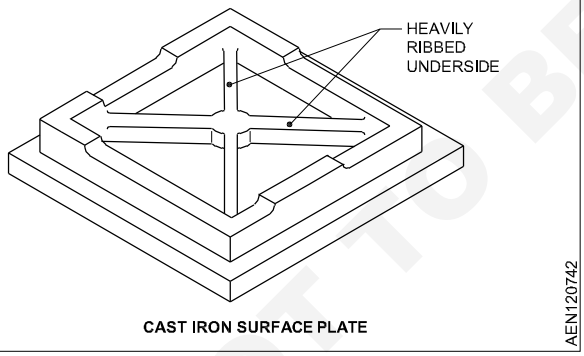


EFFECT OF MARKING-OUT FROM NON-FLAT SURFACE. NOTE THAT THE ERRORS IN THE HOLE POSITIONS ARE EQUAL TO THE FLATNESS ERRORS

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

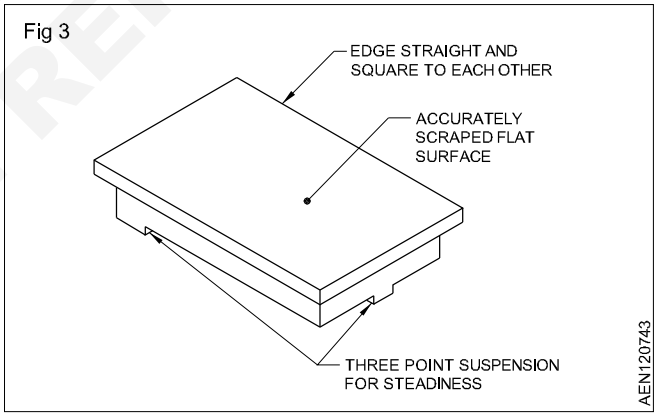
Cast iron surface plates are designated by their length, breadth, grade and the Indian Standard number.

Example

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

Marking-off tables (Fig 3)

Fig 3



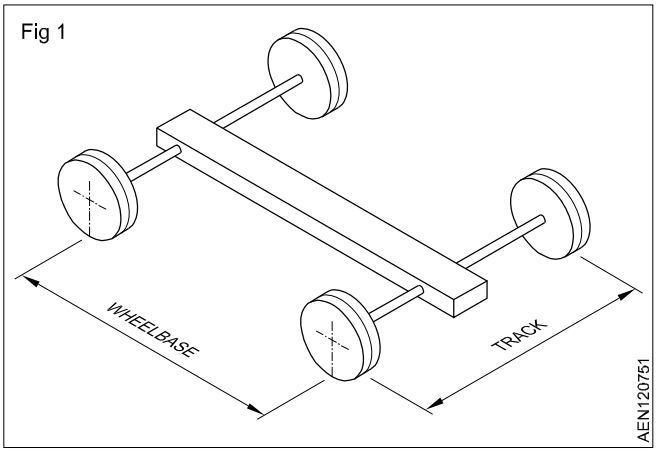
Wheelbase, wheel track and measuring tape

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

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

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



Types of measuring tape

1 Plastic Tape (Fig 3) 2 Metal Tape (Fig 2)

3 Fibre glass 4 Ribbon cloth

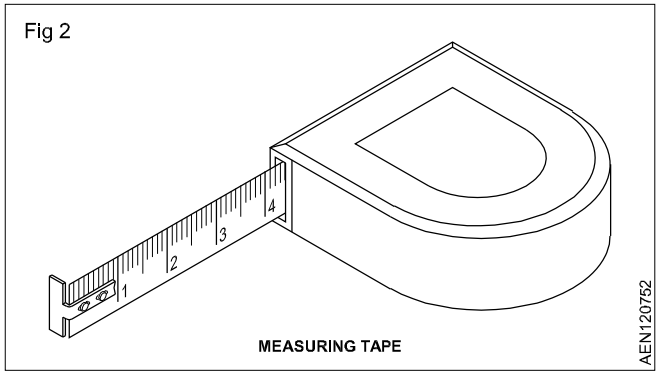
Application

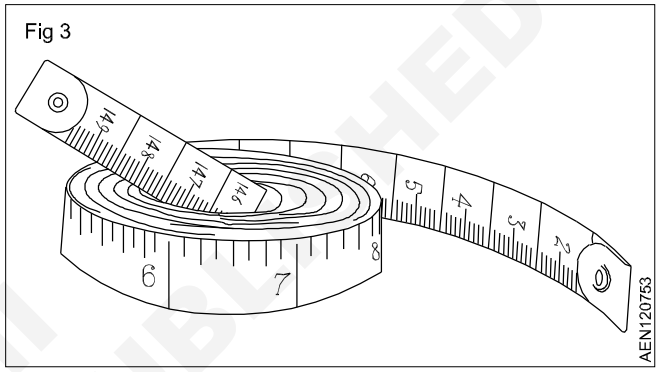
- Dress makers
- Civil Engineers
- Mechanical Engineers
- Surveyors
- Carpenters
- Medical field

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.





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

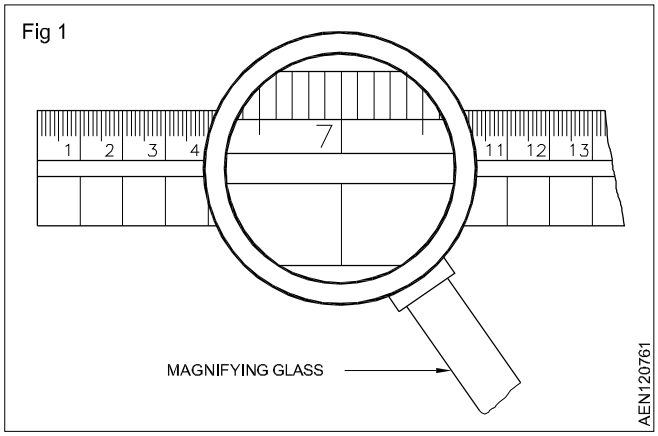
Usually, in engineering practice, the preferred unit of length measurement is the millimetre (Fig 1).

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.



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 stain-chrome finished to reduce glare, and to prevent rusting.

Sizes of steel rules (Fig 1)

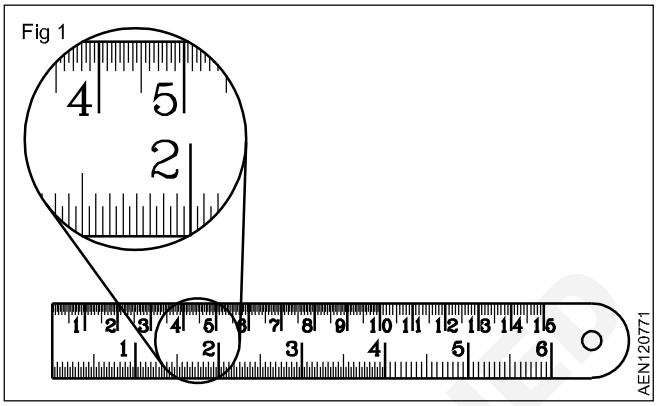
Steel rules are available in different length, the common sized being 150mm, 300 mm and 600 mm.

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.

Fig 1



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

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

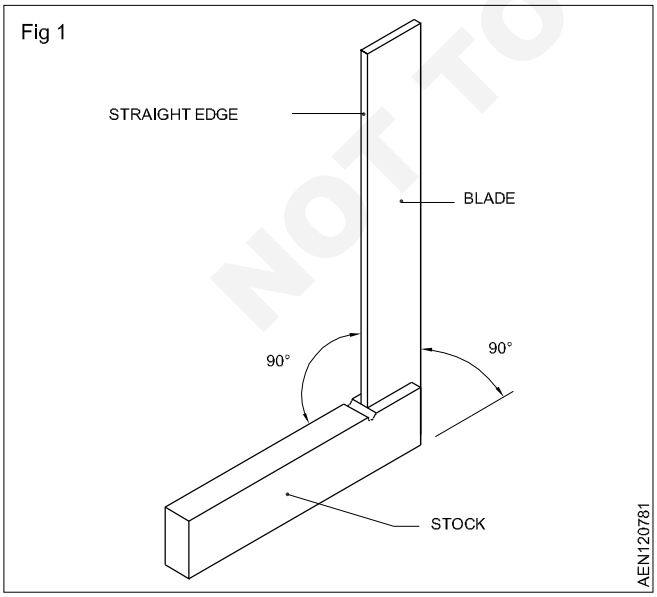
Try square

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

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

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.

Fig 1



Uses

The try squareness is used (Fig 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)

Fig 2

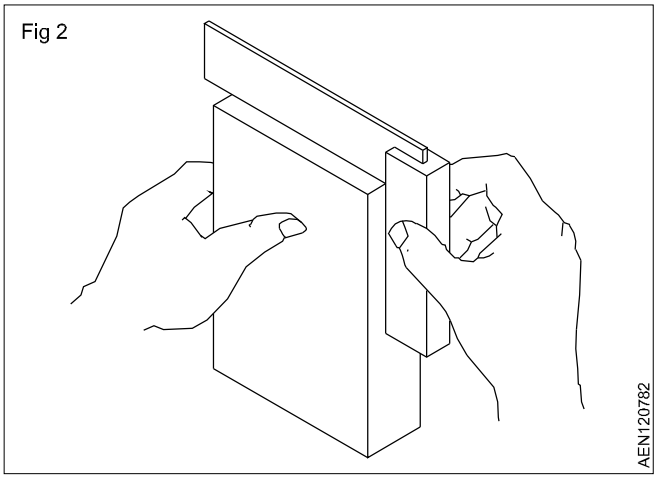


Fig 3

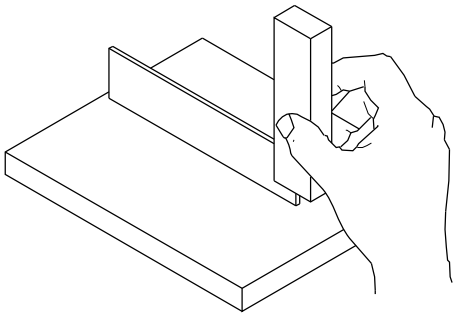


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Fig 4

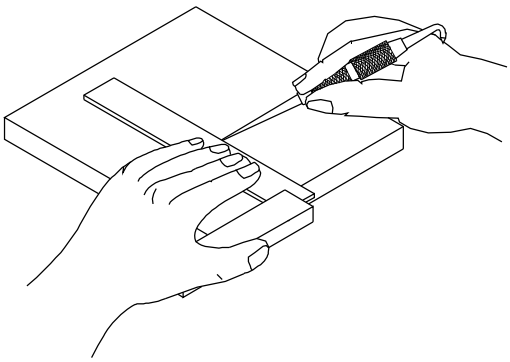

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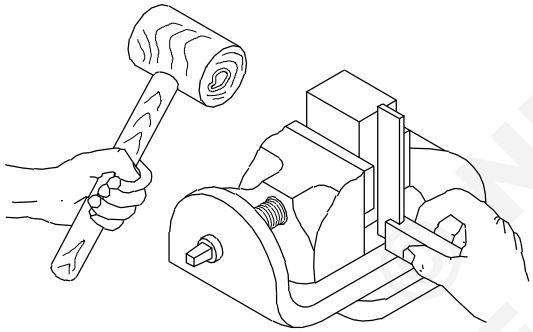
Fig 5



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Try squares are made of hardened steel.

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

Use of a try square and steel rule.

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

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

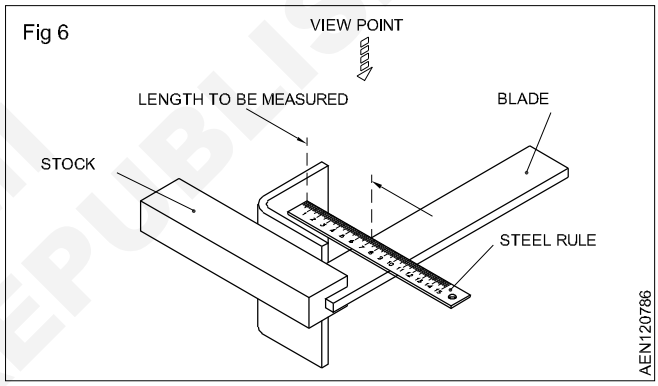
An experienced person can transfer measurements from a steel rule very accurately.

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

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

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

Fig 6



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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.

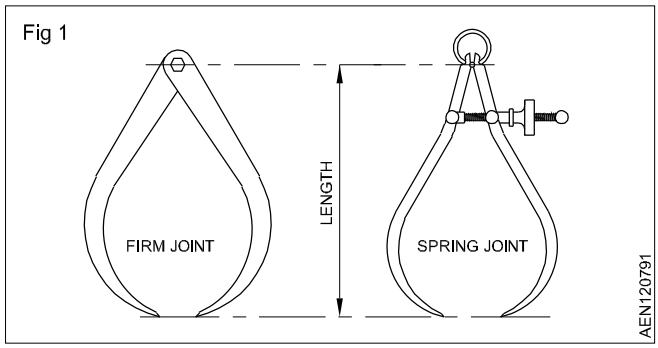
Types of joint: The commonly used calipers are;

- 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



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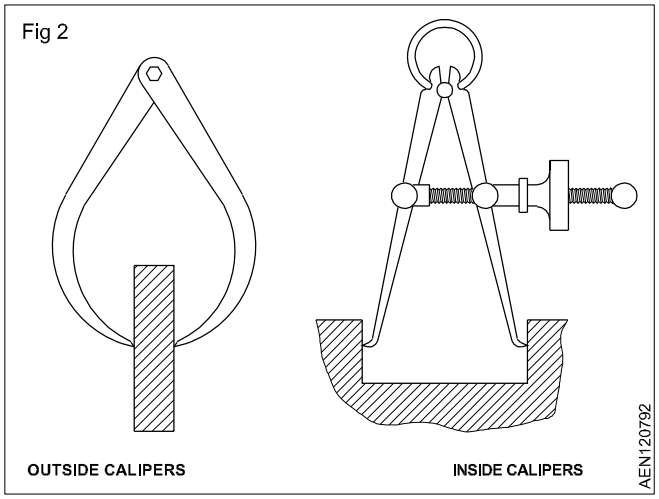
Spring joint calipers (Fig 2)

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



Spring joint calipers have the advantage of quick setting. The setting made will not change unless the nut is turned. The size of a caliper is specified by its length - which is the distance between the pivot centre and the tip of the leg.

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

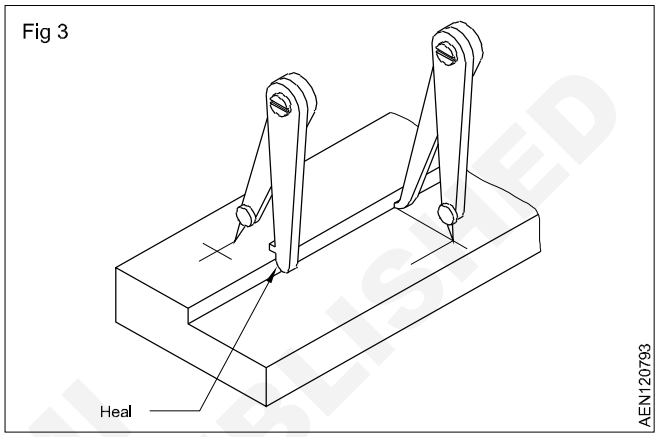
Types of legs

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

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

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

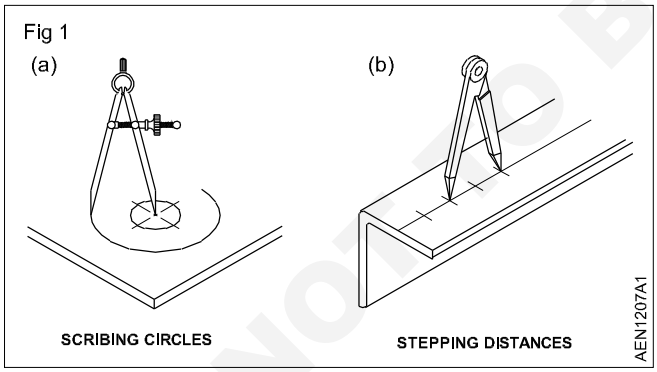
Jenny calipers are used for marking lines on inside and outside edges.



Dividers

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

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

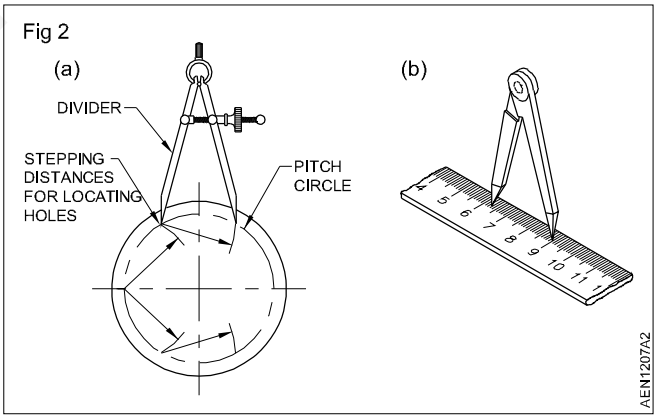


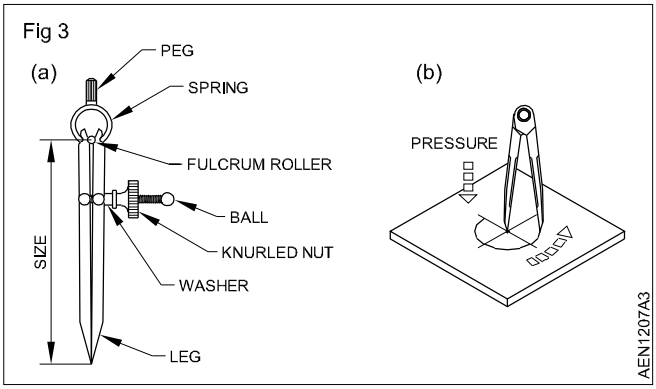
Dividers are available with firm joints and spring joints. The measurements are set on the dividers with a steel rule. (Fig 2a&2b)

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)

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





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

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

Do not sharpen the divider points on grinding wheels.

Surface Gauges

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

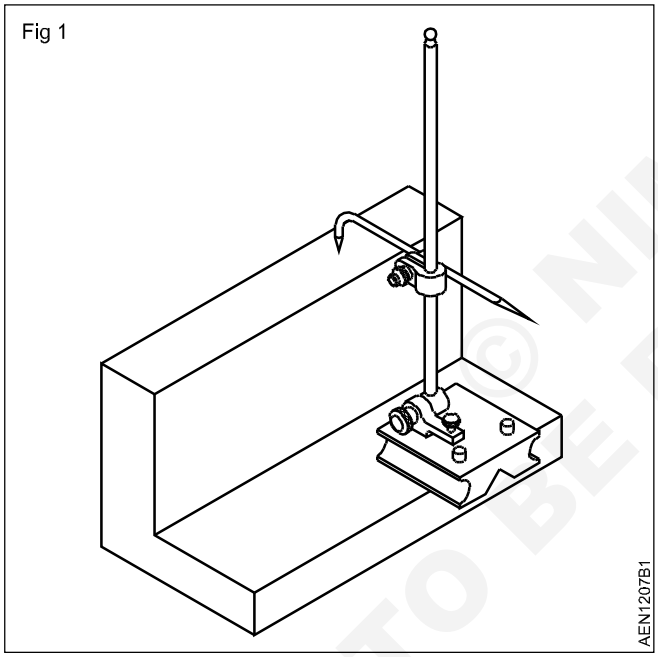
The surface gauge is one of the most common marking tools used for.

scribing lines parallel to a datum surface

Types of surface gauges

- Surface gauges/scribing blocks are of two types.
- Fixed (Fig 2)
- Universal (Fig 1)

Fig 1

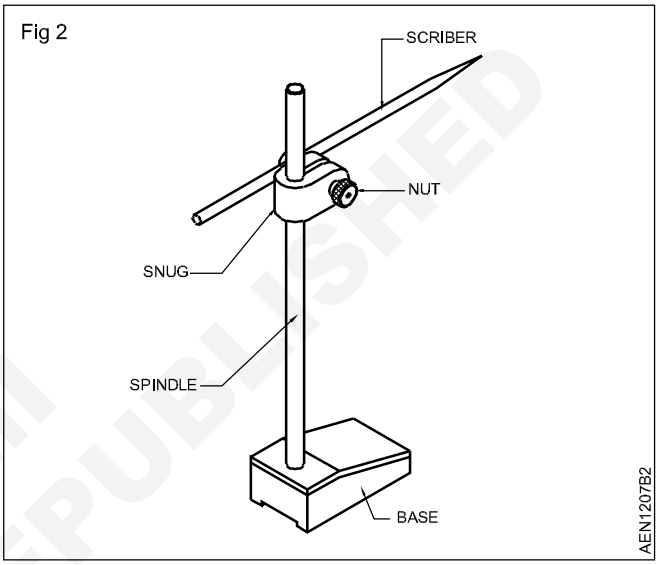


Surface gauge-fixed type (Fig 2)

- 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

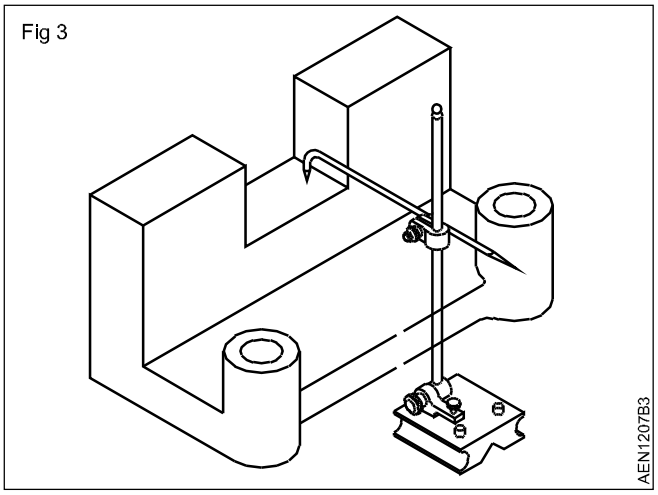
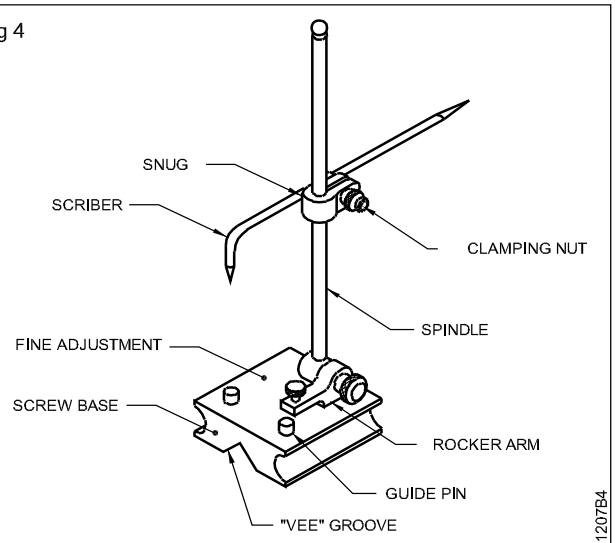


Fig 4



UNIVERSAL SURFACE GAUGE

Scriber

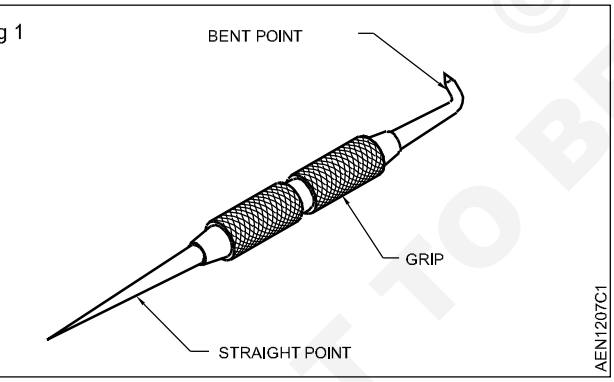
Objectives: At the end of this lesson you shall be able to
- **state the features of scribers**
- **state the uses of scribers.**

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

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

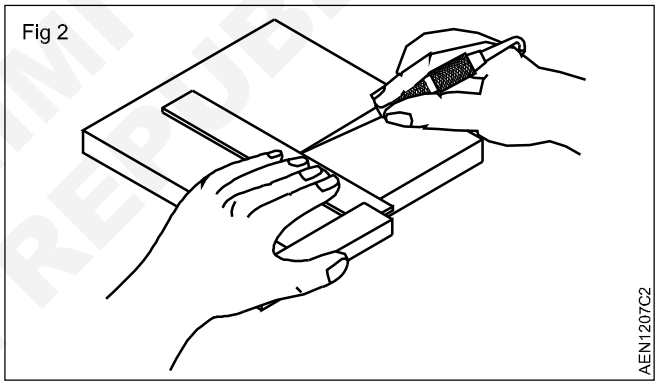
Scribes are available in different shapes and sizes. The one most commonly used is the plain scriber (Fig 1).

Fig 1



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

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)

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)

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 1

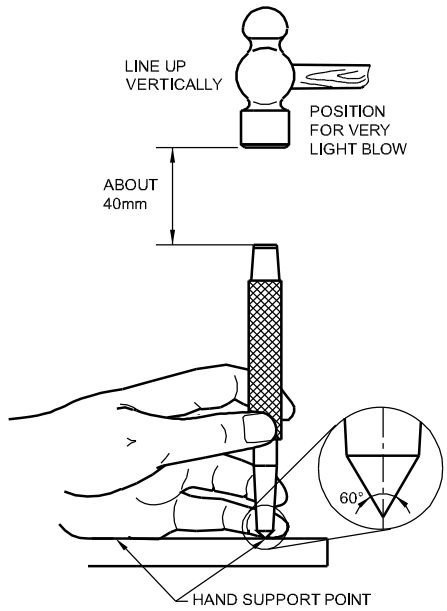


Fig 2

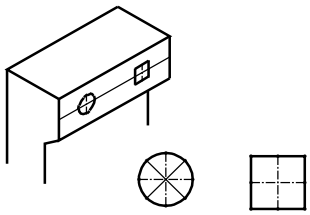
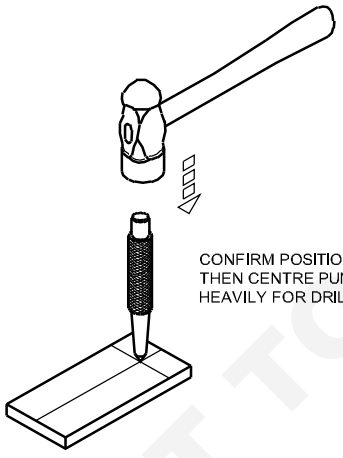


Fig 3



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.

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 4

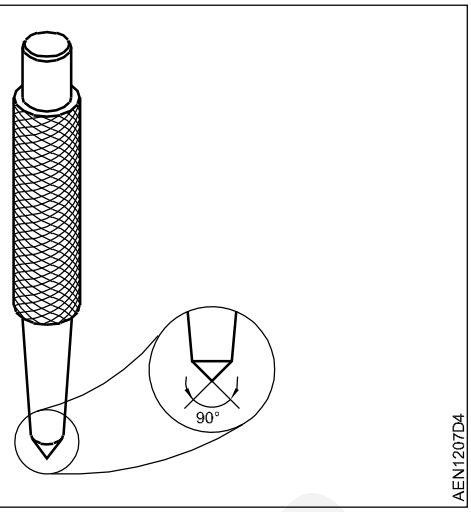
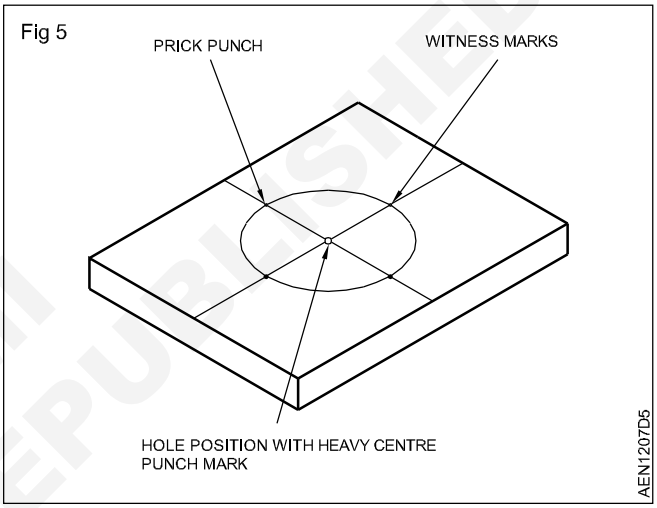


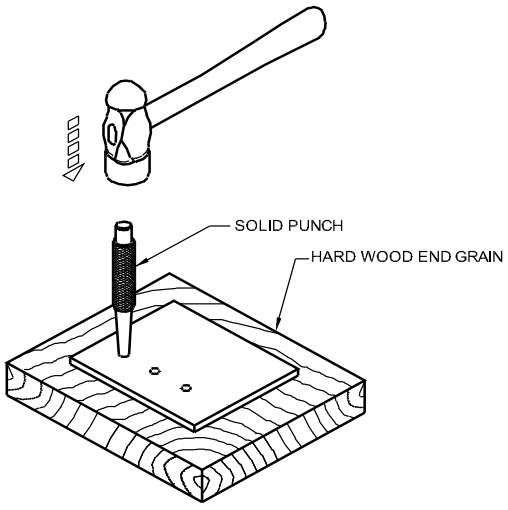
Fig 5



Solid punch (Fig 6)

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

Fig 6



PUNCHING HOLES FOR RIVETS WITH A SOLID PUNCH

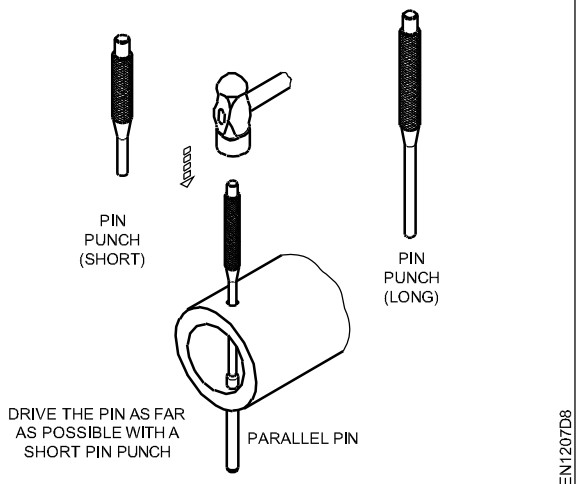
Letter and number punches

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)

Fig 8



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.

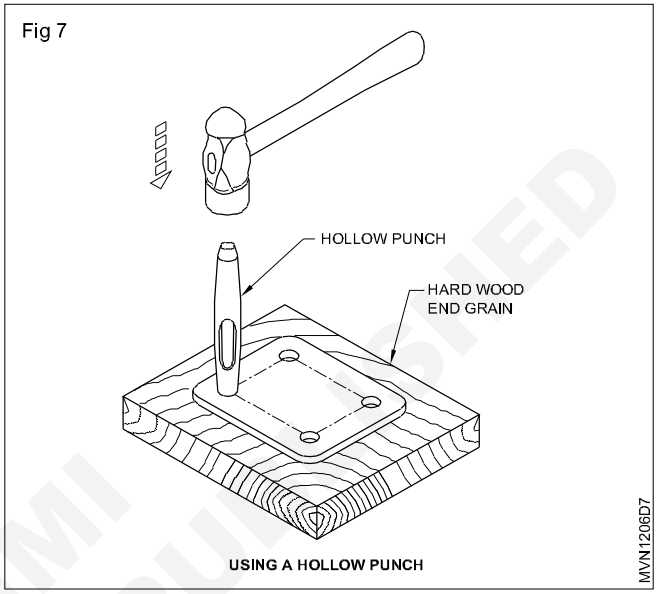
While using solid or hollow punches, the materials is rigidly supported with a block of wood (with the end of grain up) or lead. This will also avoid any damage to the tip of the punch while punching.

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 7



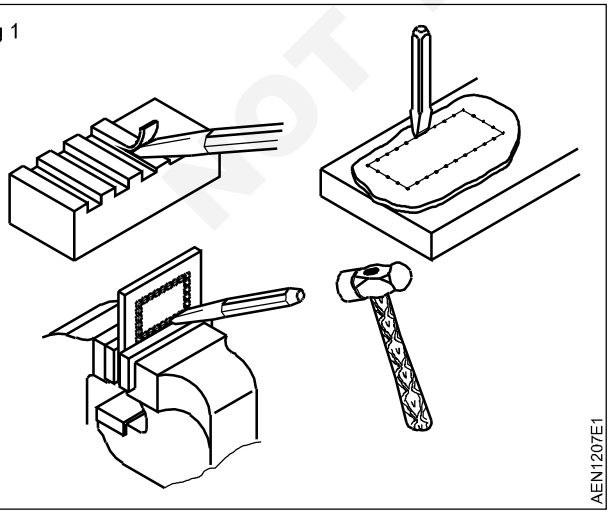
Chisel

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.

Fig 1

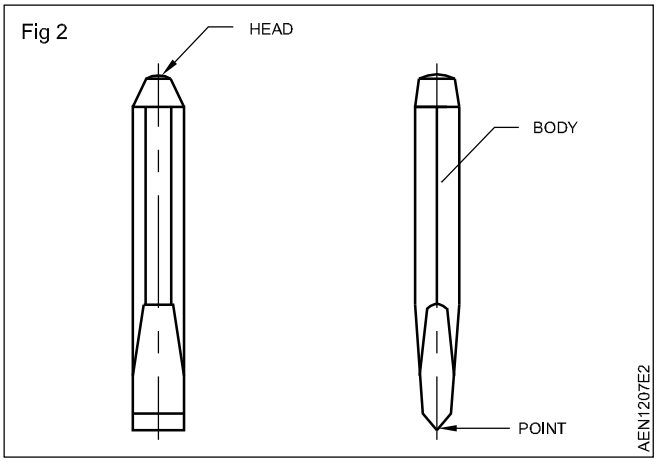


Parts of a chisel (Fig 2)

A chisel has the following parts:

- Head
- Body
- Point or cutting edge

Fig 2



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.

Common types of chisels

There are four common types of chisels

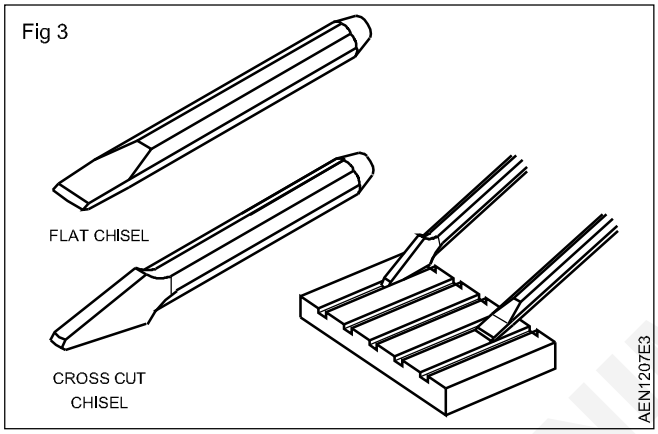
- Flat chisel (1)
- Cross-cut chisel (2)
- Hall round nose chisel
- Diamond point chisel

Flat chisels (Fig 3)

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

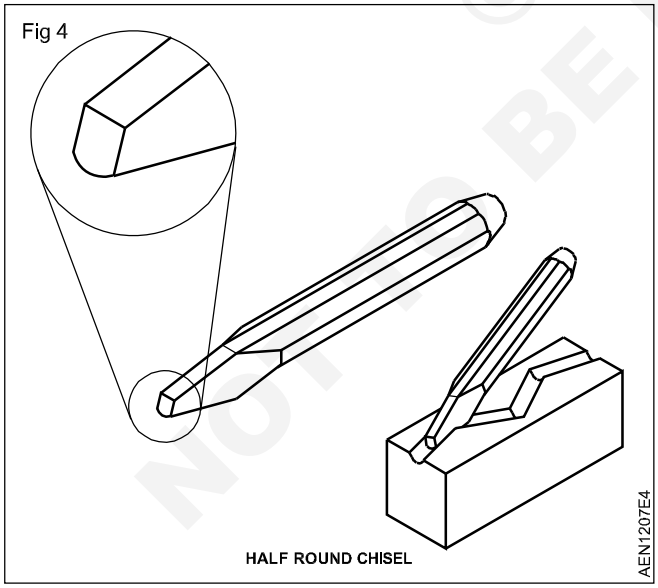
Cross-cut or cape chisels (Fig 3)

These are used for cutting keyways, grooves and slots.



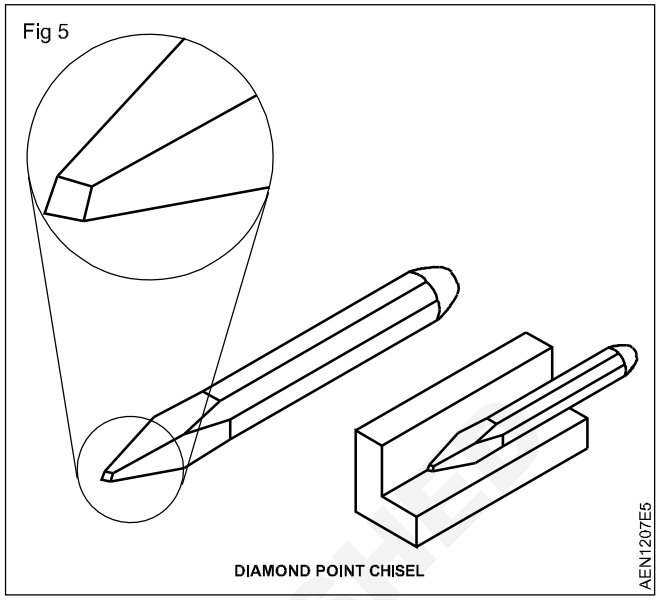
Half round nose chisels (Fig 4)

They are used for cutting curved grooves (oil grooves)



Diamond point chisels (Fig 5)

These are used for squaring materials at the corners.



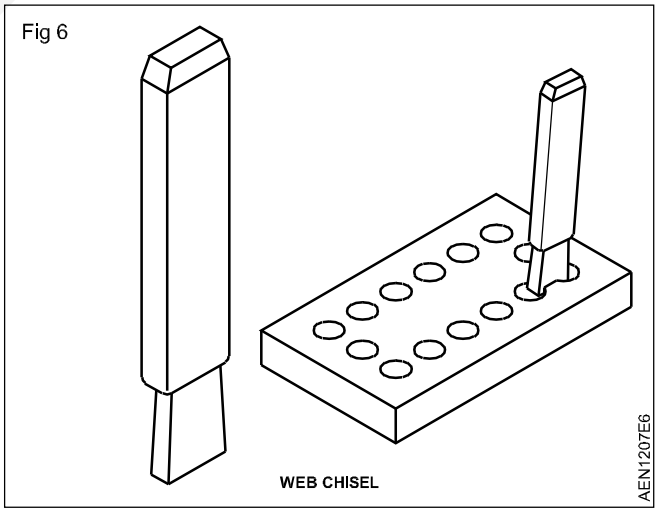
Web chisels/punching chisels (Fig 6)

These chisels are used for separating metals after chain drilling.

Chisels are specified according to their

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

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



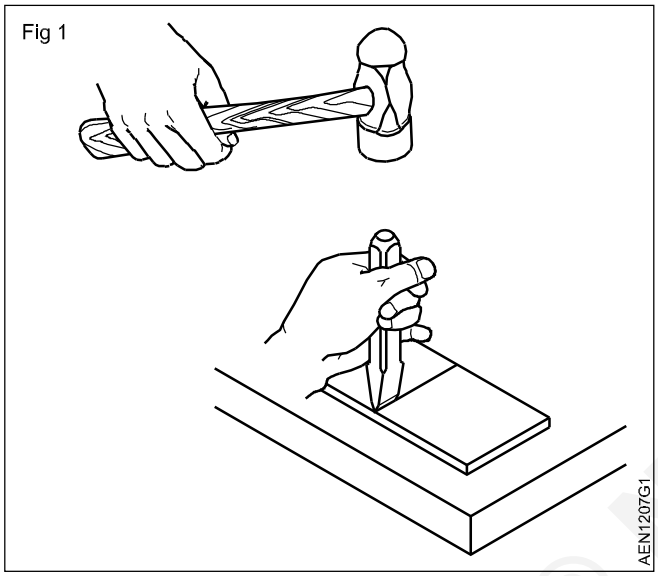
Hammers

Objectives: At the end of this lesson you shall be able to
- **state the uses of an engineer's hammer**
- **list the parts of an engineer's hammer and state their functions**
- **name the types of engineer's hammers**
- **specify the engineer's hammer.**

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

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

Fig 1

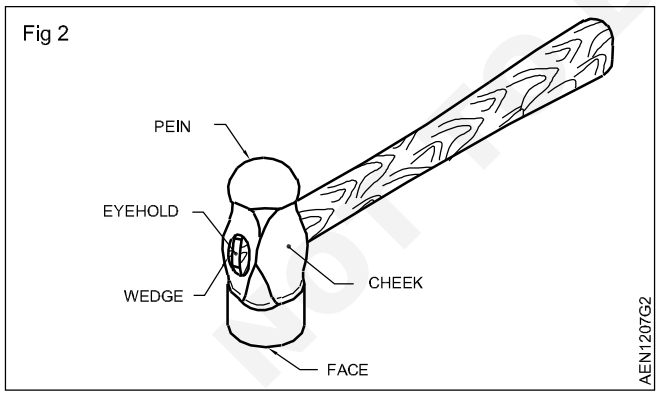


Major parts of a hammer (Fig 2)

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

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

Fig 2



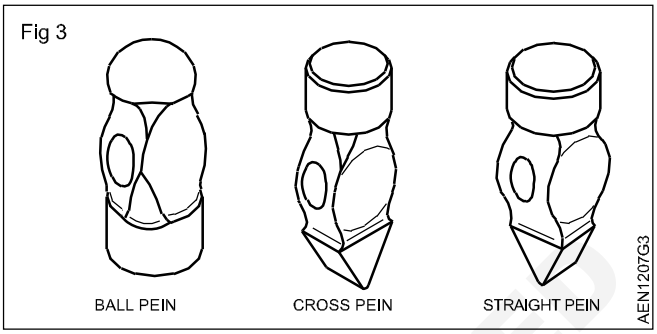
The parts of a hammer head are the

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

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

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

Fig 3



- ball pein
- crosspein
- straight pein

The face and the pein are hardened.

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

This portion of the hammer-head is left soft.

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

Fig 4

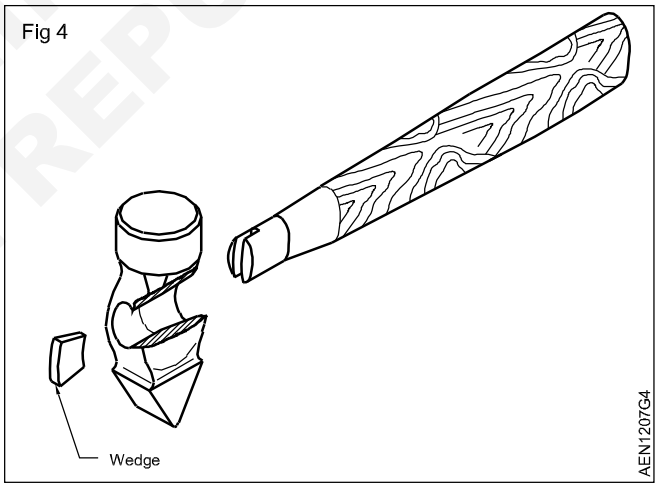
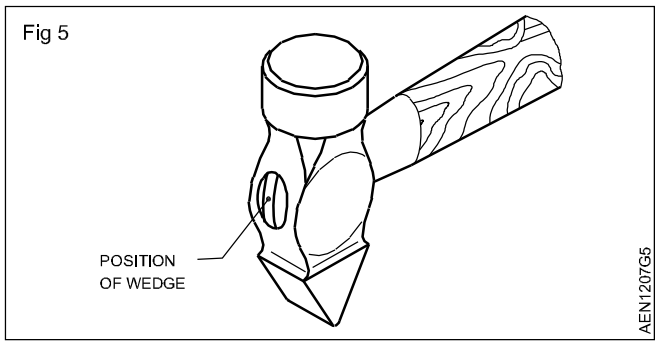


Fig 5



Specification

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

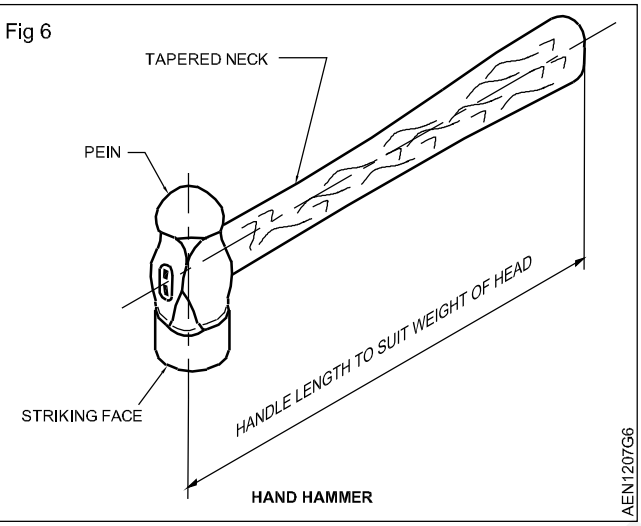
The ball pein hammers are used for general work in a machine/fitting shop.

Before using a hammer

Make sure the handle is properly fitted.Select a hammer with the correct weight suitable for the job.Check the head and handle for any cracks. Ensure the face of the hammer is free from oil or grease.

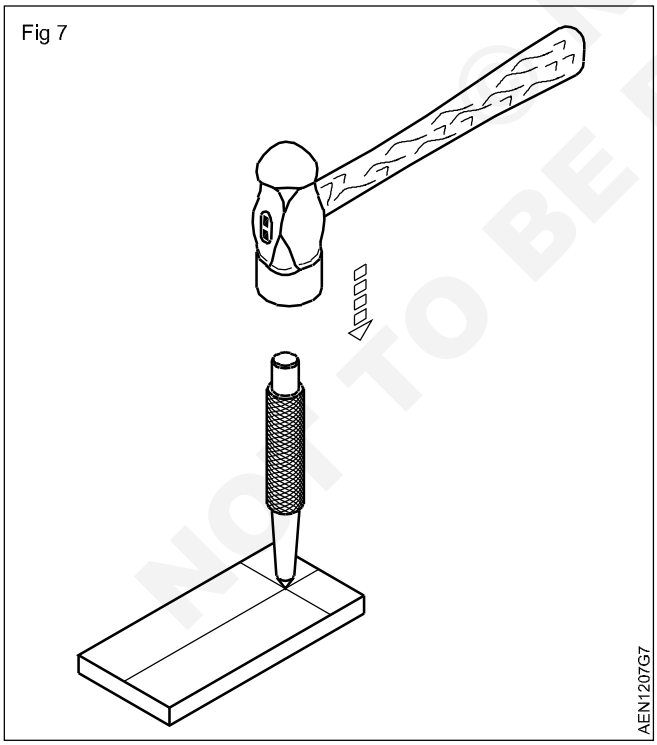
The figure shows the different parts of a hammer.The handle is fitted in the eye-hole of the hammer. (Fig 6)

Fig 6



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

Fig 7



Ball pein hammer (Fig 8)

A ball pein head is used to spread metal in all directions. This hammer has a semi-spherical pein suitable for riveting. (Fig 9)

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

Fig 8

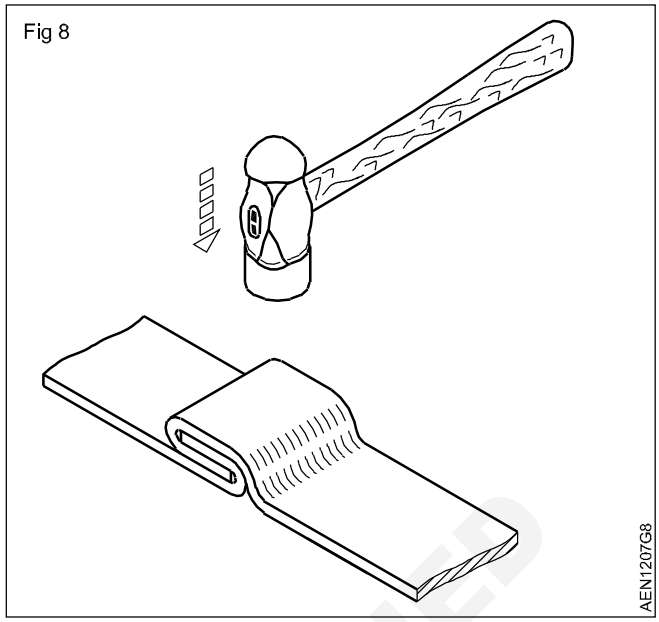
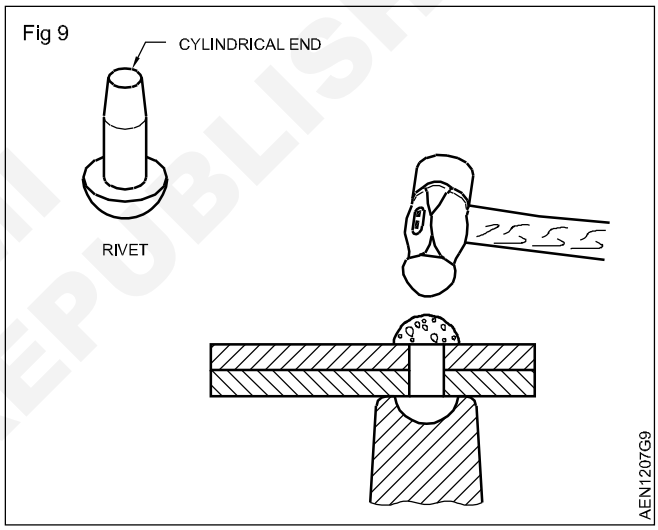


Fig 9

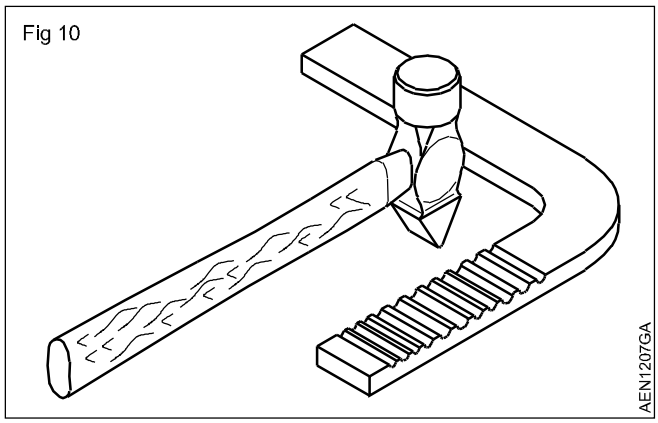


Cross pein hammer (Fig 10)

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

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

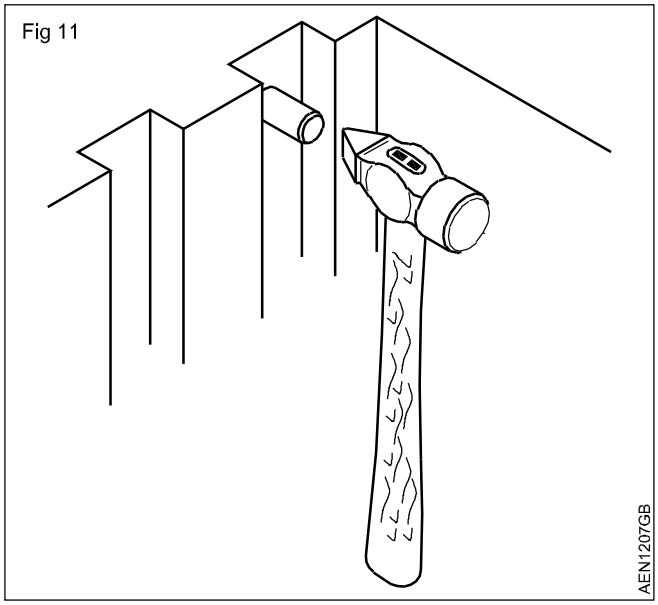
Fig 10



Straight pein hammer

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

Fig 11



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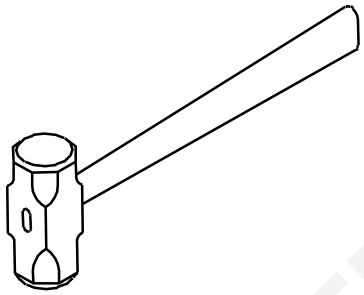
This hammer has a blunt wedge-shaped pein in line with the axis of the handle.

A lump hammer or club hammer is a small sledgehammer (Fig12) 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



AEN1207GC

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.

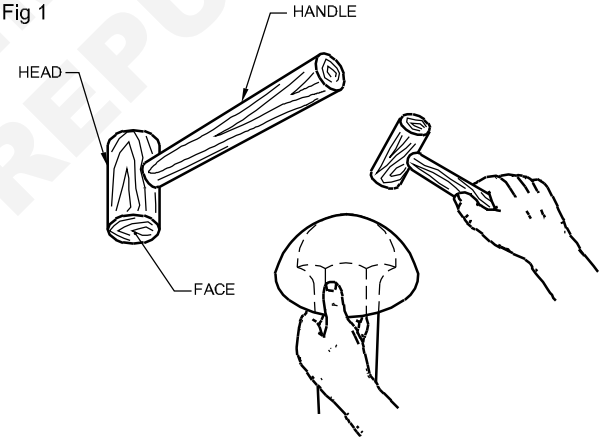
Types and uses

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.

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

Fig 1



STANDARD WOODEN MALLET

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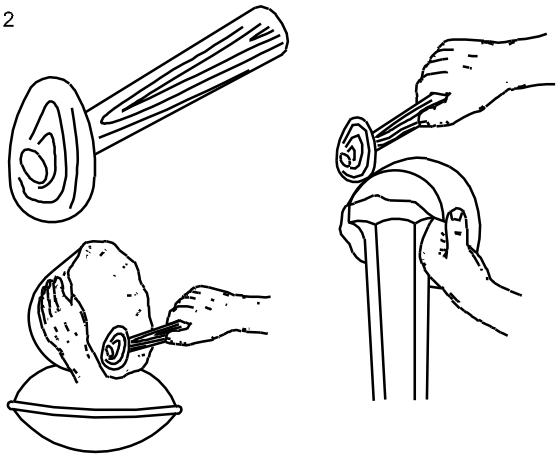
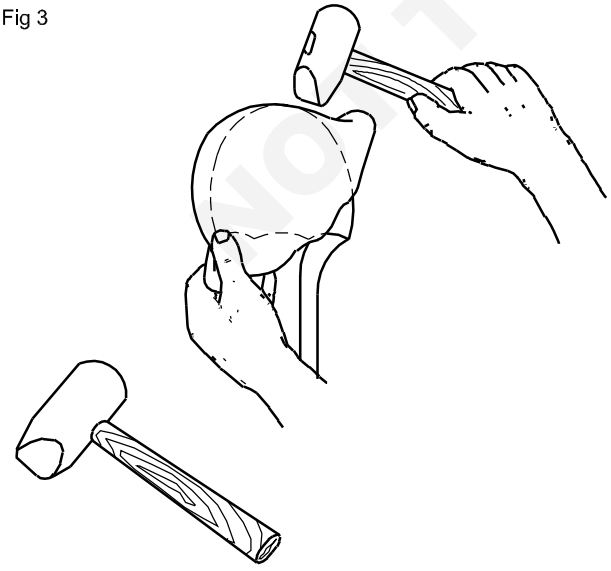
Fig 2



SHAPING THE HEMISPHERICAL BOWL BY RAISING
BOSSING MALLET

AEN1207H2

Fig 3



AEN1207H3

Screwdrivers

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

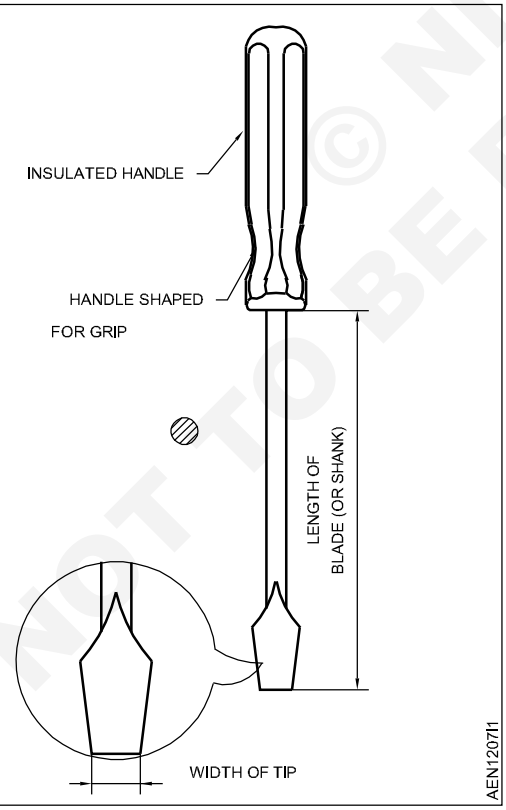
- Standard type with tips to suit recessed head screw slots.
- Special type with tips to suit recessed head screws

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.

Fig 1



Standard screwdrivers: Standard screwdrivers are classified as:

- heavy duty screwdrivers
- light duty screwdrivers
- stumpy screwdrivers

Heavy duty screwdrivers (Fig 2 & 3)

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

Fig 2

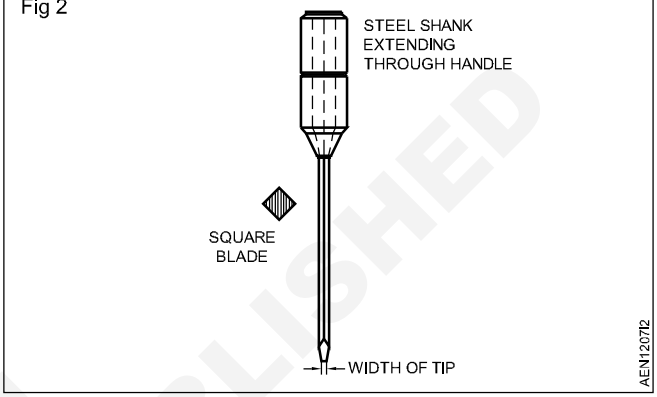
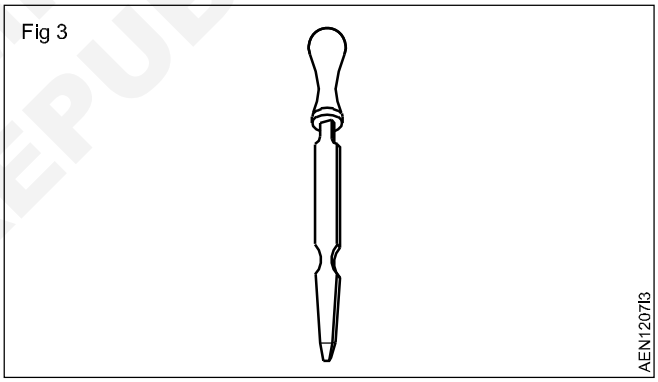


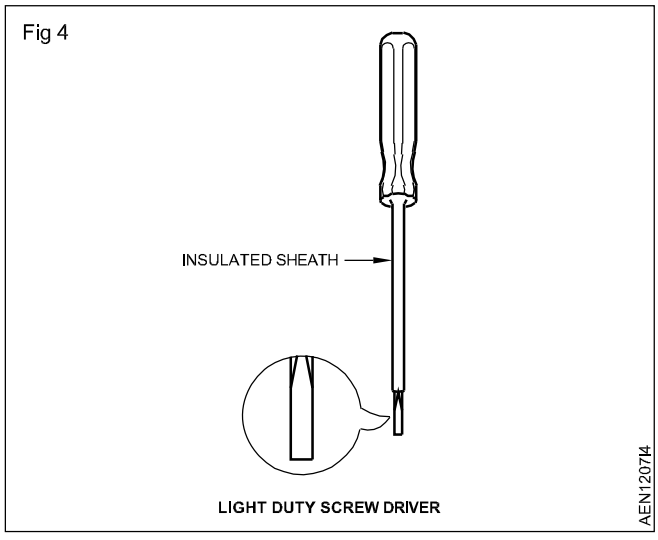
Fig 3



Light duty screwdrivers (Fig 4)

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

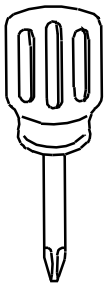
Fig 4



Stumpy screwdrivers (Fig 5)

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

Fig 5



STUMPY SCREW DRIVER

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Special screwdrivers and their uses

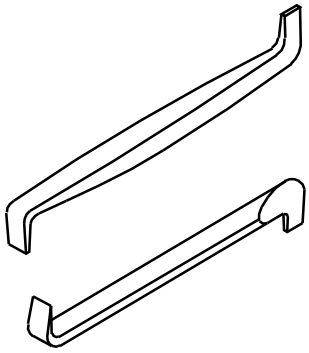
Offset screwdriver (Fig 6)

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

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

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

Fig 6



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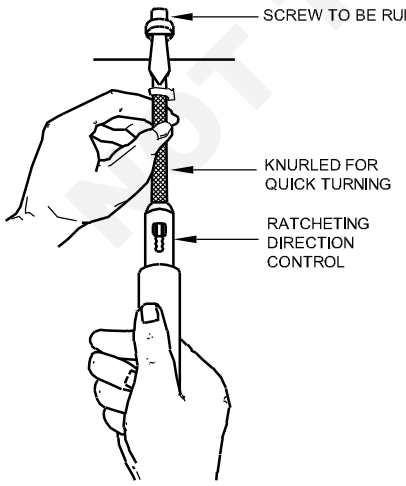
Ratchet screwdriver (Fig 7)

The following are the features of ratchet screwdrivers.

Fig 7



RATCHET SCREWDRIVER

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

They are used for tuning screws in confined spaces.

They can be operated without changing the hand grip.

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

They are used in mass production.

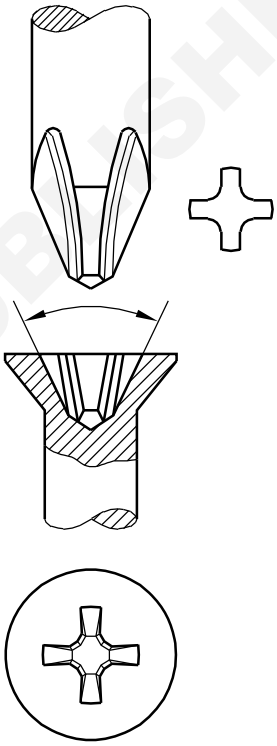
Phillips (cross-recess) screwdrivers (Fig 8)

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°.

Fig 8



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

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

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 9

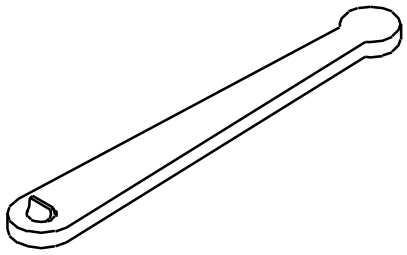

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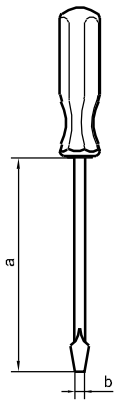
Fig 10



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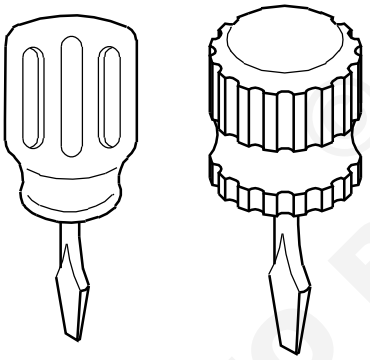
Screwdrivers for special uses

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

Fig 11



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

Precautions

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

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)

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

Fig 12

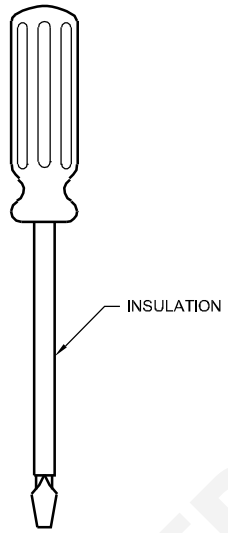

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Fig 13

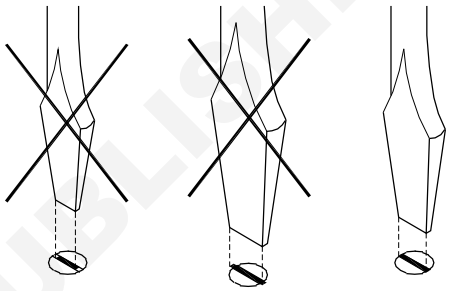

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Fig 14

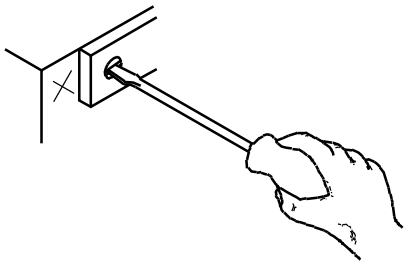

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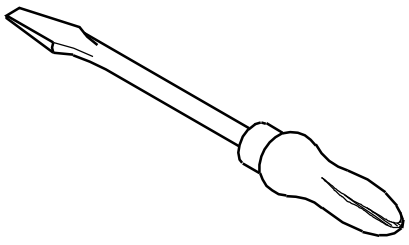
Fig 15



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

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

Specification of a screwdriver

Screwdrivers are specified according to the

- length of the blade
- width of the tip

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

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

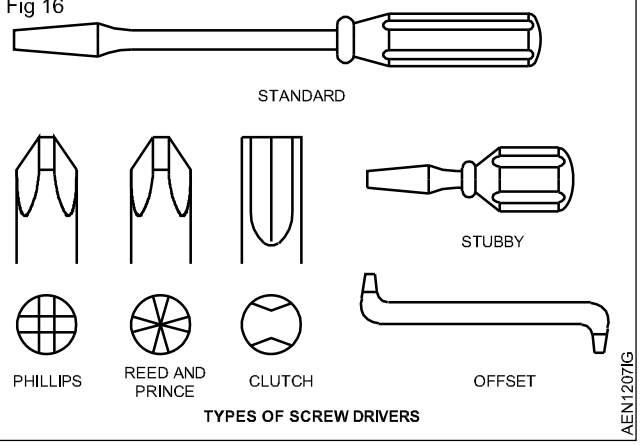
The offset screw driver is useful in tight quarters where even a “Stubby” cannot be used.

Safety

1 Always use correct type and size screw drivers.

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

Fig 16



TYPES OF SCREW DRIVERS

Allen keys

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

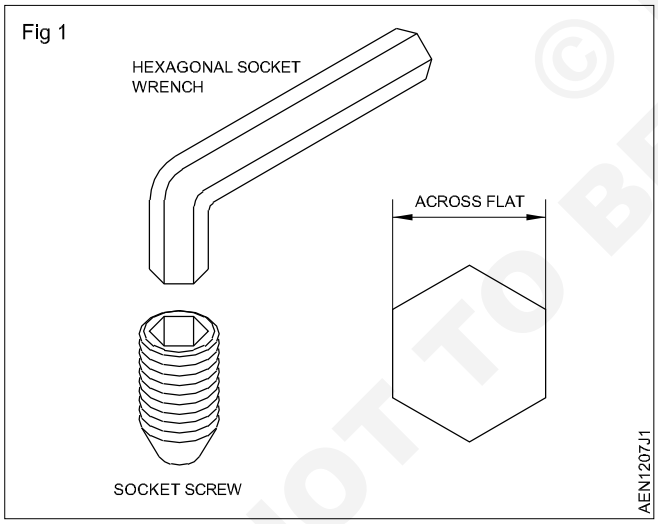
Hexagon socket screw keys/Allen keys are made from hexagonal section bars of chrom vanadium steel.

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

Uses

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

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

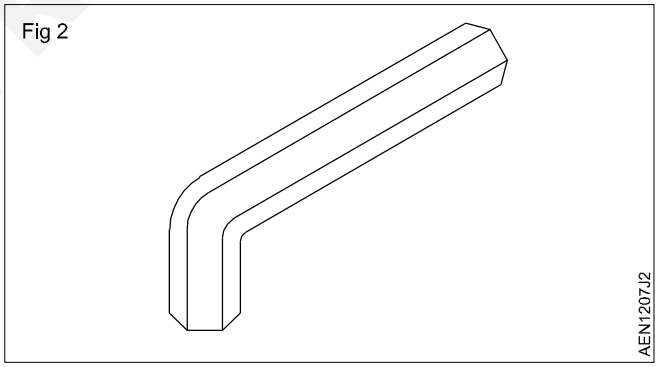
Sizes of Allen keys (Fig 1)

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.

Fig 2



Bench vice

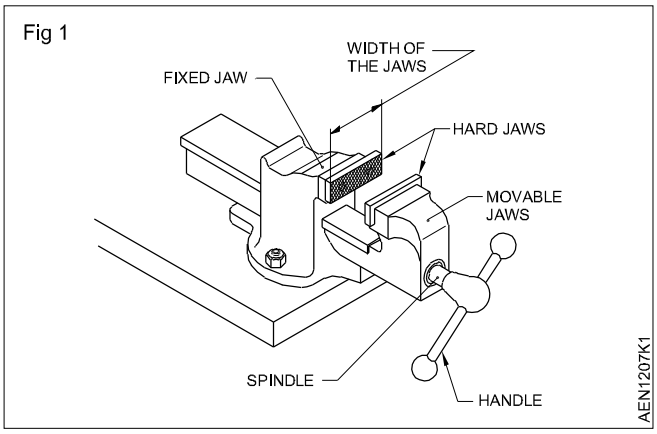
Objectives: At the end of this lesson you shall be able to
- **name the parts and uses of a bench vice**
- **specify the size of a bench vice**
- **state the uses of vice clamps.**

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.

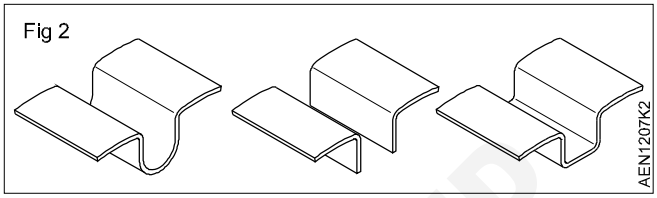
Fixed jaw, movable jaw, hard jaws, spindle, handle, box-nut and spring are the parts of vice.

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.



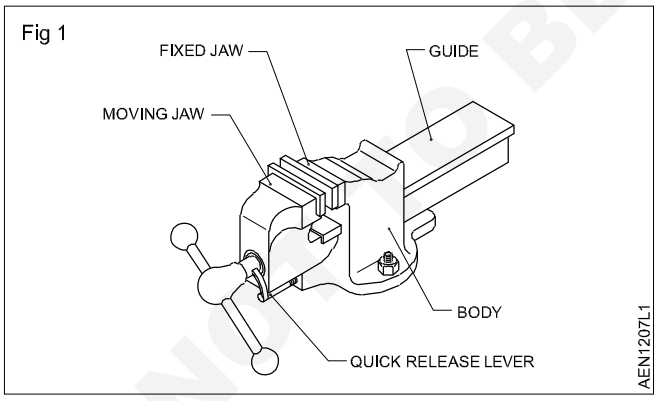
Types of vices

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

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

Quick releasing vice (Fig 1)

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



Pipe vice (Fig 2)

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

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

Hand vice (Fig 3)

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

Pin vice (Fig 4)

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

Toolmaker's vice (Fig 5)

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

Toolmaker's vice is accurately machined.

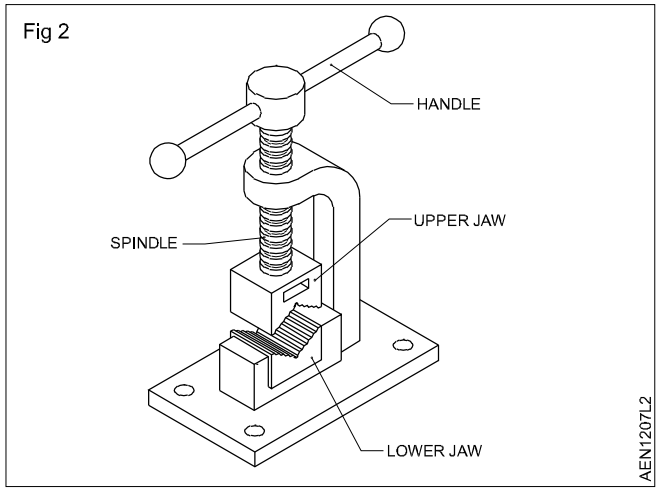


Fig 3

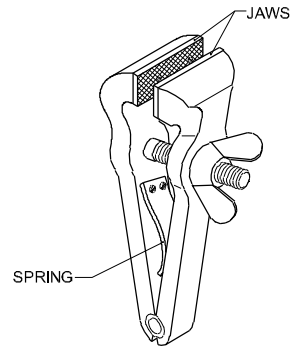
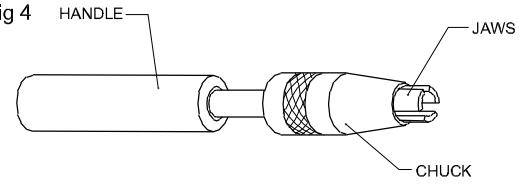
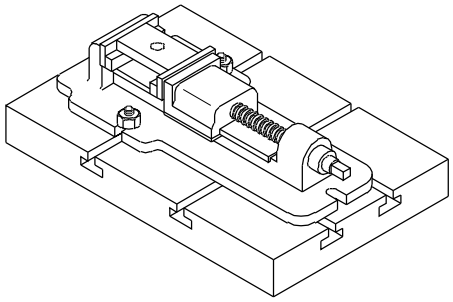


Fig 4



PIN VICE

Fig 5



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.

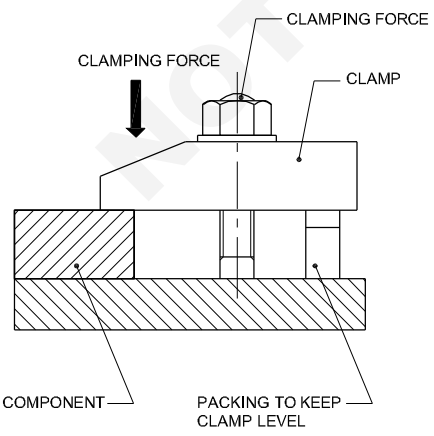
Should provide the required clamping force.

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.

Fig 1



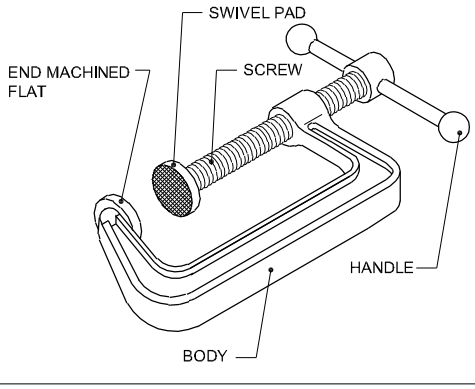
'C' Clamps

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.

Fig 2



Toolmaker's clamps

This is the type most commonly used by toolmakers for holding small, machined, flat pieces for further operations. They have two rectangular pieces of steel perfectly machined. The inner faces which come in contact with

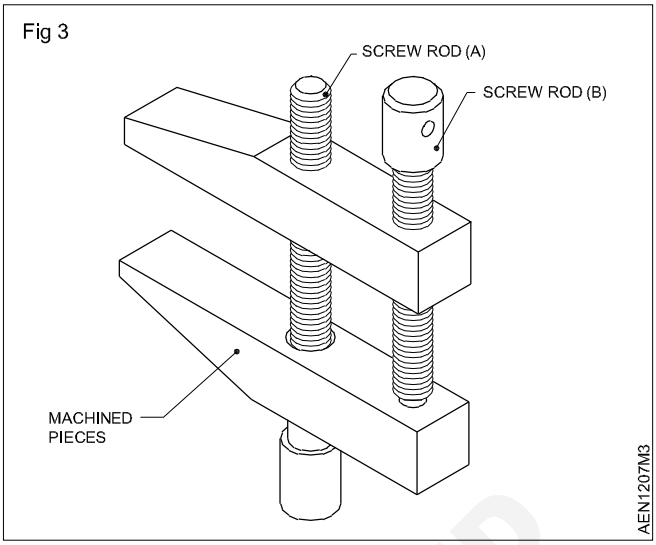
the workpiece are perfectly parallel. They are assembled by means of two threaded rods. The screw-rod (A) is rotated in one direction to adjust the gap between the two holding faces. The other screw (B) when tightened maintains the required pressure. (Fig 3)

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

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

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

Fig 3



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.

Fig 1

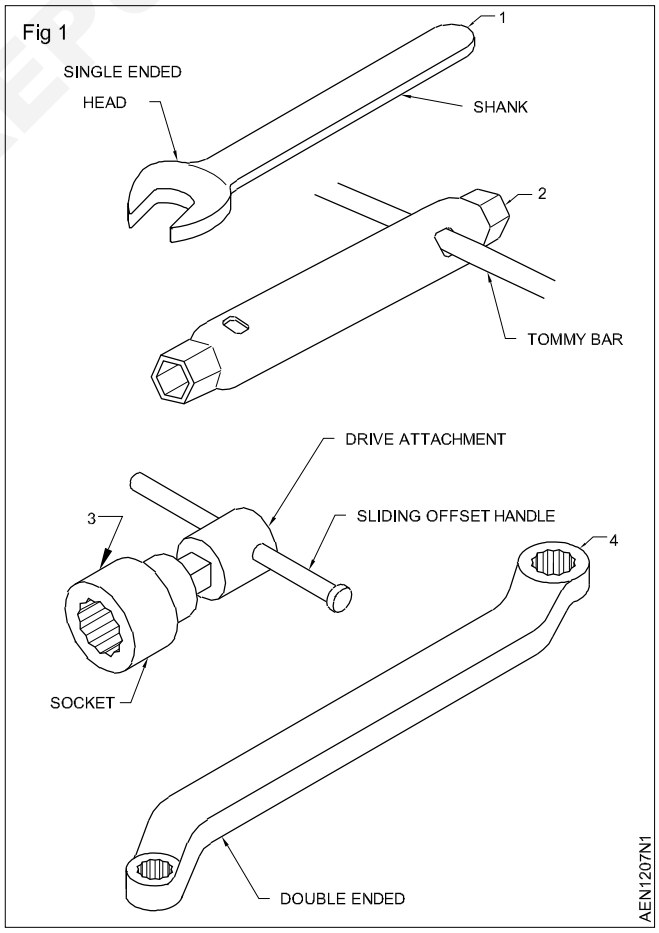
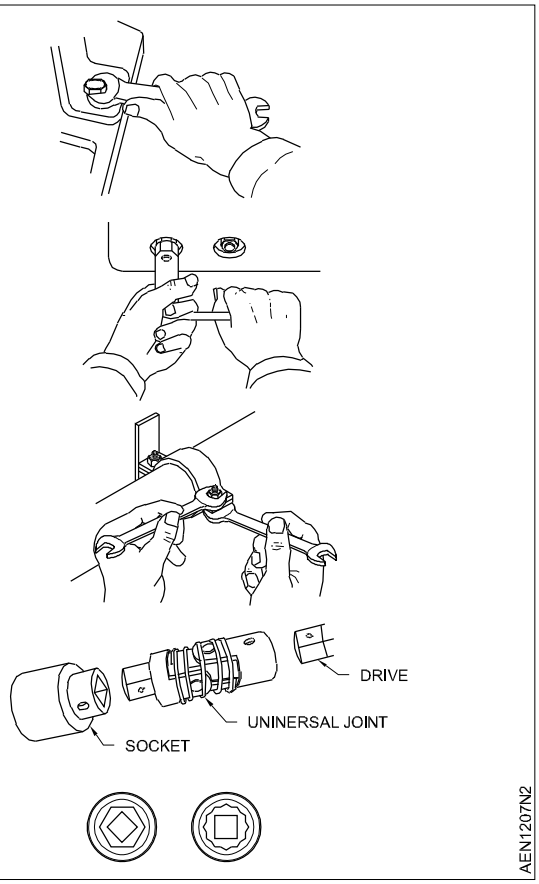


Fig 2



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:

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

Fig 3

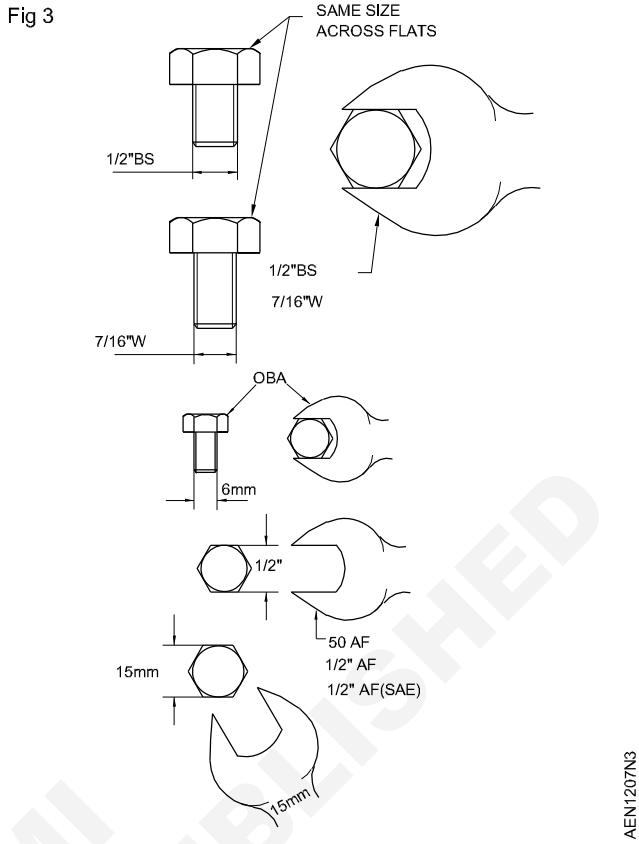
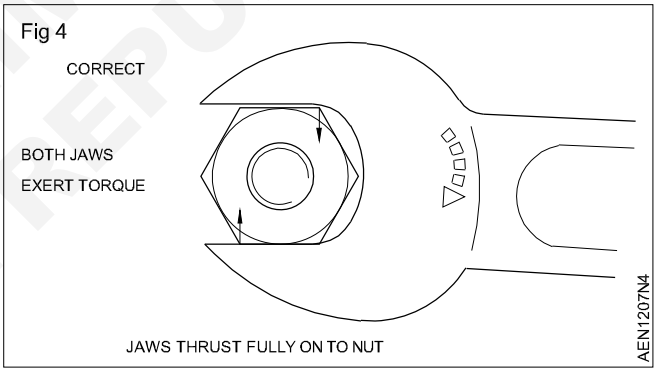


Fig 4



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

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

Incorrect use damages the spanners & the nuts too.

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

Choose spanners that allow room for use.

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

Length of spanners (Fig 6)

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

Fig 5

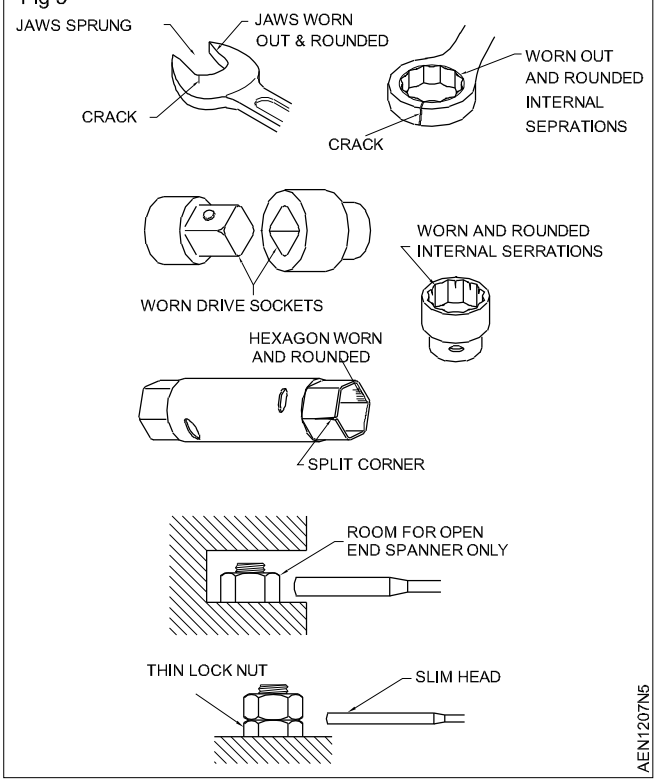
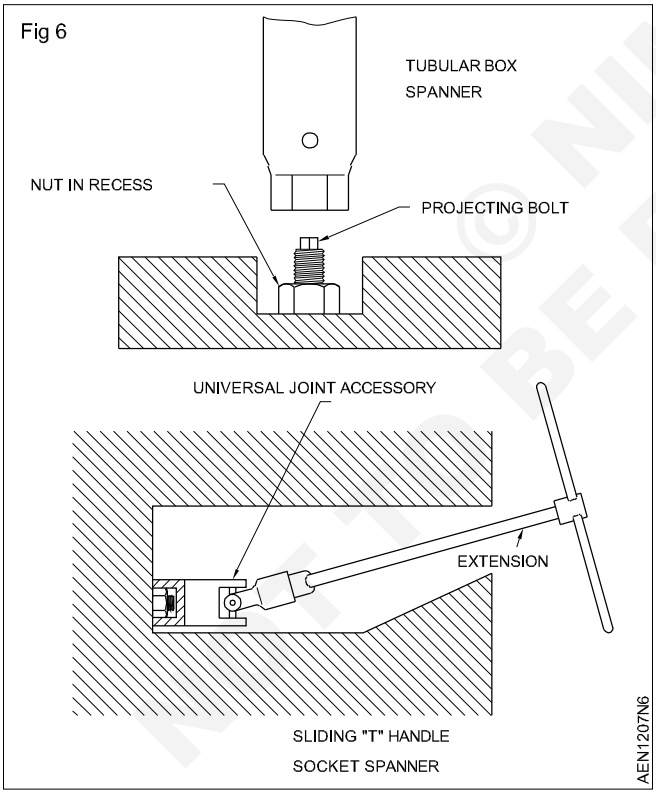


Fig 6



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)

Fig 7

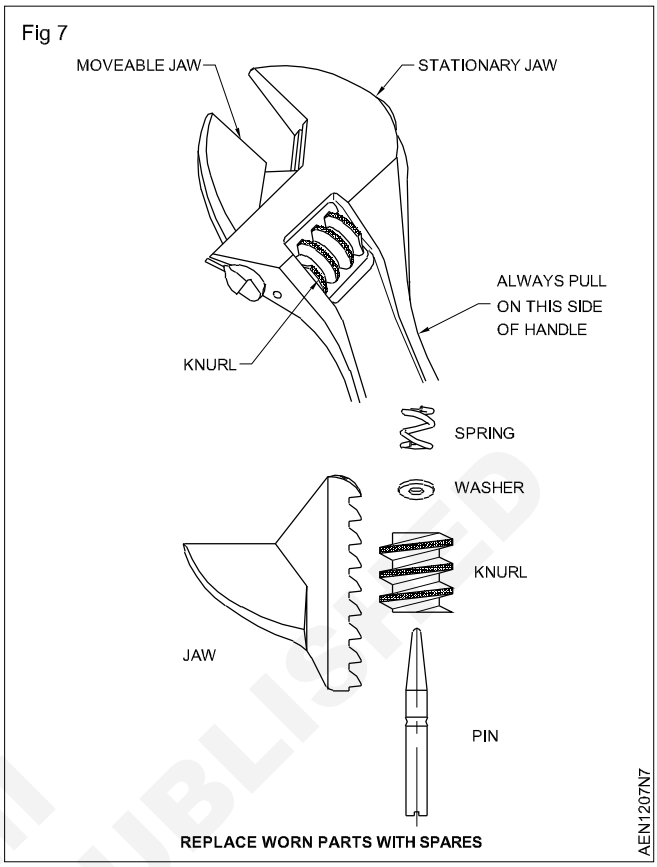
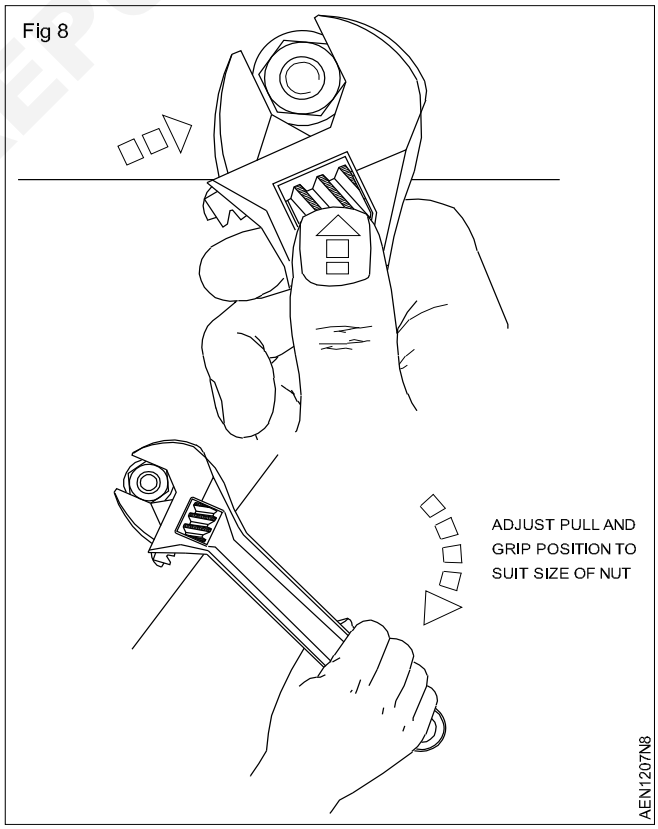


Fig 8



Most common types of adjustable spanners are similar to open and spanners, but they have one movable jaw. The opening between the jaws of a typical 250 mm spanner can be adjusted from zero to 28.5 mm. Adjustable spanners may range in length from 100 mm to 760 mm.

the type illustrated has its jaws set an angle of 22 1/2^0 to the handle. Adjustable spanners are convenient for use where a full kit of spanners cannot be carried about. They are not intended to replace fixed spanners which are more suitable for heavy service. If the movable jaw or knurled screw is cracked or worn out, replace them with spare ones.

When using the adjustable spanner follow the steps given below.

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

Push the jaws into full contact with the nut.

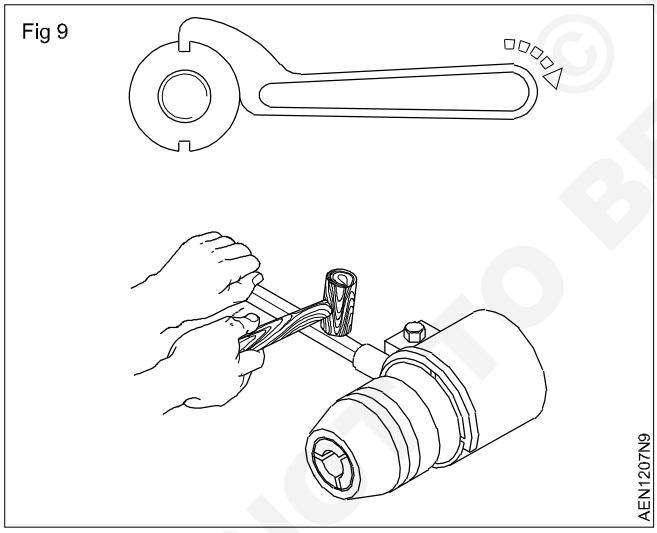
Use the thumb to tighten the adjusting knurl so that the jaws fit the nut strongly.

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

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

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

Fig 9



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

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

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

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

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

Fig 10

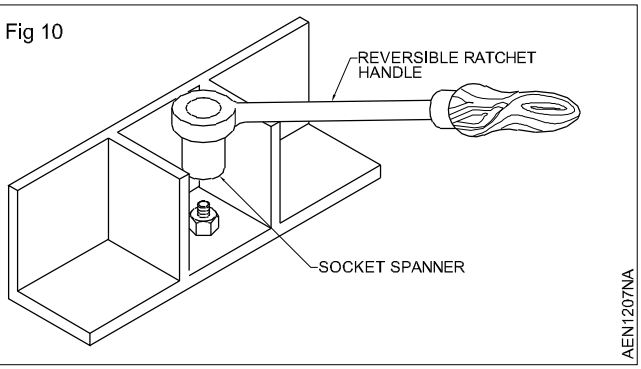


Fig 11

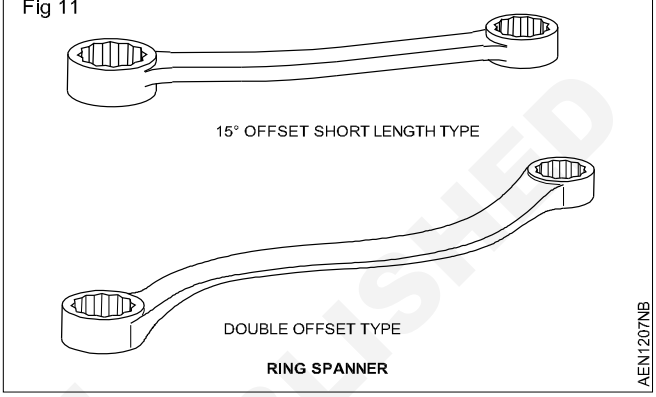
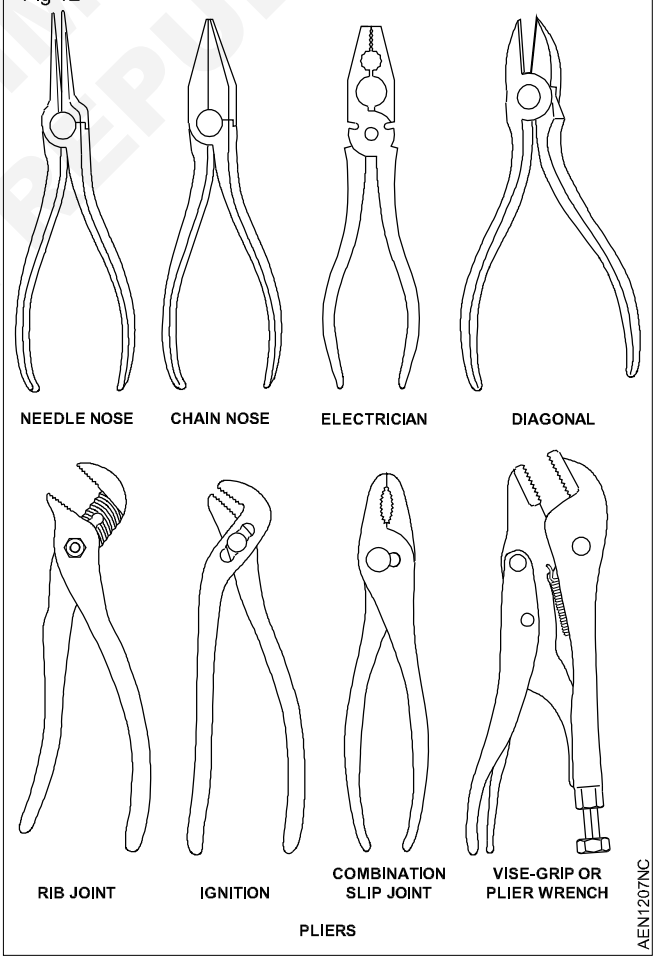


Fig 12



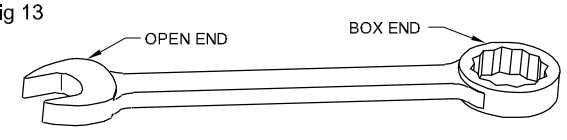
Safety

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



COMBINATION OF RING AND OPEN END SPANNER

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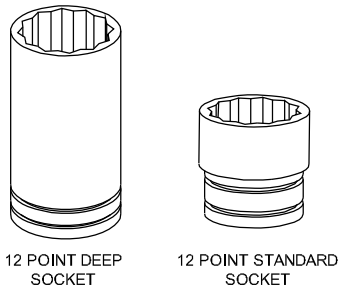
Socket spanners (Fig 14)**:** The socket is one of the fastest and most convenient of all the spanners. Sockets come in two sizes; standard and deep.

Fig 14



SOCKET SPANNER

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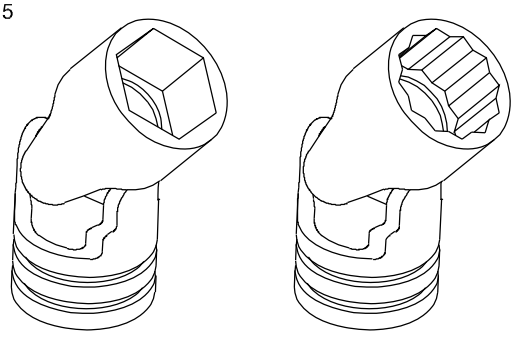
Standard sockets will handle the most of the works, while the extra reach of the deep socket is occasionally needed.

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

Fig 15



SWIVEL SOCKETS

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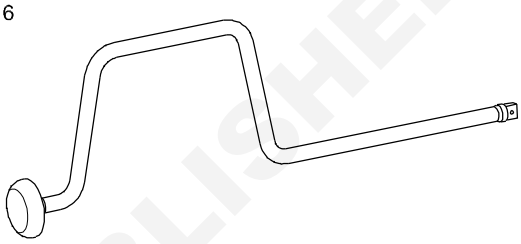
Socket handles: Several different drive handles are used. The speed handle (Fig 16 & 17) is used whenever possible as it can be turned rapidly.

Fig 16



SOCKET SPEED HANDLE

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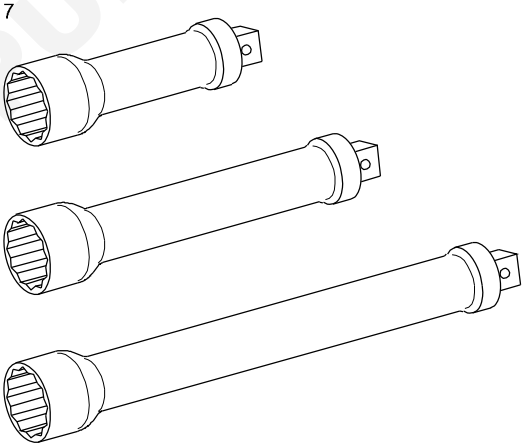
Fig 17



SOCKET EXTENSION BARS

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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
- Side Cutters
- Handles
- Pipe grip
- Joint cutters

Features

Flat jaw tips are serrated for general gripping.

Pipe grip is serrated for gripping cylindrical objects. (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)

Handles are used for applying pressure by hand.

Fig 1

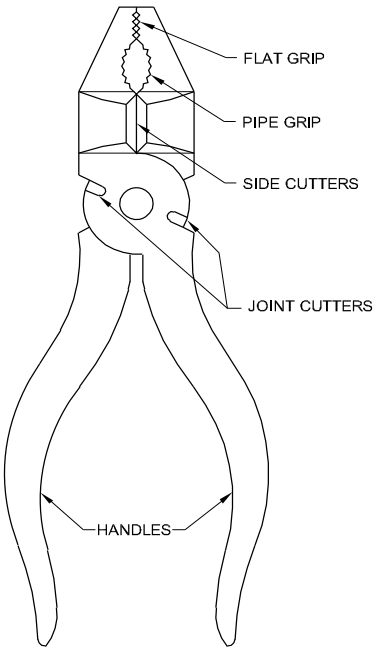


Fig 2

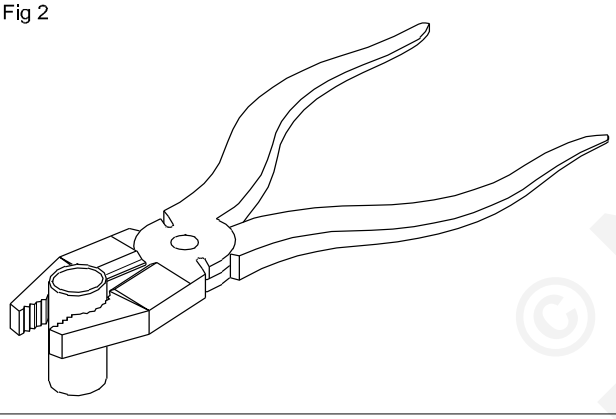
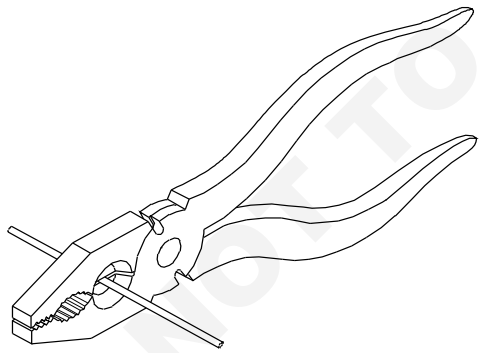


Fig 3



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)

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

Fig 4

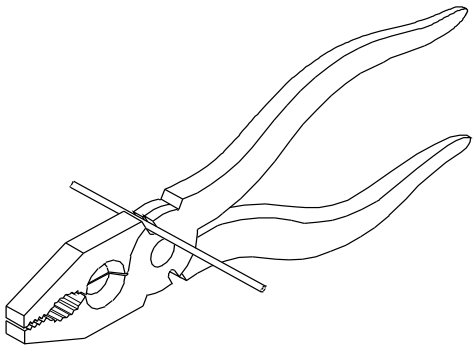


Fig 5

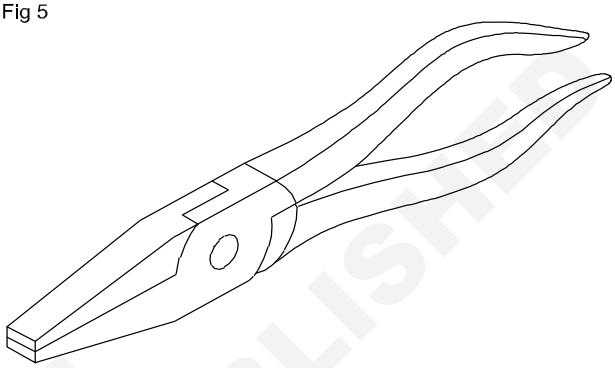
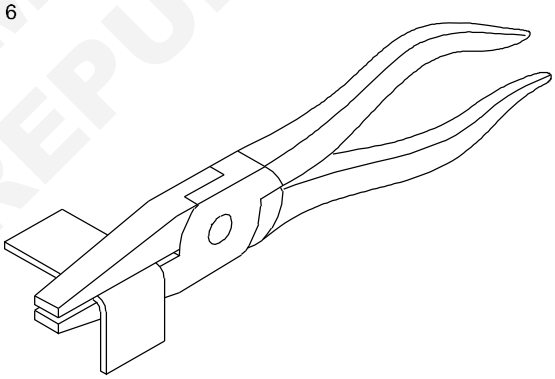
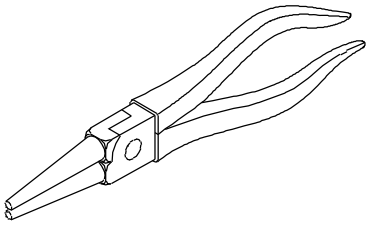


Fig 6



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

Fig 7



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)

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

Fig 8

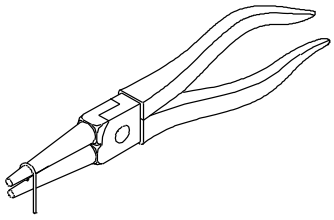


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Fig 9

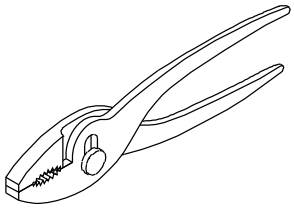

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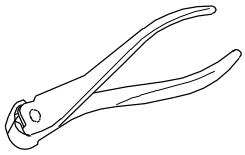
Fig 10

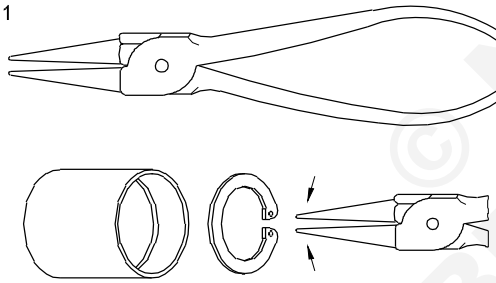


AEN1207OA

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

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

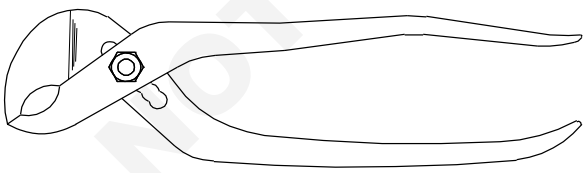
Fig 11



AEN1207OB

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

Fig 12



AEN1207OC

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

Side cutting pliers

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

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

They are also used for spreading the cotter pin. (Fig 16)

Fig 13

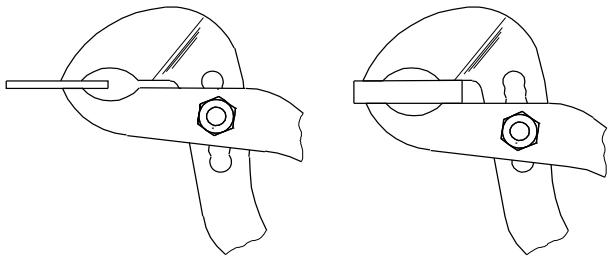


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Fig 14

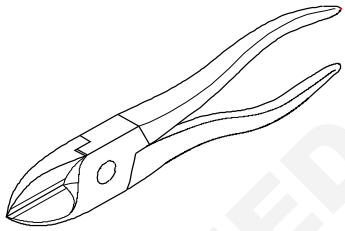

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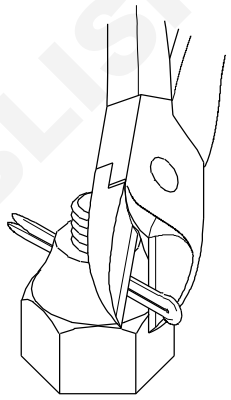
Fig 15



AEN1207OF

External circlip pliers

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

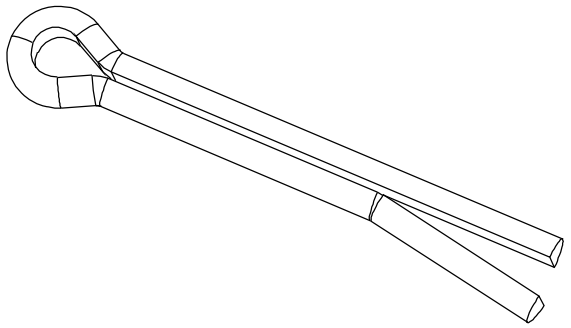
Locking pliers

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

It has high gripping power.

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

Fig 16



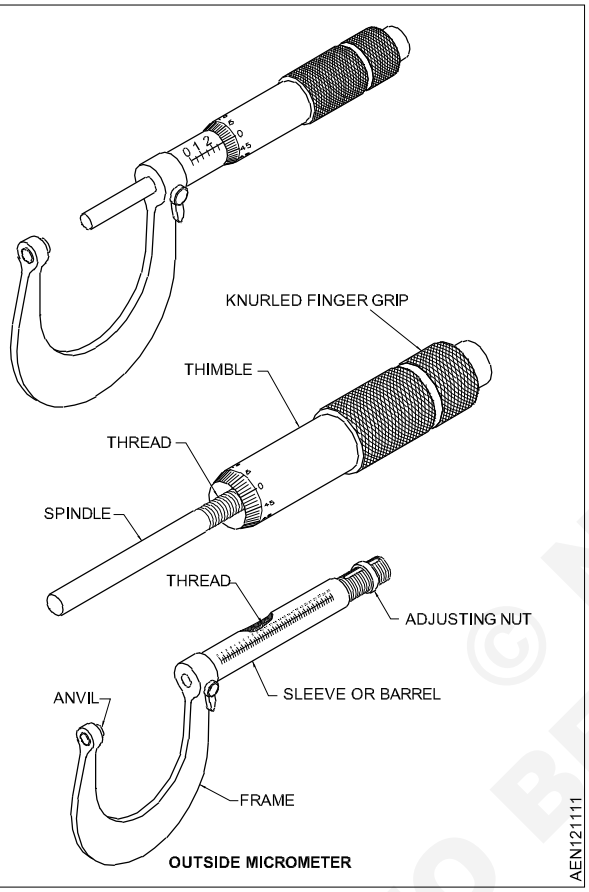
AEN1207OG

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)

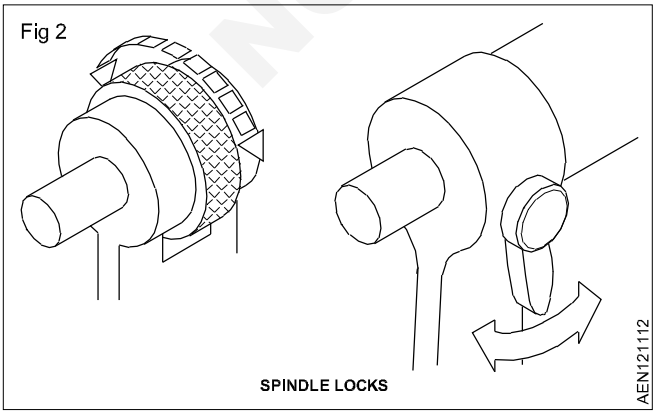
Fig 1



OUTSIDE MICROMETER

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.

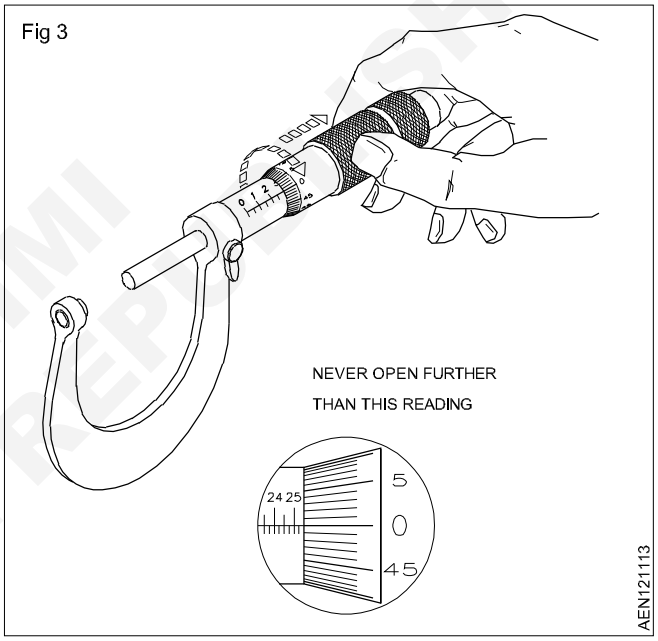
Fig 2



SPINDLE LOCKS

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

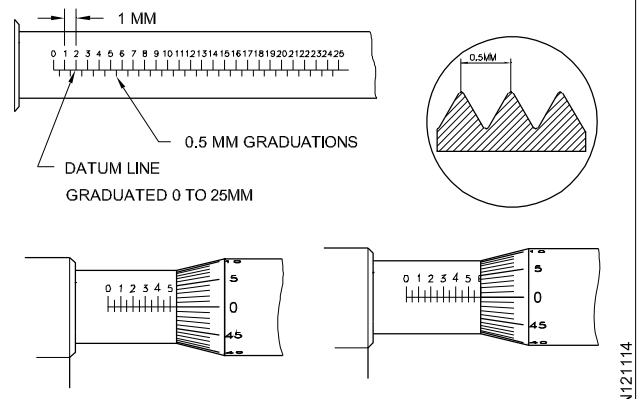
When the face of the anvil and the face of the spindle are in contact, the “O” graduations of the index line and “O” graduation of the thimble coincide with each other.

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

Deriving the least count of a metric micrometer

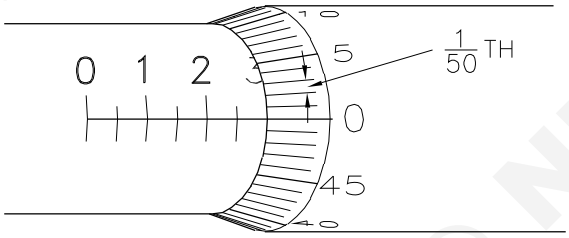
The main scale is graduated in ½ mm. Every 5th mm is shown with the reading. The pitch of the screw thread is accurately maintained to ½ mm. (Fig 4)

Fig 4



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.

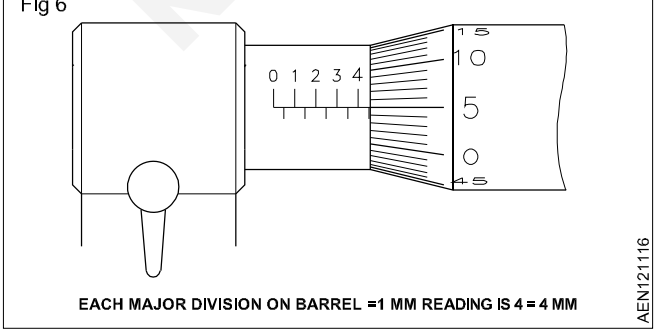
The faces of the anvil spindle must be free from dust.

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 4 mm. (Fig 6)

Fig 6

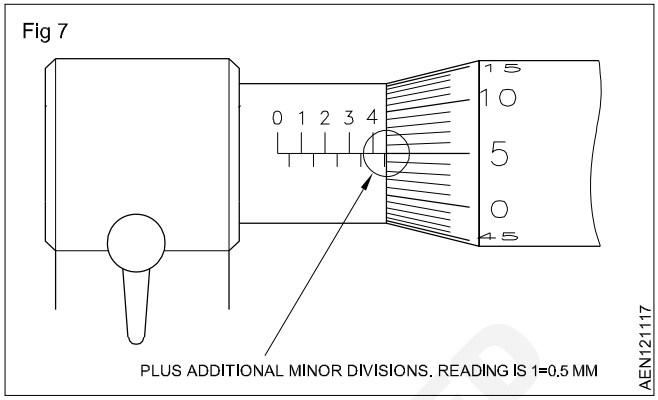


Add to this any half millimeters that are completely visible from the bevel edge of the thimble.

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)

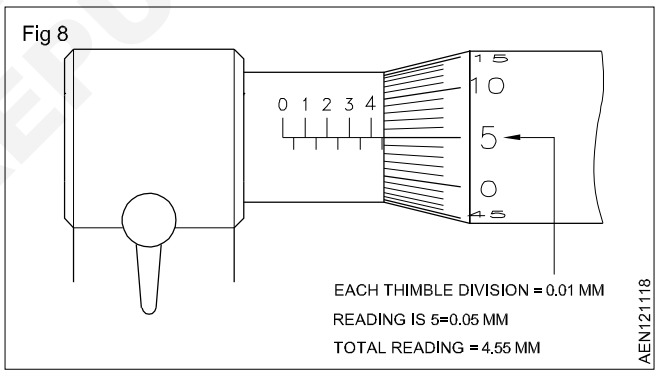
a 4.00 mm

b 0.50 mm

c 0.05 mm

Total reading 4.55 mm

Fig 8



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

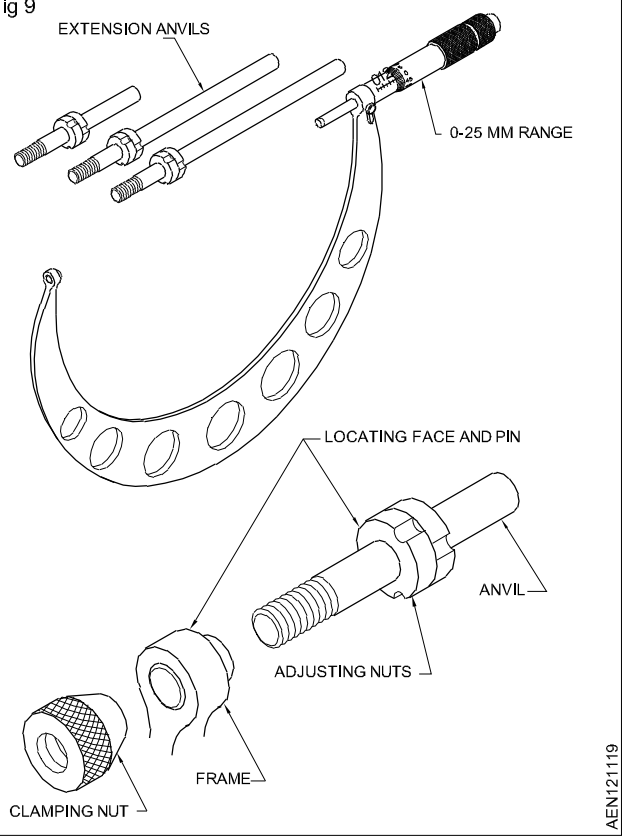
A 0-25mm capacity outside micrometer can read a maximum dimension of 25mm. For measuring sizes over and above this, we have to change to the next capacity micrometer 25-50 mm, then 50-75 mm and so on depending on the size of the job. As such, a good number of micrometers will have to be used for finishing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

Large micrometers (Fig 9)

Method of reading the micrometer 0-25 range: Look at the reading which has been taken from the workplace (Fig 10).

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

Fig 9



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

Figure 'b' shows 1 division = 0.5 mm.

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

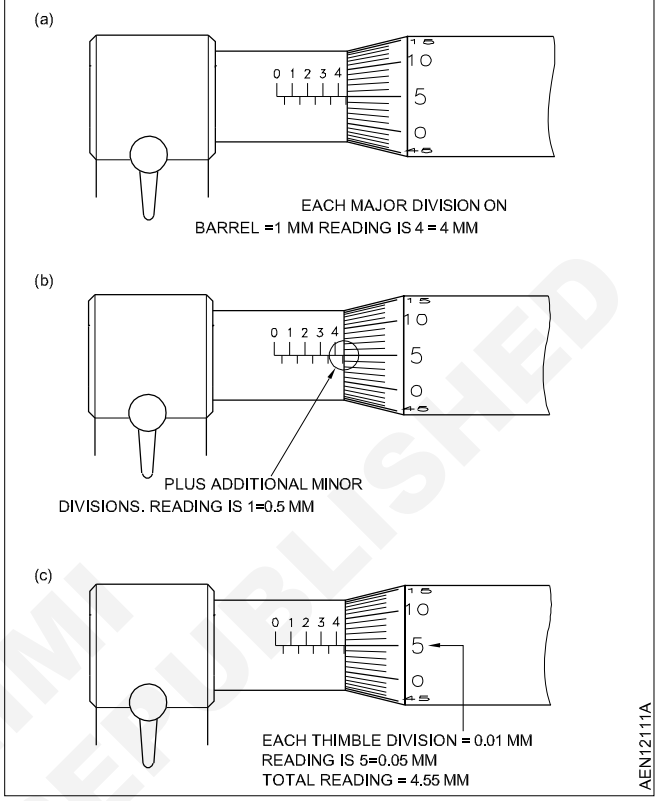
4. 00 mm

0.50 mm

0.05 mm

Total reading 4.55 mm

Fig 10



Depth micrometer

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

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

Constructional features (Fig 1)

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

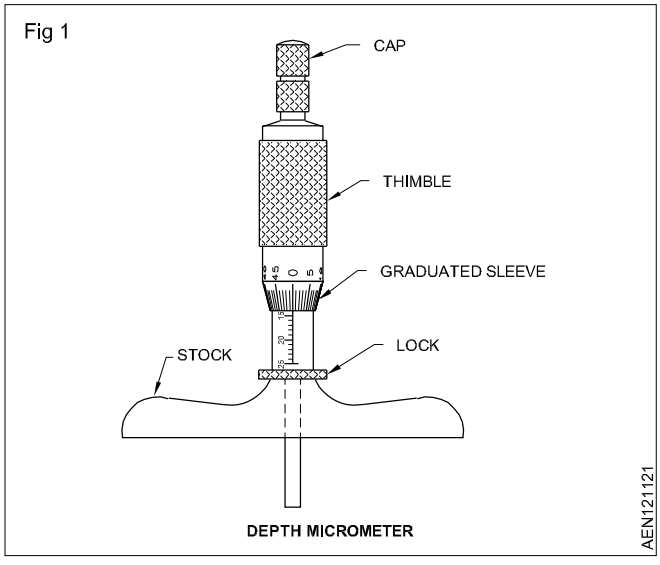
The other end of the sleeve is threaded with 0.5 mm pitch 'V' thread.

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

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

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

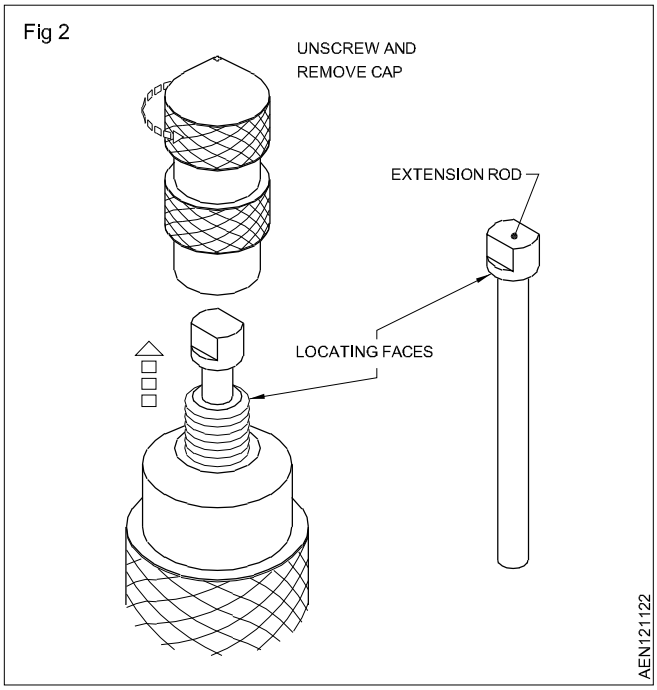
Fig 1



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)

Fig 2



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

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

Graduation and least count

On the sleeve a datum line is marked for a length of 25 mm. This is divided into 25 equal parts graduated. Each line represents one millimeter. Each fifth line is drawn little longer and numbered. Each line representing 1mm is further subdivided into two equal parts. Hence each subdivision represents 0.5 mm. (Fig 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, 20, 25, 30, 35, 40, 45 and 50 (0). (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.

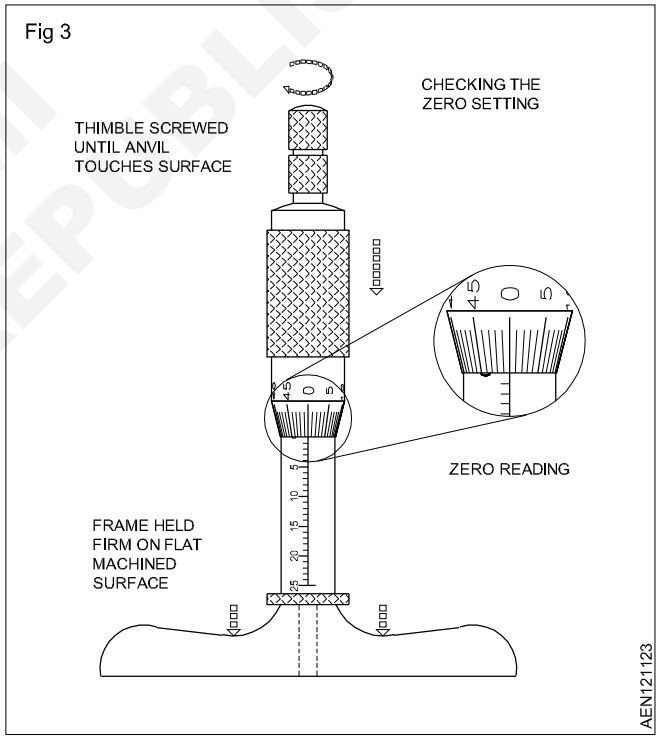
This will be the smallest measurement that can be taken with this instrument, and so this is the accuracy of measurement of this instrument.

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.

Fig 3



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 vernier caliper**
- **state the constructional features of the universal vernier caliper**
- **state the functional features of universal vernier caliper**
- **list out the points for taking the measurements.**

This precision instruments having the principle of vernier applied to 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

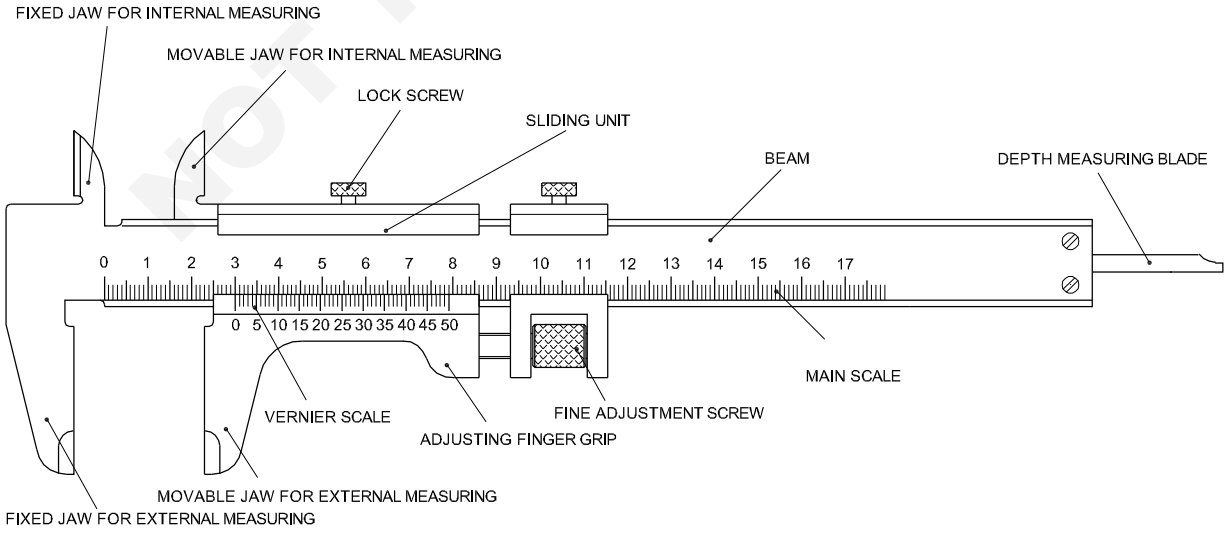
Accuracy of reading depends on the skill of the operator.

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.

Fig 1



To read a measurement

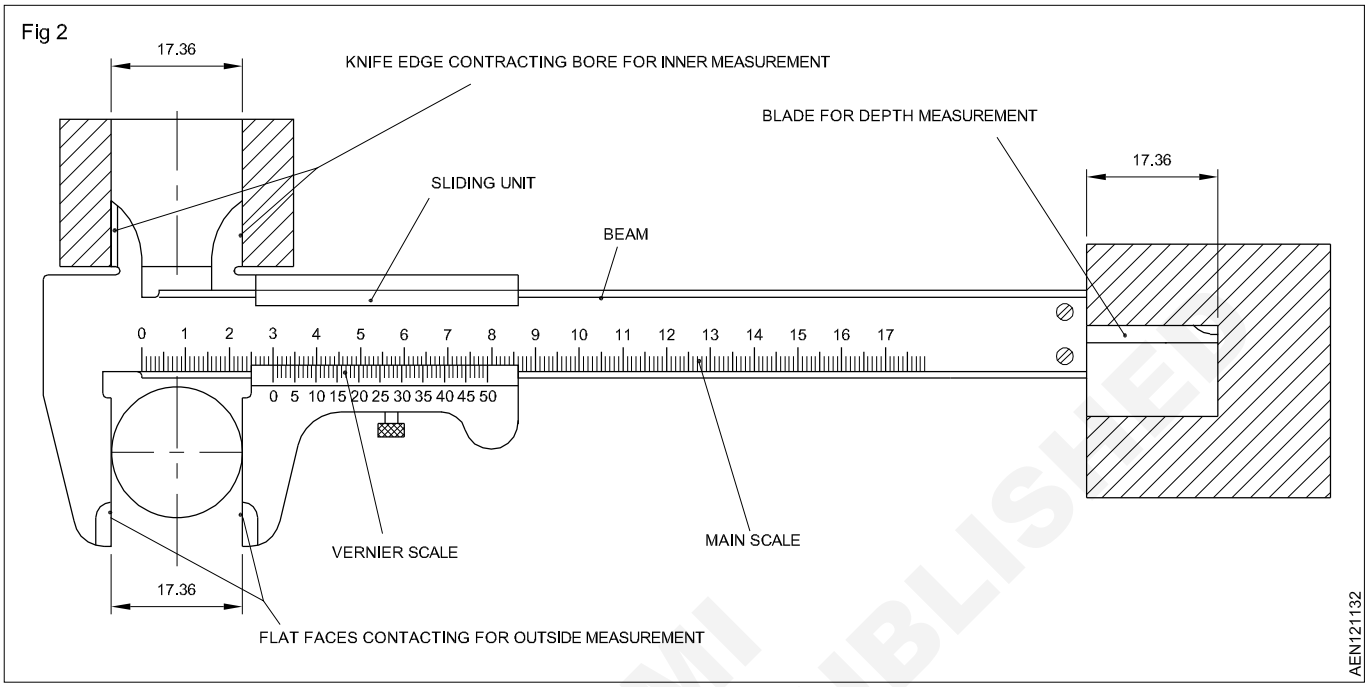
Note the number of graduations on the main scale passed by the zero of the vernier. This gives the full mm.

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

Multiply this number with the least count.

Add the multiplied value to the main scale reading.

Fig 2



Dial test indicators

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

- **state the principle of a dial test indicator**
- **state the types of dial test indicator**
- **identify the parts of a dial test indicator**
- **state the important features of a dial test indicator**
- **state the functions of a dial test indicator**
- **identify the different types of stands**
- **state the important of straight edge.**

Dial test indicators

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

Principle of working

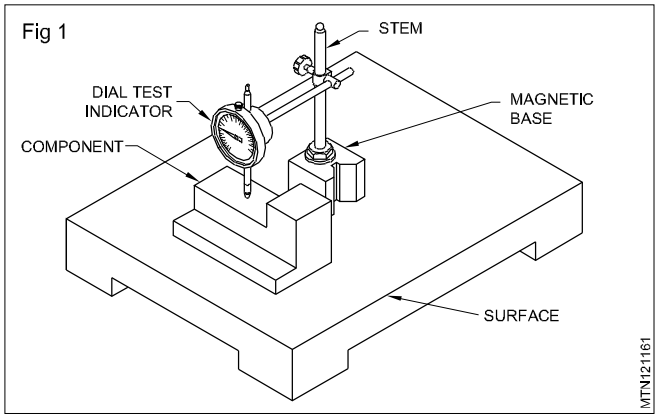
The magnification of the small movement of the plunger or stylus is converted into a rotary motion of the pointer on a circular scale.

Types

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

- Plunger type (Fig 2)
- Lever type. (Fig 3)

Fig 1



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)

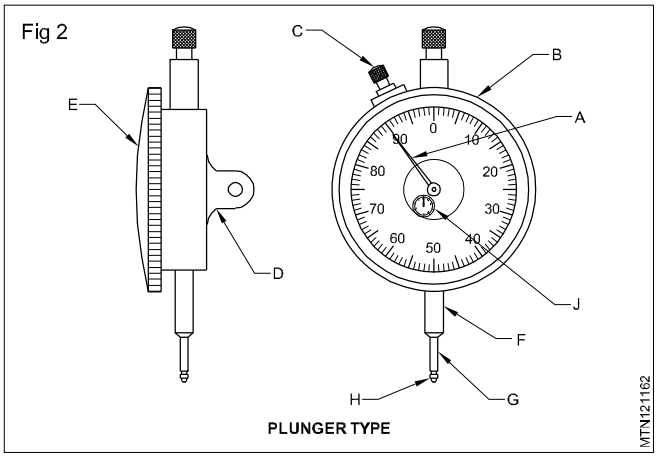
Stem (F)

Plunger (G)

Anvil (H)

Revolution counter (J)

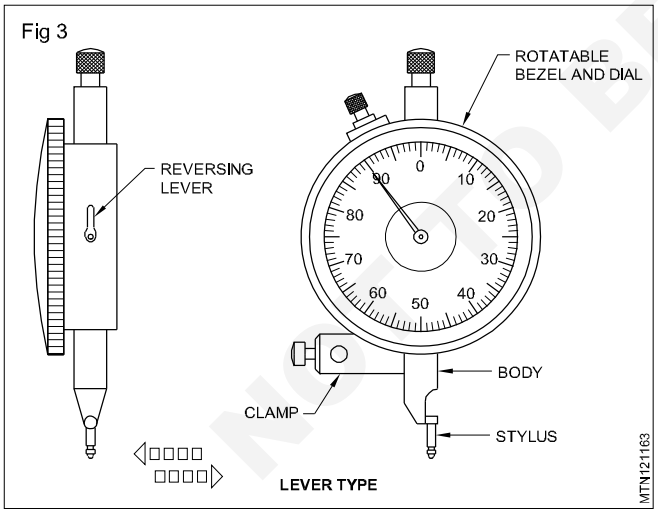
For converting the linear motion of the plunger, a rack and pinion mechanism is used.

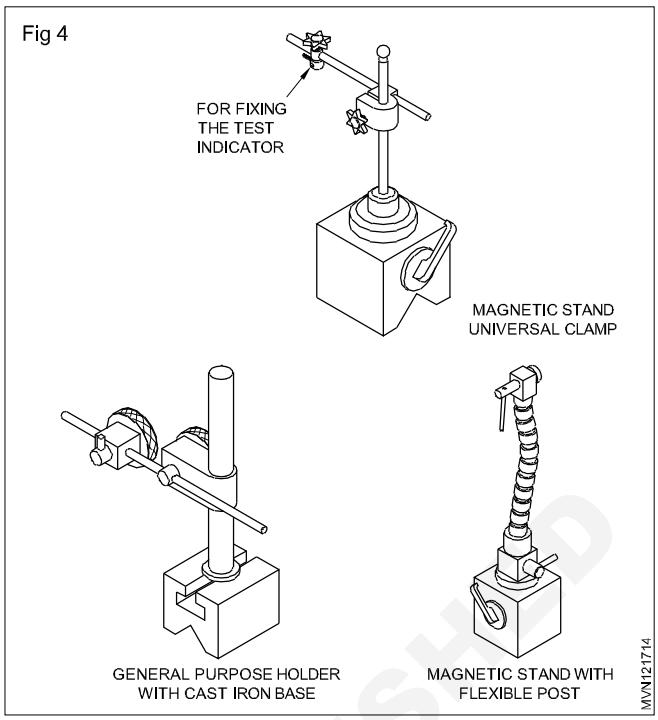


The lever type dial test indicator (Fig 3 to 5)

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.

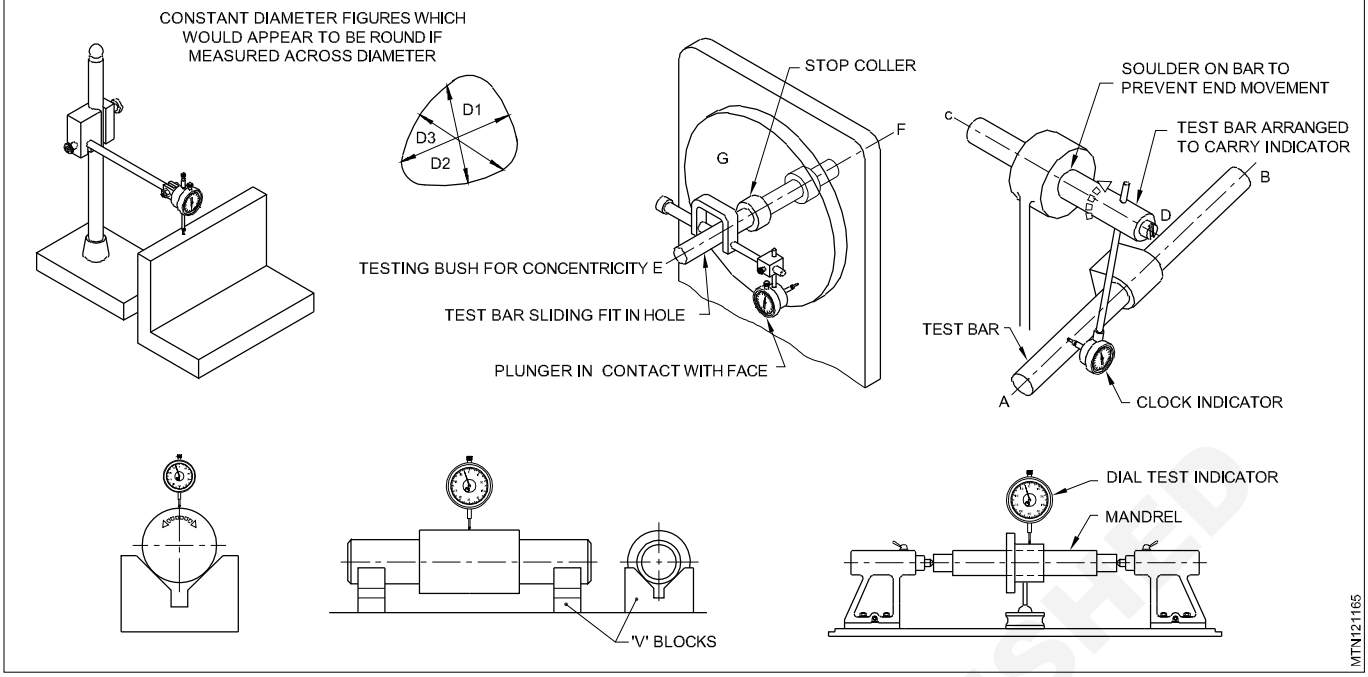
Uses

- 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



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.**

Purpose

A screw pitch gauge is used to determine the pitch of a thread.

It is also used to compare the profile of threads.

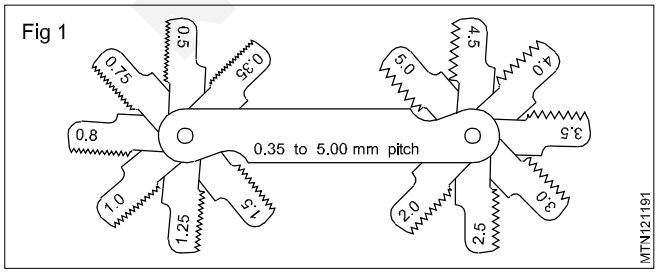
Constructional features

Pitch gauges are available with a number of blades assembled as a set. Each blade is meant for checking a particular standard thread pitch. The blades are made of thin spring steel sheets, and are hardened.

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

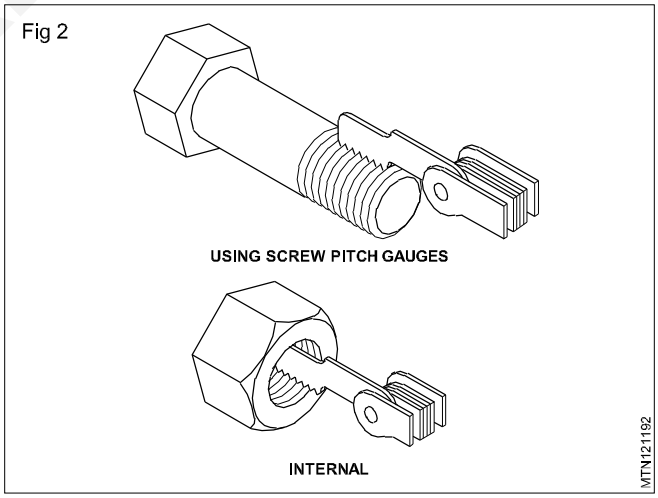
The thread profile on each blade is cut for about 25 mm or 30 mm. The pitch of the blade is stamped on each blade. The standard and range of the pitches are marked on the case. (Fig 1)

Fig 1



For obtaining accurate results while using the screw pitch gauge, the full length of the blade should be placed on the threads. (Fig 2)

Fig 2

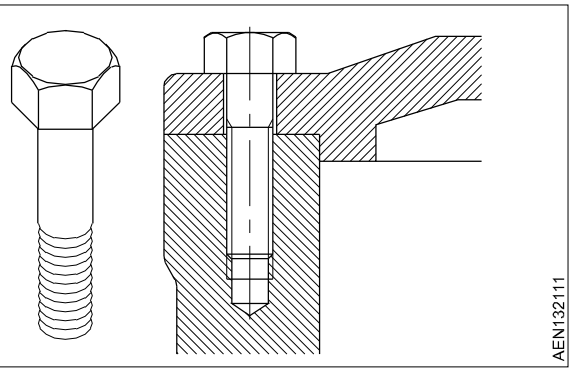


Different types of screws, nuts, studs and bolts

Objectives: At the end of this lesson you shall be able to
- **name the different types of machine screws used in heavy duty assembly**
- **name the different types of machine screws used in light assembly work**
- **state the uses of different types of machine screws**
- **name the different types of set screws.**

Machine screws are used when a nut cannot be used in the assembly and the component in the assembly has a threaded hole to receive the screws (Fig 1)

Fig 1



Types of machine screws (Heavy duty)

- Hexagon head screws
- Hexagon socket head cap screws
- Square head countersink head screws

These are heavy duty screws.

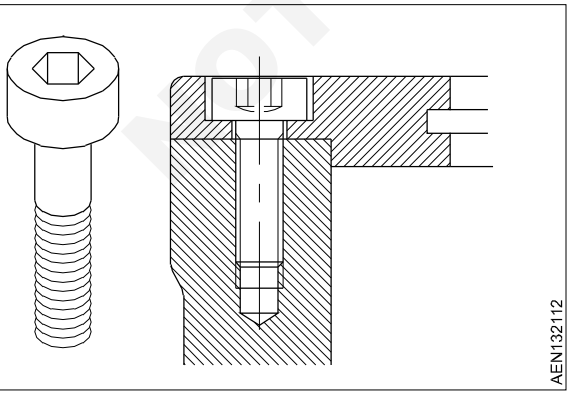
Hexagon head screws

These are used when the projection of the screw head will not be an obstruction in the assembly (Fig.1)

Hexagon socket head cap screws

These are used when the projection of the screw head above the surface is to be avoided. (Fig.2) The Indian Standard specification head socket cap screws cover the range from 1.6 mm to 36mm.

Fig 2



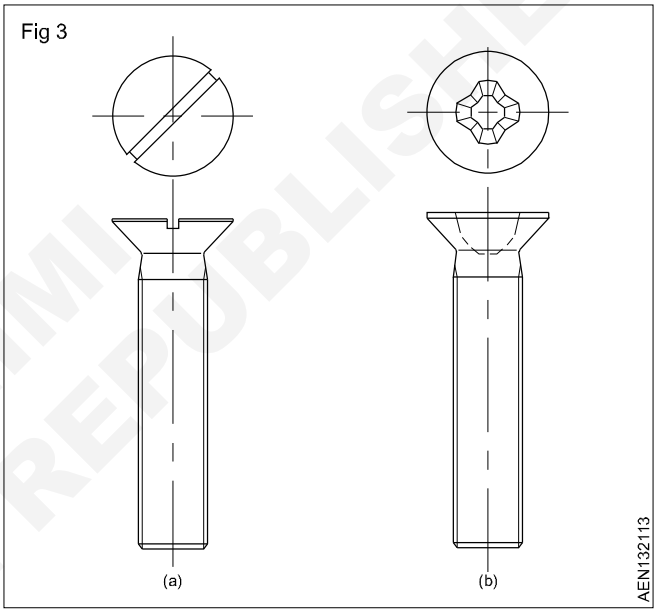
Hexagon head screws and hexagon socket head screws are made of steel. Hexagon head screws used in electrical work are made of brass.

Countersink head screws

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

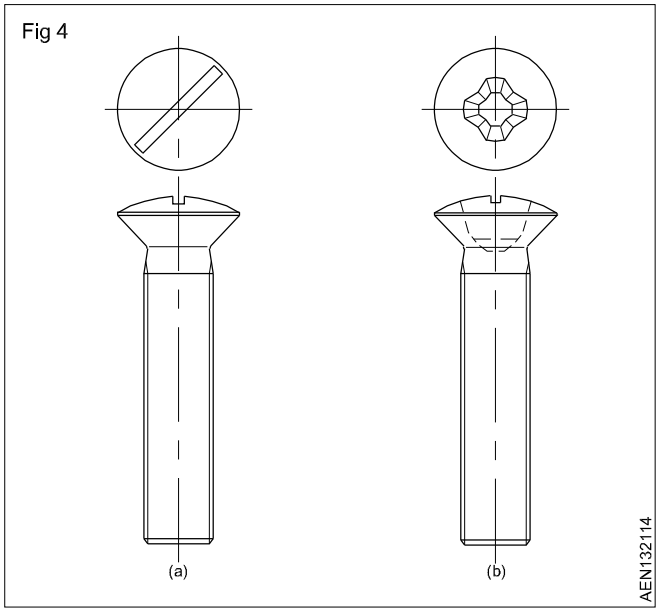
- slotted countersink head screws (Fig 3a)
- cross-recessed countersink head screws (Fig 3b)

Fig 3



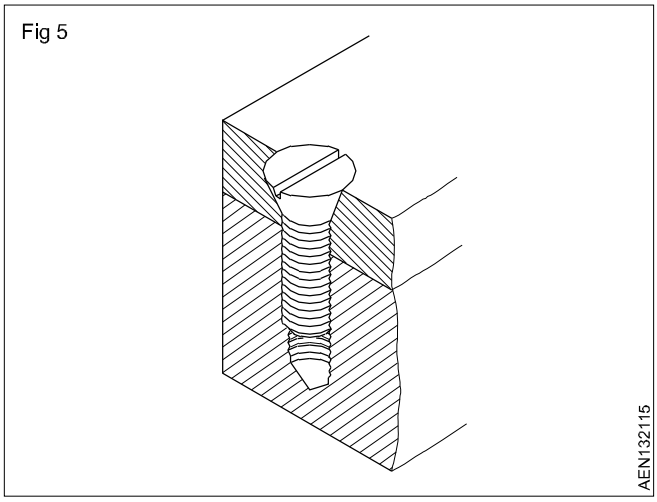
- slotted raised countersink head screws (Fig 4a)
- cross recessed, raised countersink head screws. (Fig 4b)

Fig 4



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

Fig 5

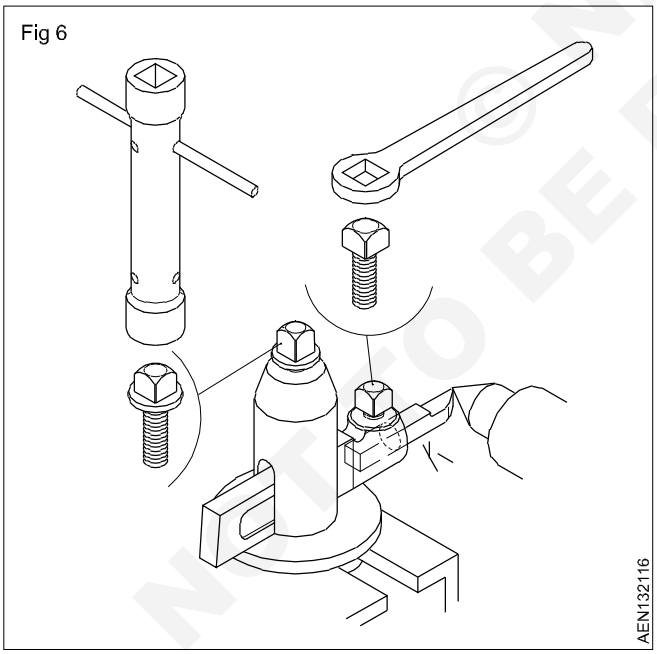


The projection of the screw head above the assembly is also avoided. B.I.S. specification covers the following ranges of countersink head screw sizes in different types.

- 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.

Square head screws (Fig 6)

Fig 6

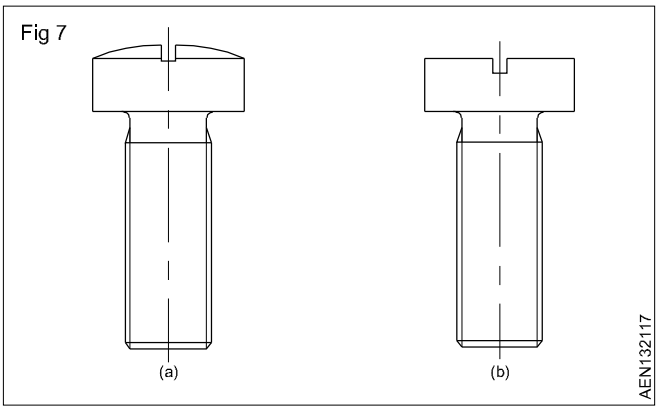


Square head screws are used in places where there is frequent removal and refitting of the assembly. These screws are tightened to a higher torque using a wrench. (Fig 6) Square head screws are also available with a collar. In this there is a washer at the base which is an integral part of the head. The purpose of this collar is to protect the work-surface from damages due to constant use of wrenches.

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

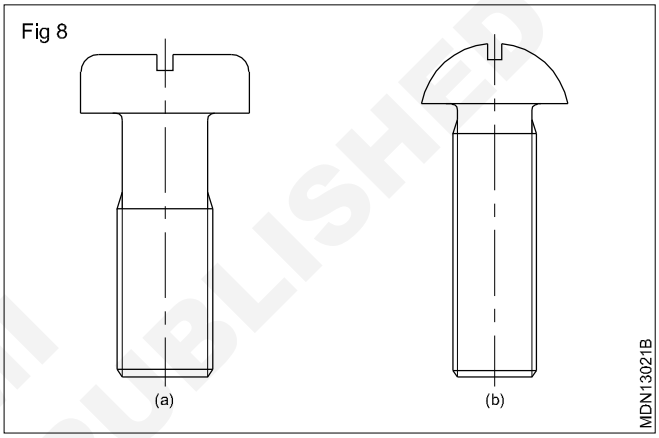
Pan head (Fig 7a) ; Cheese head (Fig 7b)

Fig 7



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

Fig 8



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

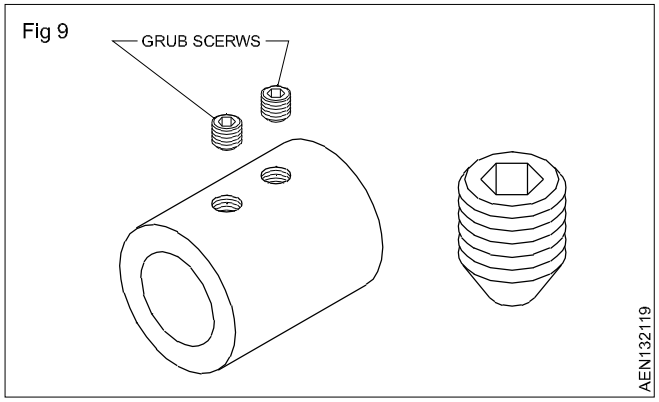
The screws used for light duty are normally available up to 10mm thread diameter.

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)

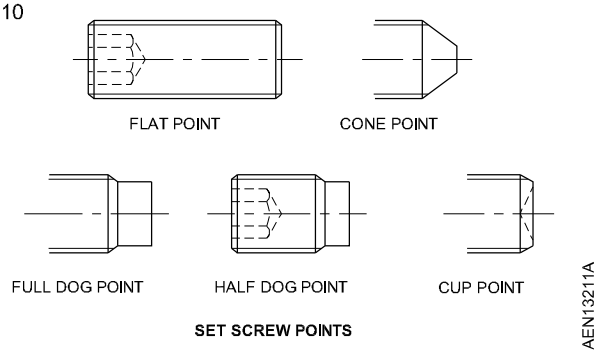
Fig 9



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

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.

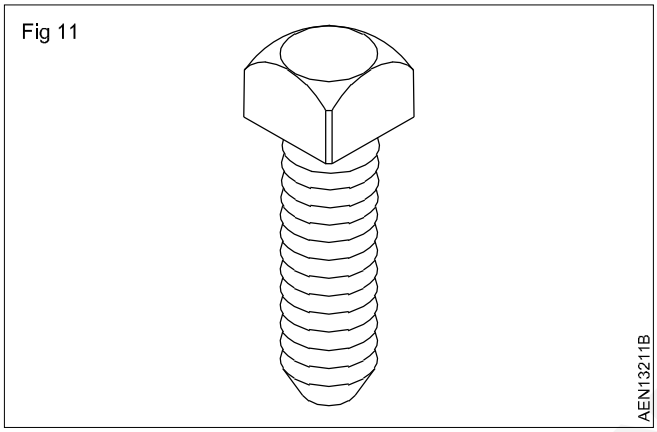
Fig 10



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.

Fig 11



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

Grub screws

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

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

Fig 12

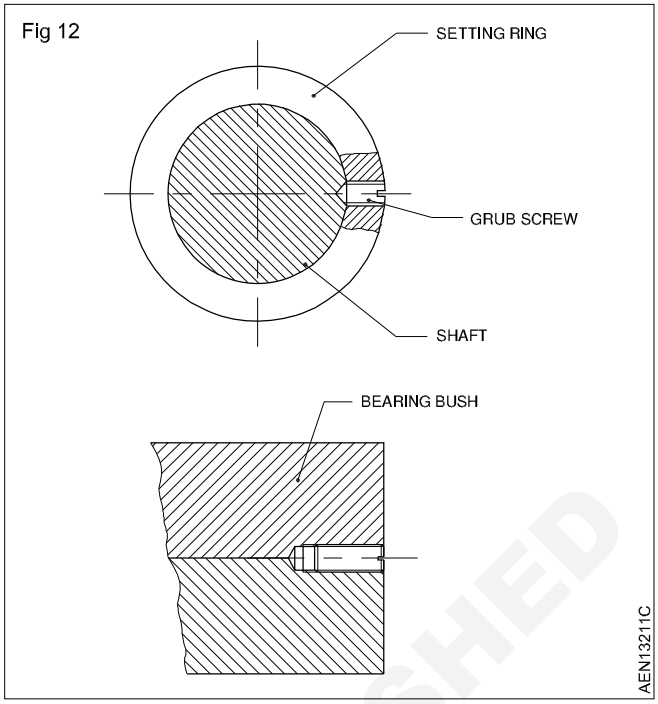
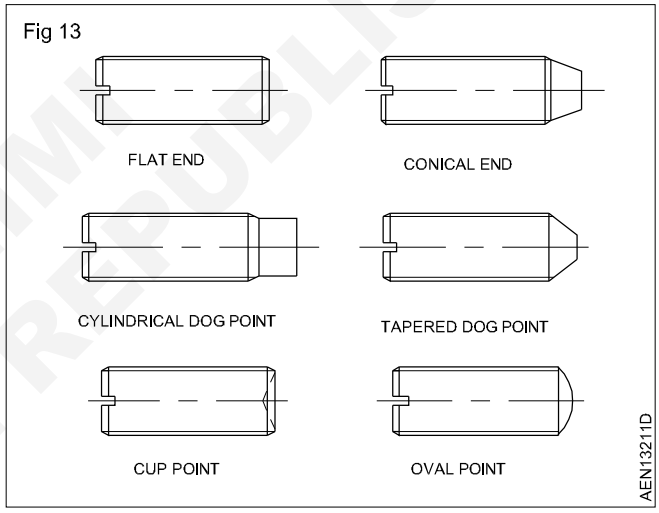


Fig 13



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)

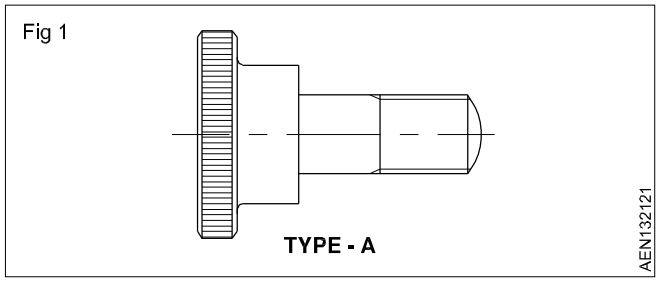
Type-C Slotted thumb screw partially threaded (Fig 3)

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

Type-E Flat thumb screws (Fig 5)

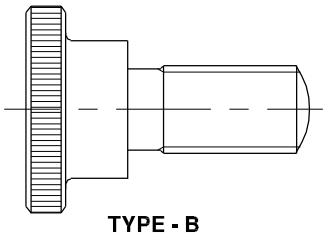
The type of thumb screw selected depends on the actual requirement in the assembly.

Fig 1



Sizes: Thumbs screws are available in the following sizes as per B.I.S.

Fig 2



TYPE - B

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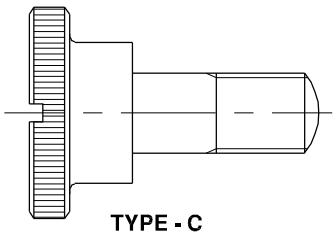
Fig 3



TYPE - C

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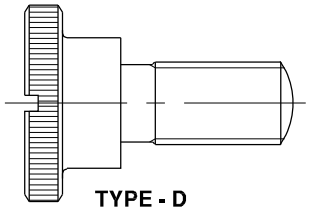
Fig 4



TYPE - D

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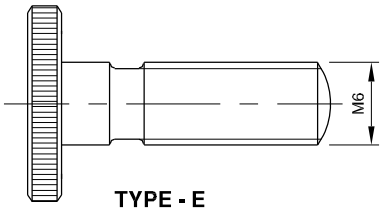
Fig 5



TYPE - E

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M1.6, M2, M2.5, M3, M4, M5, M6, M8 and M10.

Designation of thumb screws

Thumb screws shall be designated by the nomenclature, type, thread size, nominal length, the number of Indian Standard and the symbol for mechanical properties.

Example

A thumb screw of Type `A', size M6, nominal length 12mm and of property class 4.6 shall be designated as:

Thumb screws A M6 x 12 IS: 3726-4.6

When brass or any other non-ferrous metal is used for the manufacture of thumb screws, the word Brass or the name of the non-ferrous metal used will replace the property class number in the designation.

Types of Nuts

Objectives: At the end of this lesson you shall be able to
- **name the common types of nuts**
- **state the features and uses of the common types of nuts.**

Different types of nuts are used depending on the requirement of the assembly.

Hexagonal nuts (Figs 1 & 2)

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

Fig 1

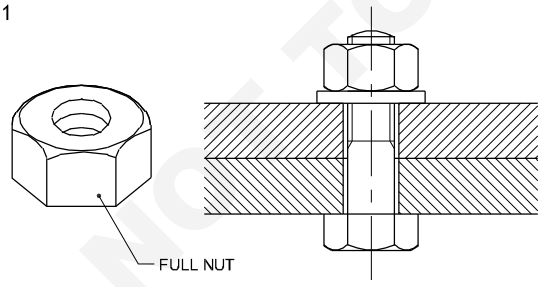

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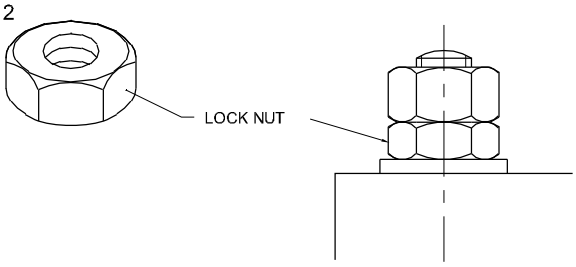
Fig 2



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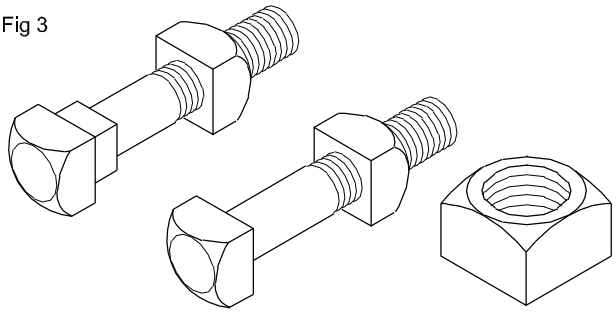
Hexagonal nuts are available in different thicknesses. Thin nuts are used as lock-nuts.

Square nut (Fig 3)

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

Fig 3



AEN132133

Self-locking nuts (Simmonds lock-nut) (Fig 4)

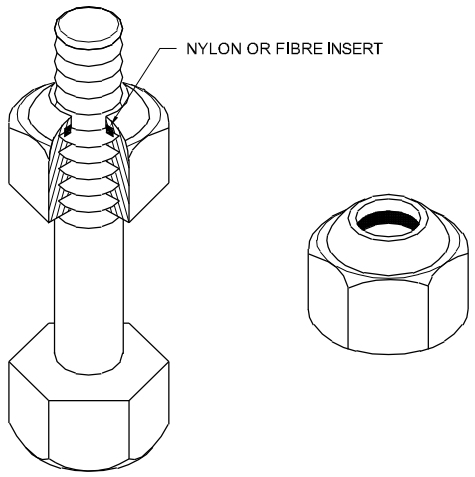
This nut has an internal groove cut in which a fibre or nylon ring is inserted. This ring holds the nut tightly on the bolt and serves as a locking device.

Self-locking nuts are not used with studs.

T-nuts

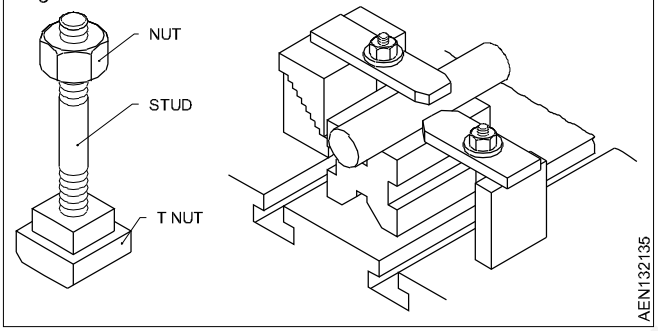
T-nuts are used along with studs on machine tools for fixing/holding devices or workpieces.

Fig 4



Slotted and castle nuts (Fig 5)

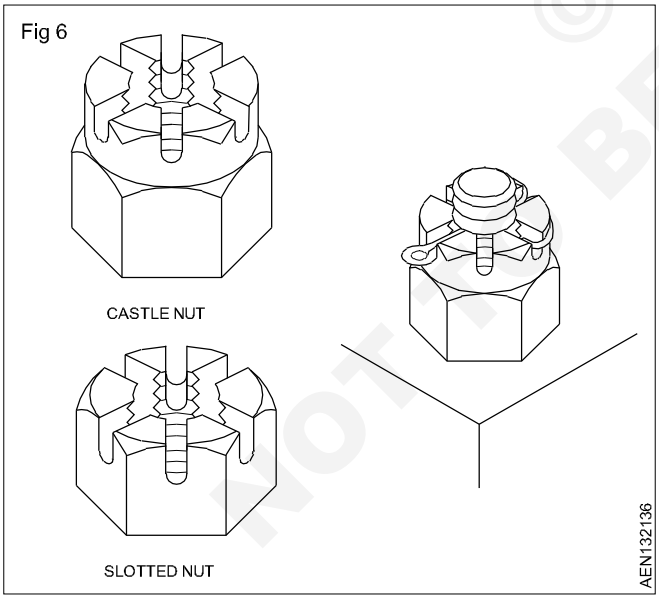
Fig 5



Round nuts (Fig 6 to 10)

Round nuts of different types are available for special applications.

Fig 6



Slotted round nut (Figs 7, 8, 9 & 10)

Slotted round nut for hook wrench.

Round nut with set pin holes on sides

Round nut with holes in the face.

Fig 7

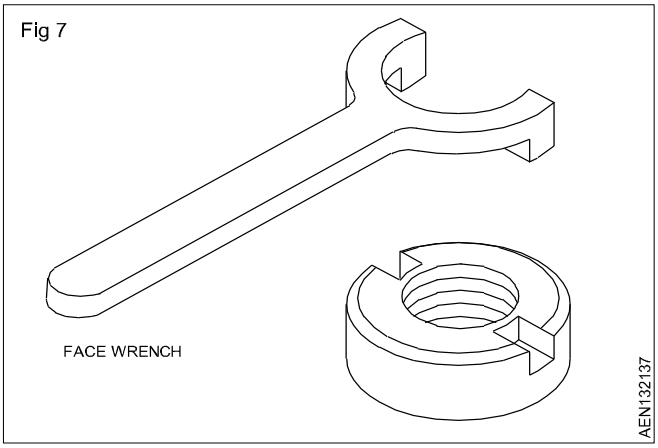


Fig 8

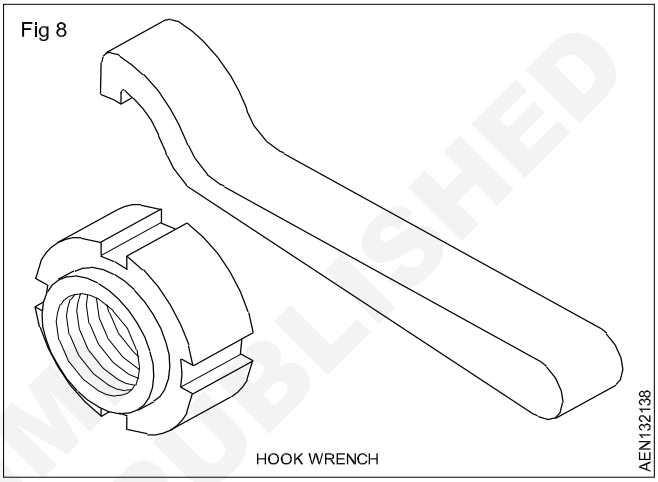


Fig 9

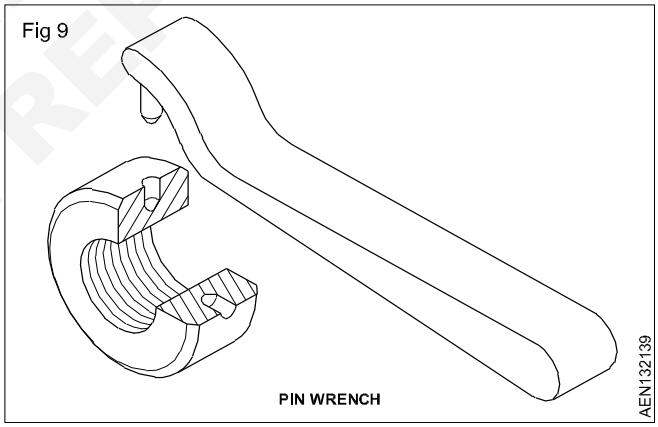
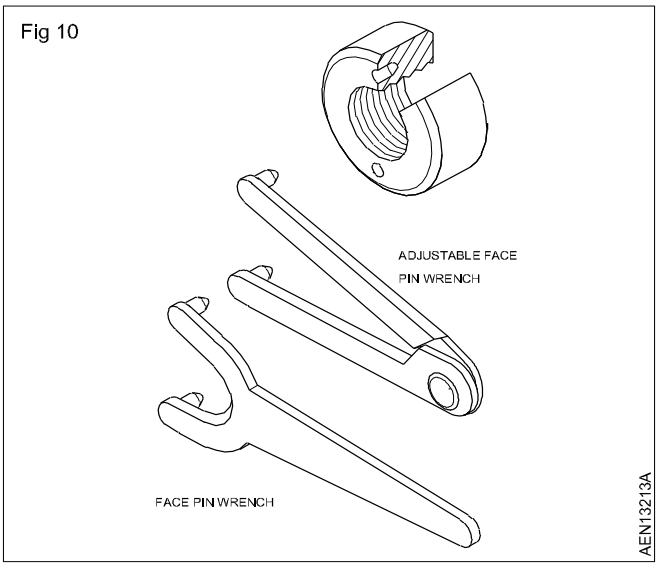


Fig 10



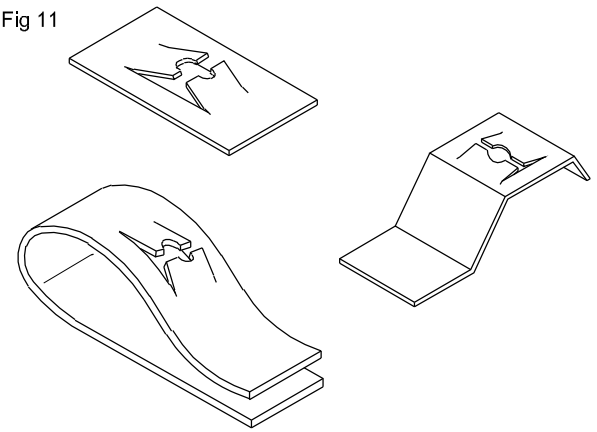
Speed nut (Fig 11)

Speed nuts are available in a variety of forms and are made form different materials such as spring steel, stainless steel etc. The speed nut consists of a strip of metal stamped in such a manner that one or more thread engaging portions are pressed upwards from the base to form part of a screw thread.

Speed nuts are generally used in conjunction with coarse thread or sell-tapping screws. As the screw is tightened, the pressure exerted on the tongues gives a self-locking action.

This is used for lacking and soldering of joining points.

Fig 11



AEN13213B

Bolts, studs and nuts

Objectives: At the end of this lesson you shall be able to
- **state the situations in which bolts and nuts are used**
- **state the advantages of using bolts and nuts**
- **name the different types of bolts**
- **state the applications of the different types of bolts**
- **state the situations in which studs are used**
- **state the reason for having different pitches of threads on stud ends.**

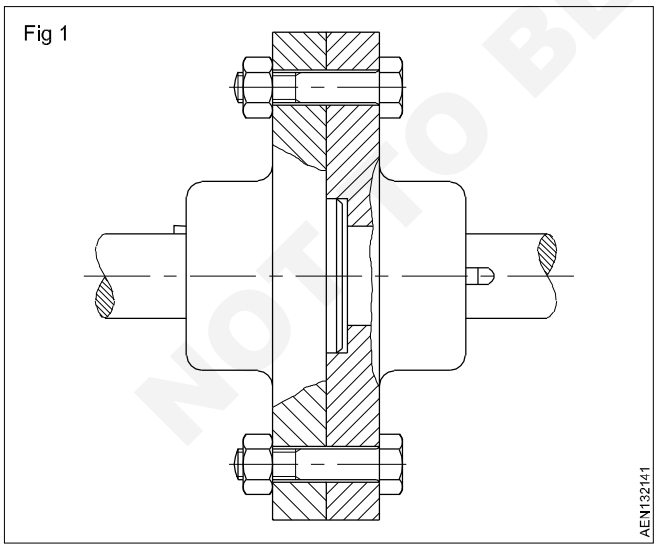
Bolts and nuts (Fig 1)

These are generally used to clamp two parts together.

When bolts and nuts are used, if the thread is stripped, a new bolt and nut can be used. But in the case of a screw directly fitted in the component. When threads are damaged, the component may need extensive repair or replacement.

Depending on the type of application, different types of bolts are used.

Fig 1



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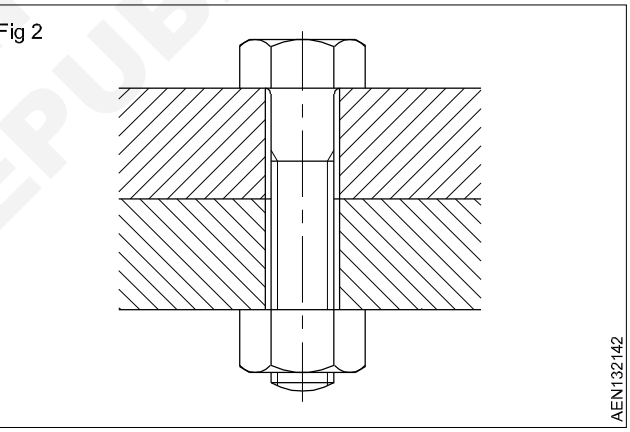
Bolts with clearance hole (Fig 2)

This is the most common type of fastening arrangement using bolts. The size of the hole is slightly larger than the bolt (clearance hole)

Slight misalignment in the matching hole will not affect the assembly.

Fig 2



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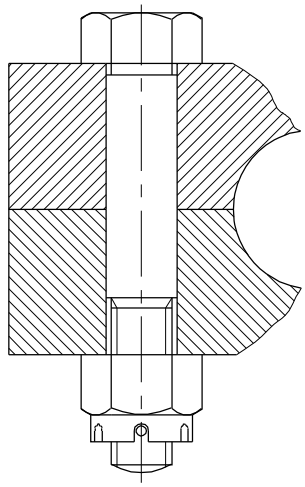
Body fit bolt (Fig 3)

This type of bolt assembly is used when the relative movement between the workpieces has to be prevented.

Fig 3



BODY FIT BOLT

AEN132143

The diameter of the threaded portion is slightly smaller than the shank diameter of the bolt.

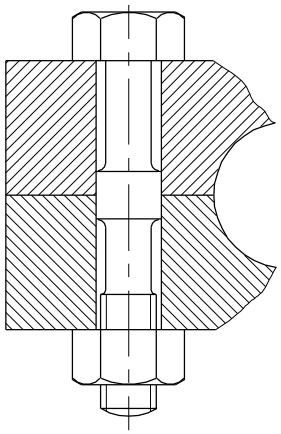
The bolt shank and the hole are accurately machined for achieving perfect mating.

Anti-fatigue bolt (Fig 4)

This type of bolt is used when the assembly is subjected to alternating load conditions continuously. Connecting 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



ANTI-FATIGUE BOLT

AEN132144

Studs (Fig 5)

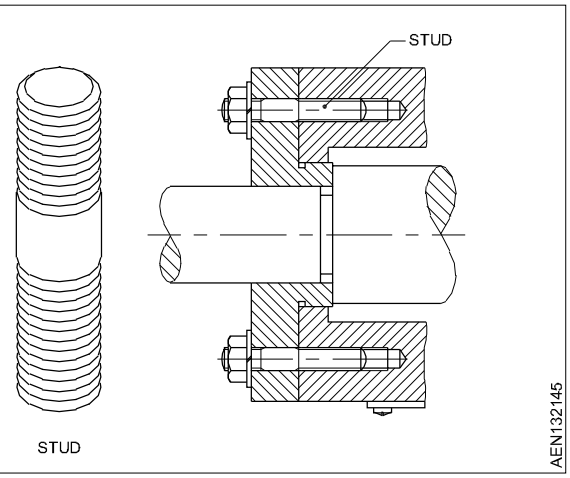
Studs are used in assemblies which are to be separated frequently.

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.

Fig 5



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 device**
- **state the classification of lock nut**
- **name the various types of locking devices**
- **state the uses of the locking devices.**

Locking devices

A locking device is a device used to lock the threaded fasteners to prevent them from loosening. Due to vibration in the moving part, there is a tendency for the threaded fastener to get slack and to slip off. Then the assembled part will get loose and cause damages. Some examples are given below to illustrate the importance of the locking device.

In the case of a micrometer, the lock-nut avoids the Movement of the spindle after taking the reading. In the case of boilers and gas cylinders, locking of the nut avoids the leakage of steam or gas.

In automobiles the lock-nut avoids the loosening of the assembled part.

Classification of lock-nuts

Lock-nuts are classified into two categories.

- Positive locking device

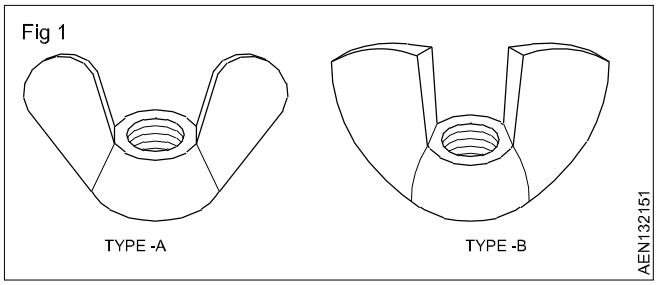
- Frictional locking device

These nuts have special provision in the form of slots for fixing split pins for locking the nuts.

Slotted nuts are hexagonal shaped throughout. In the case of castle nuts, the top part of the nut is cylindrical in shape.

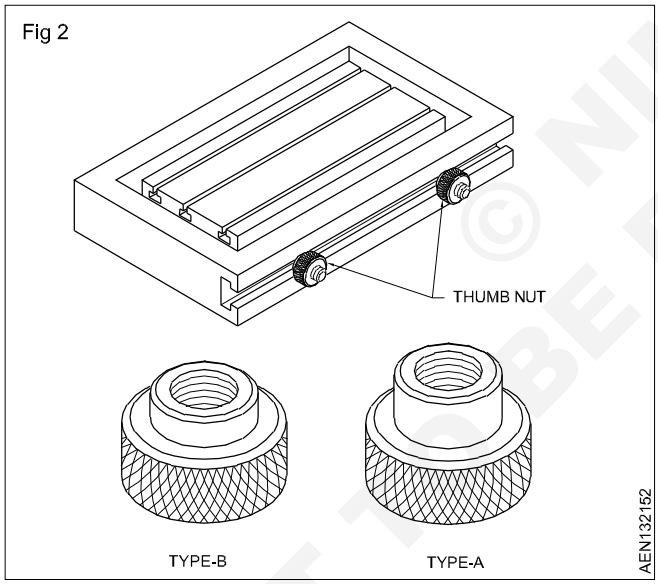
Wing-nuts (Fig 1)

Wing-nuts are used in light duty assembly which require frequent removal and fixing. These are available as hot forged/cast (Type A) and cold forged (Type B).



Thumb-nut (Fig 2)

These are used in places where frequent adjustments are required and mere finger tightening 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.

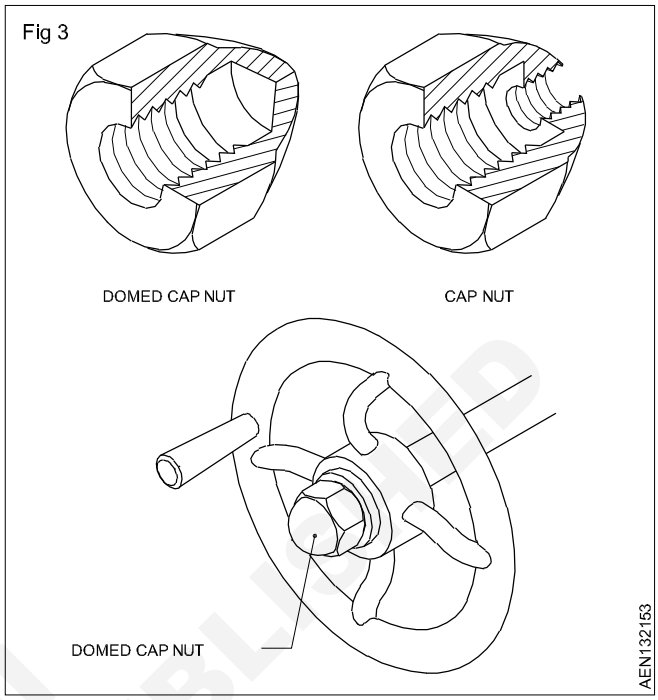
Hexagonal nuts with collar (Fig 4)

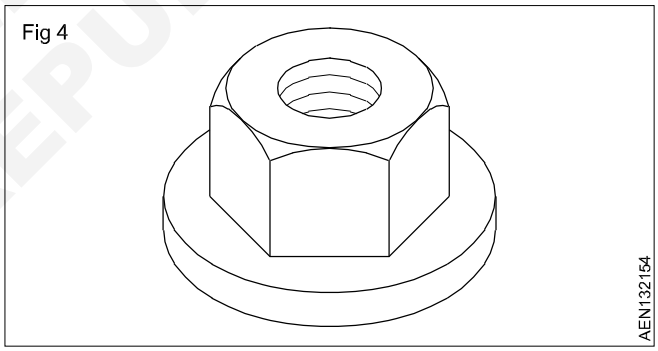
These nuts have a machined collar on one end. This provides additional bearing surface in assembly. The collar acts like a washer and is useful where frequent tightening and loosening is necessary.

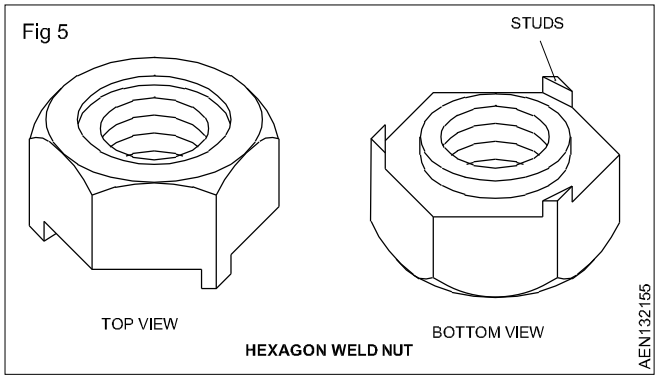
Hexagonal weld nuts (Fig 5)

These are nuts used for welding on the plate work. These nuts have:

- a spigot ring which fits in the hole of the plate
- three projections to provide a uniform contact on the surface, that is to be welded
- a countersunk hole on one end to protect the thread during welding.





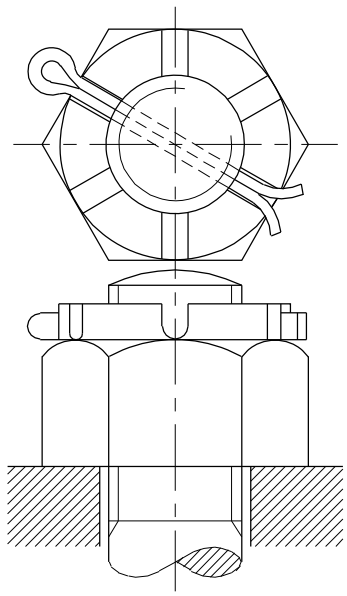


Out Castle nuts (Fig 6) are widely used in automobiles and locomotive engines to avoid sudden shock and vibration.

Circlip (Fig 7)

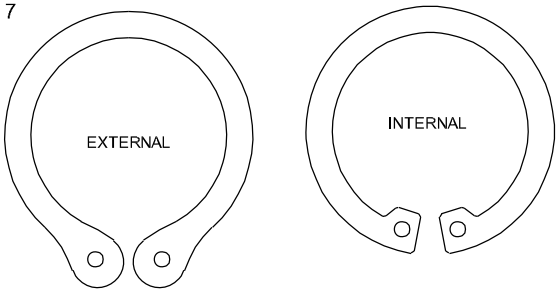
These are widely used to retain the component on a shaft or in a bore. Seating of these circlips in a slot by using a special type of pliers facilitates rapid assembly and disassembly.

Fig 6



AEN132156

Fig 7

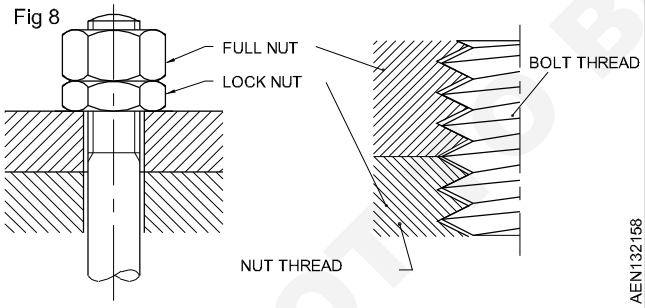


AEN132157

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

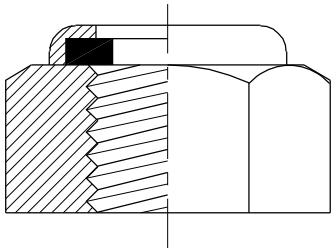


AEN132158

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



AEN132159

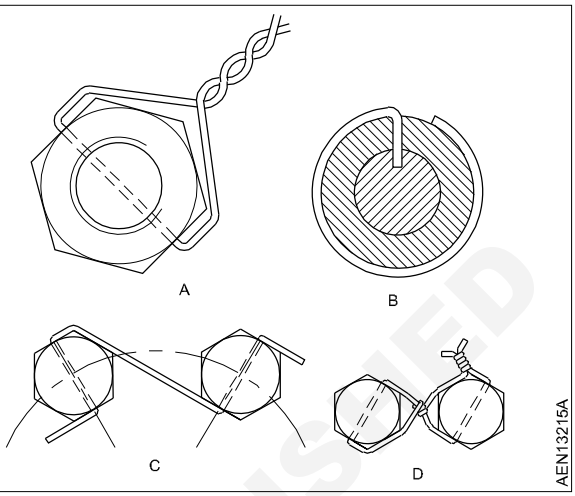
Wire lock (Fig 10)

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

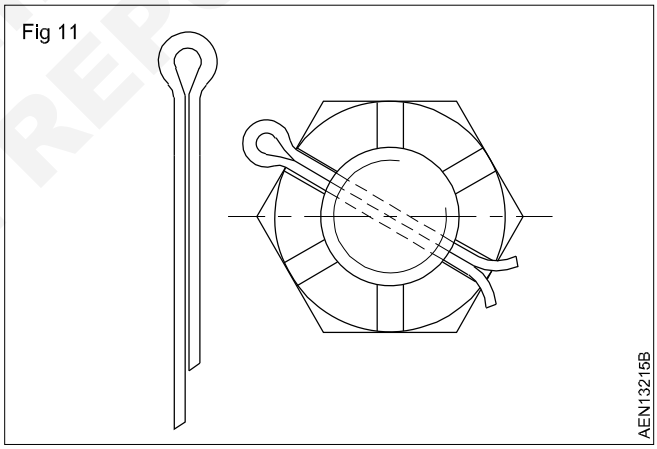


AEN13215A

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.

Fig 11



AEN132215B

Sawn nut (Wiles nut)

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

Positive locking device (Fig 12)

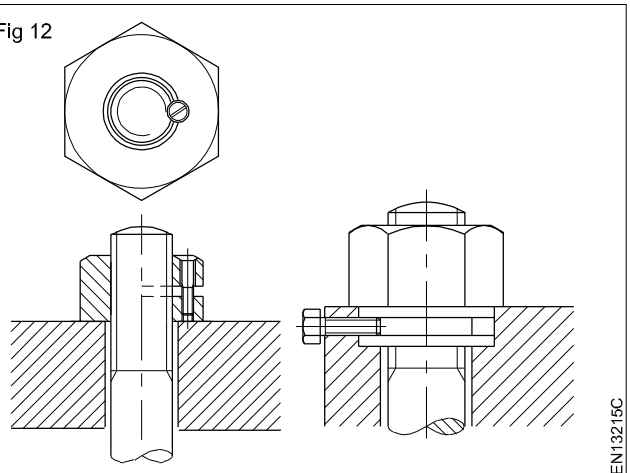
Frictional locking device

Positive locking device (Fig 13)

In the positive locking device, the locking action is positive. This locking device is difficult to fit and may take more time. But it is very essential to use this type of locking device in critical joints where failure could cause serious accidents.

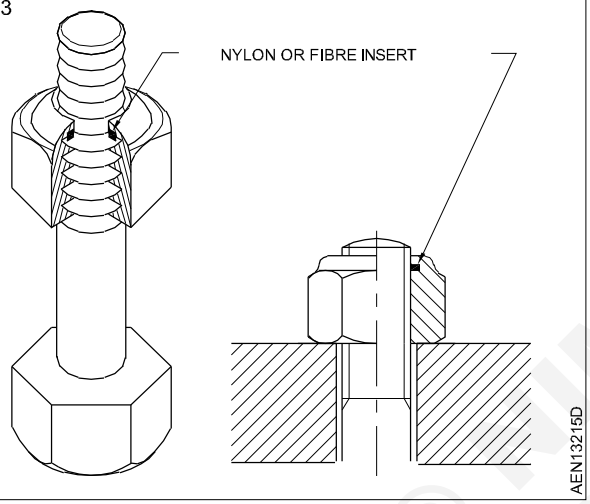
Eg. Clutches, brakes, controls etc.

Fig 12



AEN13215C

Fig 13



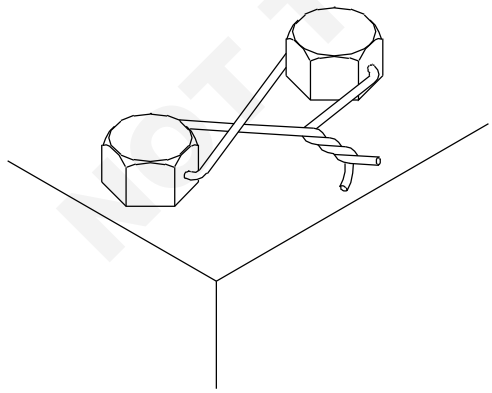
AEN13215D

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)

Fig 14



AEN13215E

These lock nuts are easy to fit and less time consuming.

The frictional locking devices are:

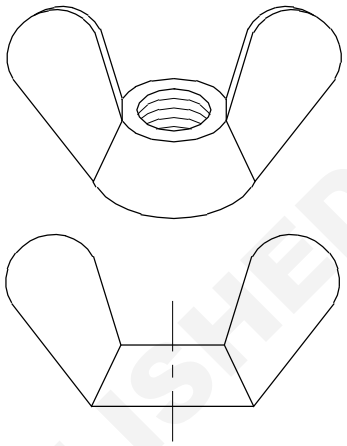
- lock-nut (chuck nut)
- spring washer
- wedge lock bolt
- simmonds lock-nut.

Common 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



AEN13215F

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.

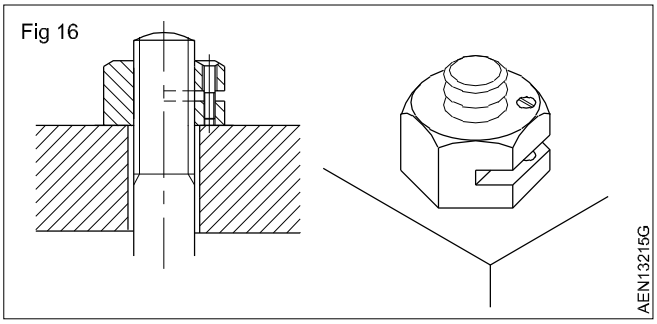
Locking ring

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



AEN13215G

Slotted and castle nut with a split pin

The position of the nut can be locked using the split pin.

Split pins are designated by the nominal size, nominal length, the number of the Indian Standard and the material. (Fig 17 & 18)

The nominal length is the distance from the underside of the eye to the end of the short leg.

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

Fig 17

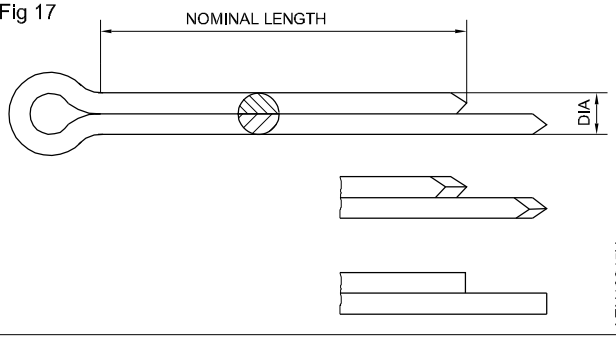
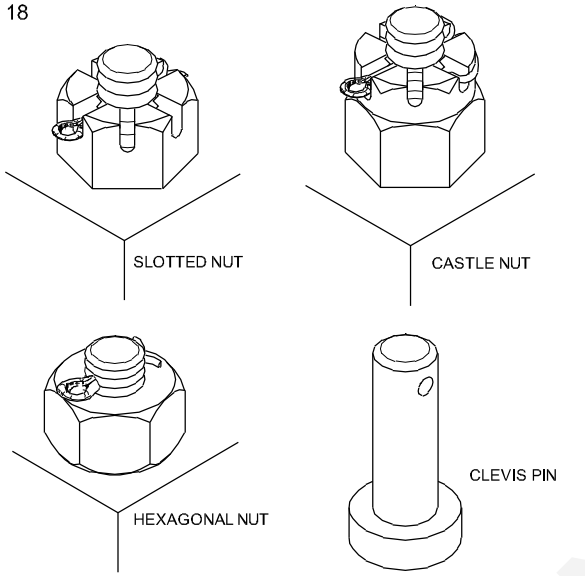


Fig 18



Grooved nut (Penning nut) (Fig 19): This is a hexagonal nut with the lower part made cylindrical. On the cylindrical surface there is a recessed groove in which a set screw is used to lock the nut.

Locking plate (Fig 20): For preventing the nut from loosening, locking plates are fixed on the outside of the hexagonal nut.

Lock washers with lug (Fig 21): In this arrangement of locking, a hole is drilled for accommodating the lug.

The movement of the nut is prevented by folding the washer against the nut.

Fig 19

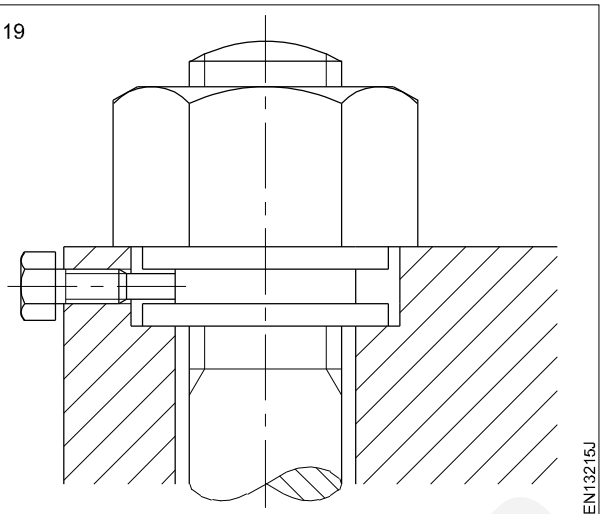


Fig 20

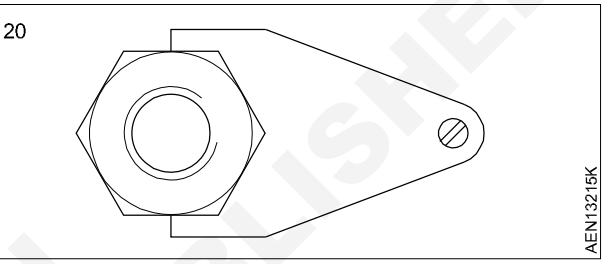
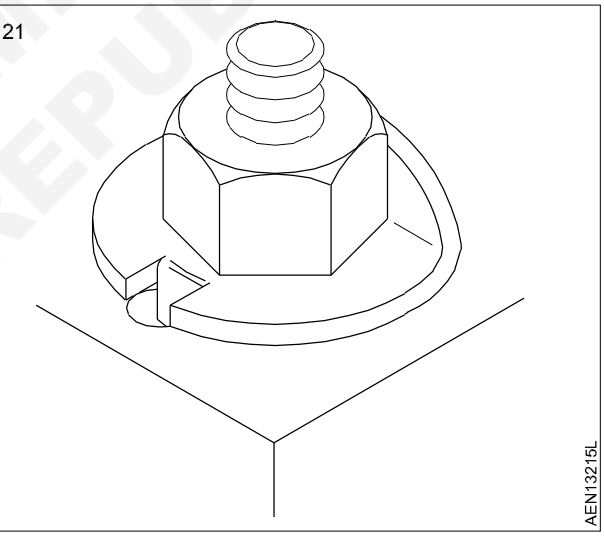


Fig 21



Keys and splines

Objectives: At the end of this lesson you shall be able to
- **name the different types of keys used in transmission**
- **state the features of each type of keys.**

Keys and splines

Keys are used for transmitting torque from a rotating shaft to a hub/wheel or from a hub/wheel to the shaft. (Fig 1)

Keys of different types are used depending on the requirements of transmission.

Hollow saddle key

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

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

Fig 1

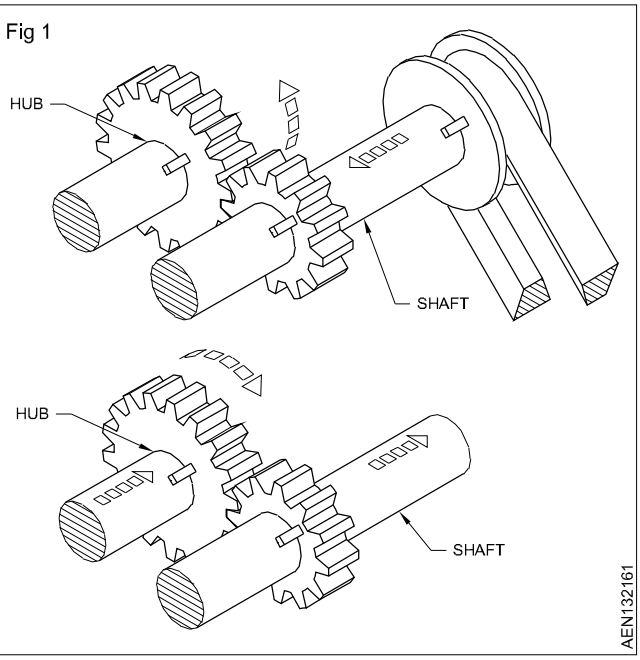
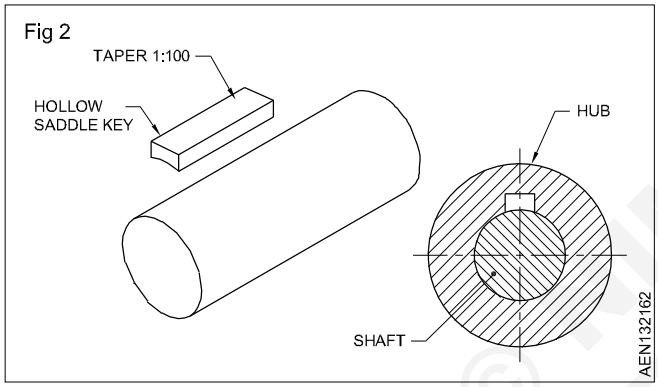


Fig 2

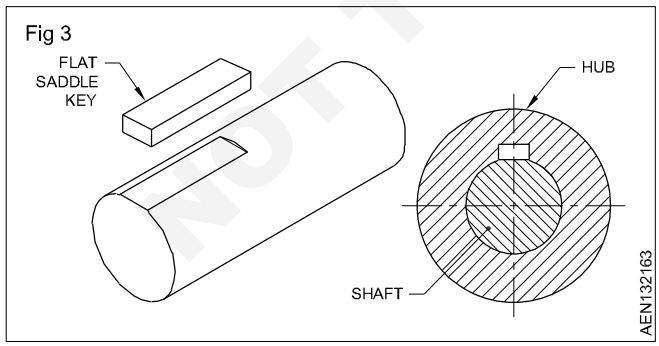


Flat saddle key

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.

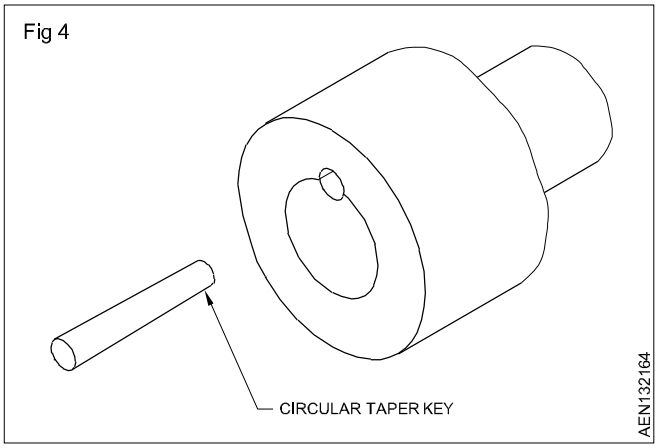
Fig 3



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.

Fig 4



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.

Fig 5

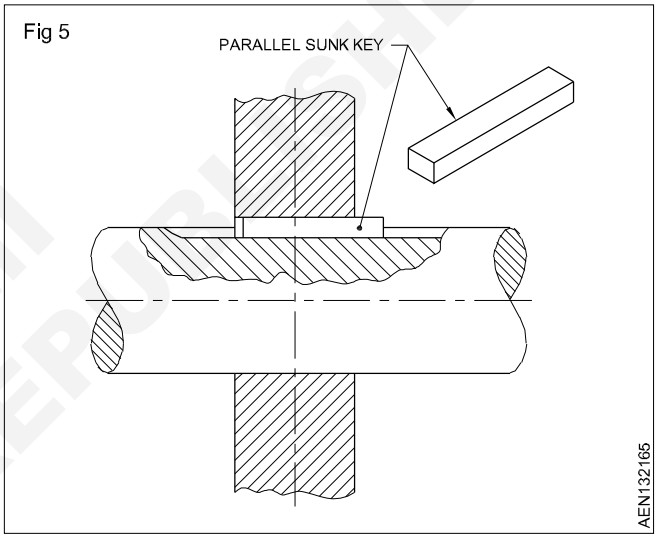
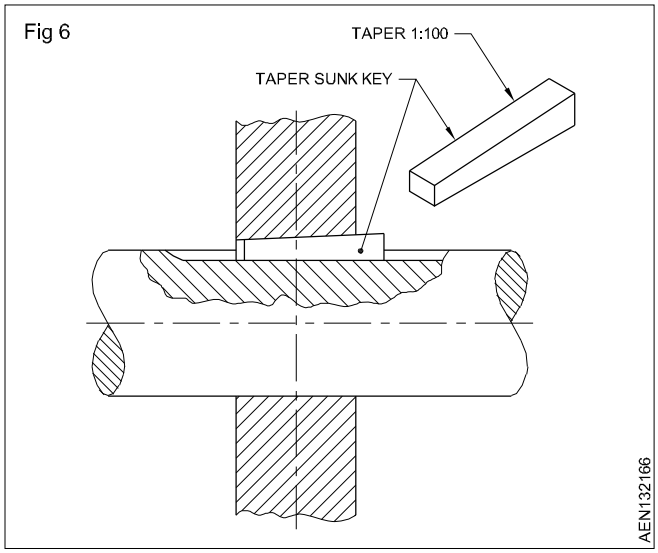


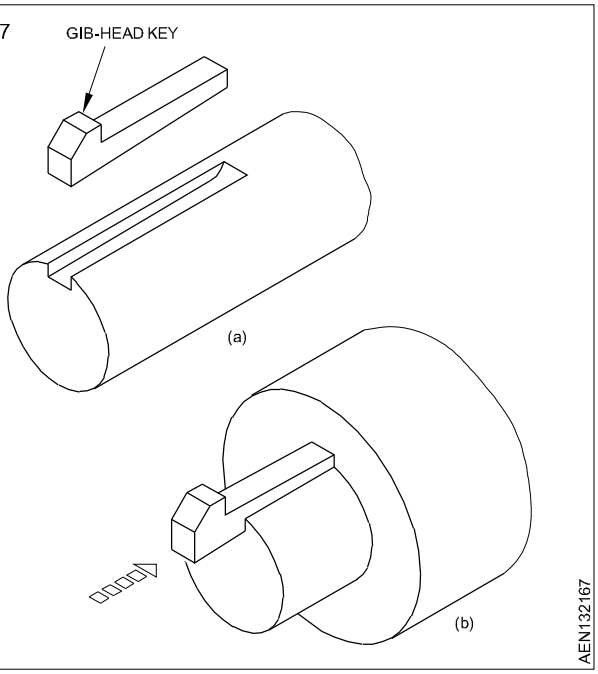
Fig 6



Gib-head key (Fig 7)

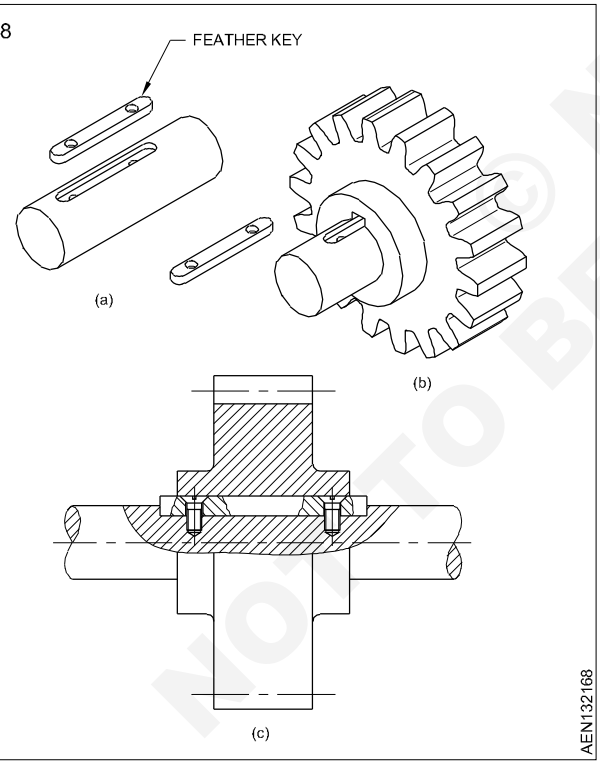
This is another type of sunk key. This has a gib-head to assist in fixing and removing the keys. (Figs 7a and b)

Fig 7



Feather key (Fig 8): This is a parallel key with rounded ends. This is useful when the hub/pulley has to slide axially on the shaft to some distance. (Figs 8a,b and c) This key may be either tightly fitted in the keyway or screwed in.

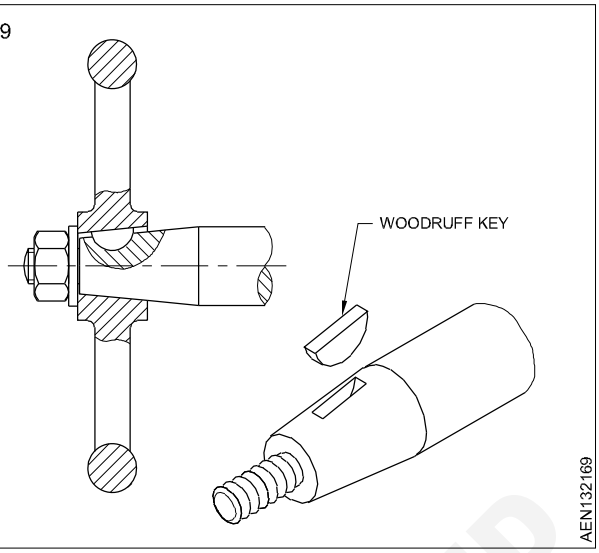
Fig 8



Woodruff key (Fig 9): This is semicircular key and it fits on to the shaft on which matching recesses are cut. The top portion of the key projects out and fits in the keyway cut on the hub. (Fig 9)

This key is particularly useful on tapered fittings of shafts.

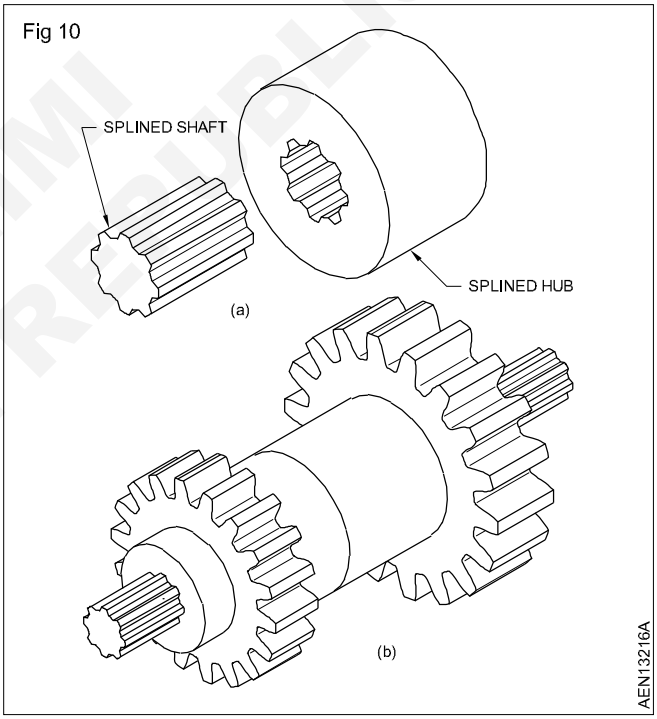
Fig 9



Splined shaft & serrated shaft

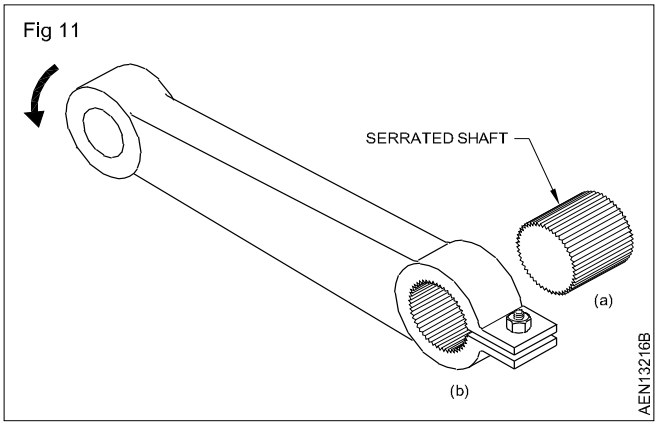
Splined shafts along with splined hubs are used particularly in the motor industry. The splined hub can also slide along the shaft, wherever necessary. (Figs 10a and b)

Fig 10



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

Fig 11

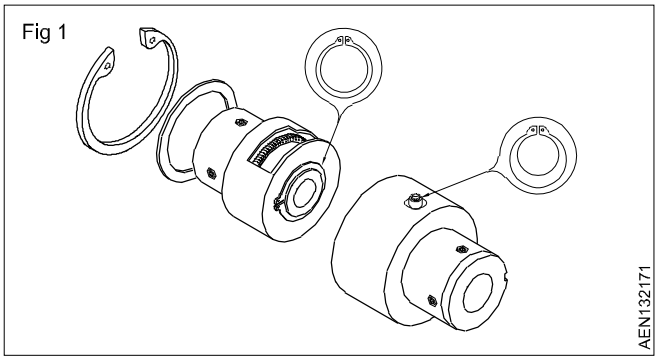


Circlips

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 condition 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;

1 **Internal circlips (Fig 2):** This type of rings are assembled in holes, bores or housing.

2 **External circlip (Fig 3):** This type of rings are installed on shafts, pins, studs and similar parts.

Both types offer a number of advantages over other types of fasteners.

- Their cost is relatively low when compared with other types of fasteners.
- Their use often results in savings in raw material and simplified machining operations for other parts in the assembly.
- One circlip often can replace two or more parts.
- Assembly toolings developed for circlips usually permit very rapid assembly of the fasteners, even by unskilled workers.

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.

Fig 2

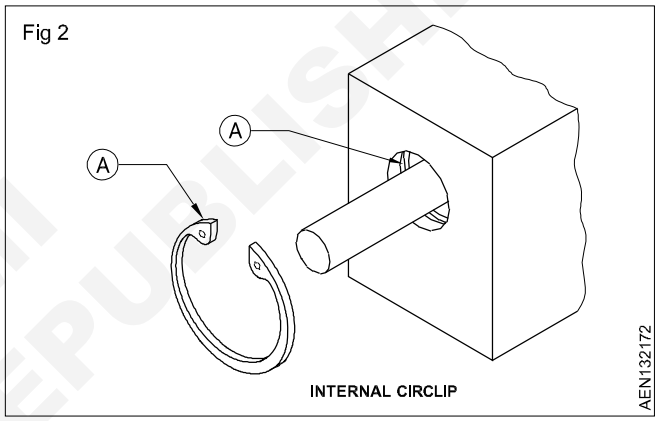
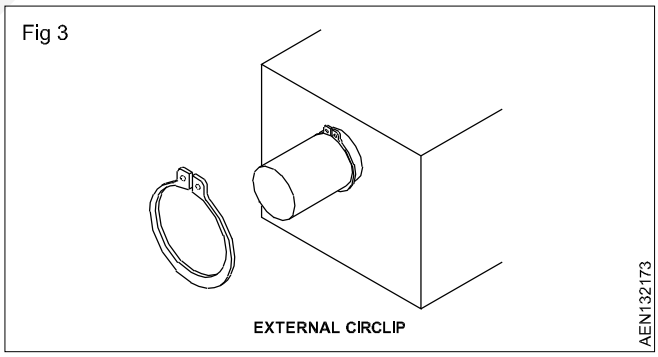


Fig 3



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)

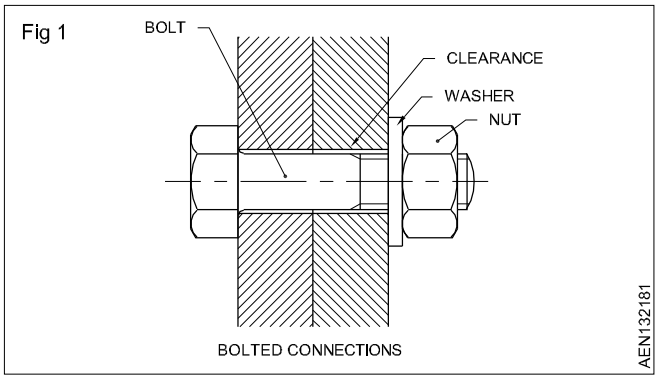
- increase the frictional grip
- prevent loosening of nuts due to vibration

- prevent damage to the work piece and
- distribute force over a larger area.

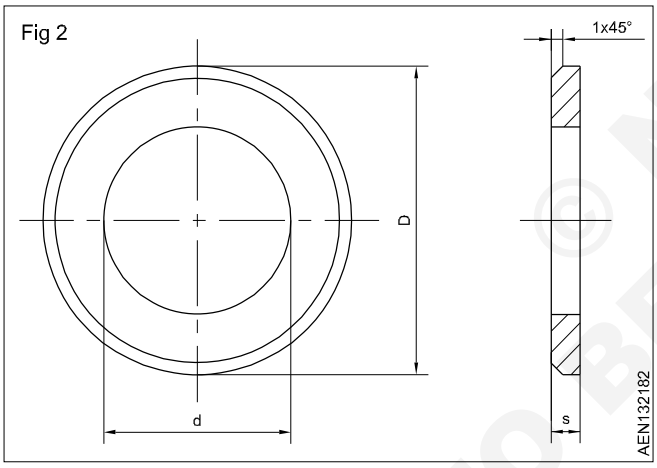
Types of washers

There are different types of washers available. They are

- plain or flat washers
- spring washers
- toothed lock washers.
- taper washers
- tab 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)



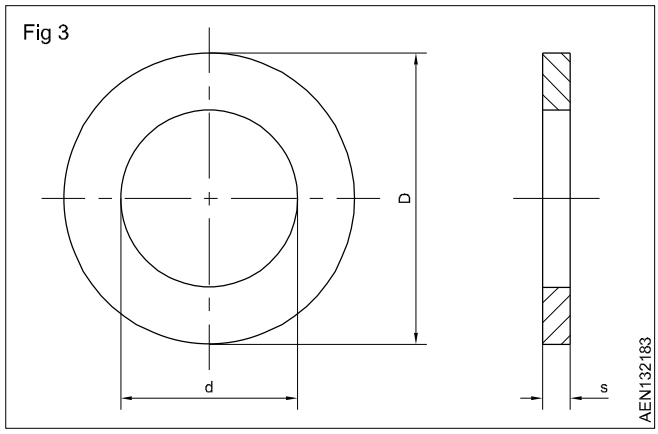
Plain washers are available as machined or punched washers.

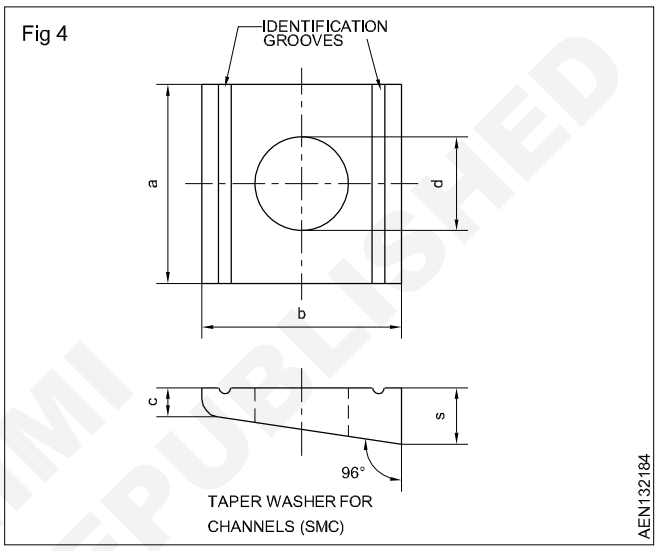
Machined washers (Fig 3): These washers are used for assemblies using machined components. These washers are available with chamber on one side or on both sides. They are heat treated and ground.

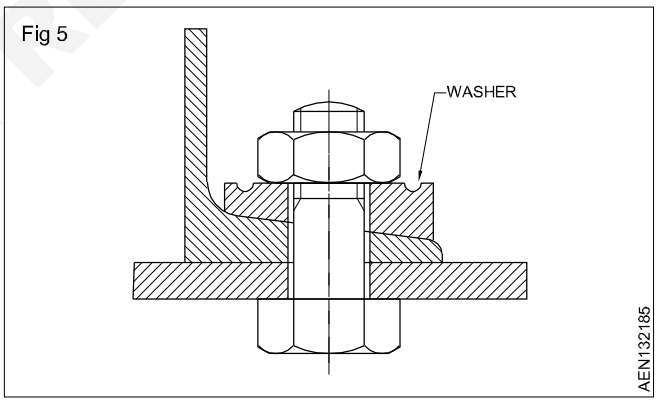
Punched washers: These do not have chamfers and are commonly used in structural fabrication work.

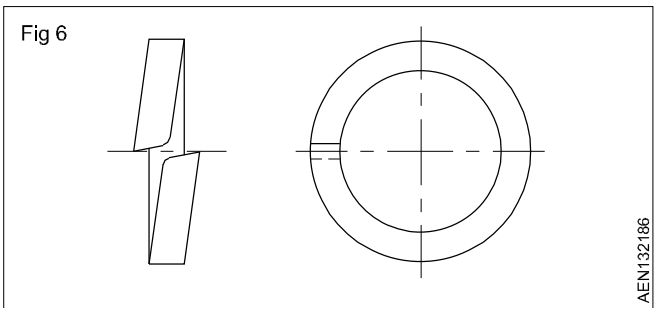
Tapered washers (Figs 4 & 5): These are used in structural assemblies with tapered surfaces like the inside of beams, channels etc. These washers help bolt head or nut to seat square to the hole.

Spring washers (Figs 6 & 7): Spring washers are used under the nuts to prevent slackening of the nuts due to vibrations. They are made of spring steel, and when compressed they create tension between the bolt and the nut.



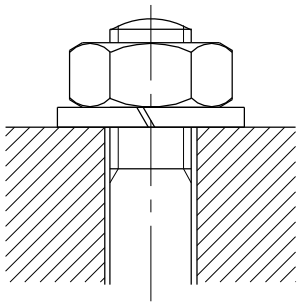






Tab washers (Fig 8): These washers are used for locking the nuts.

Fig 7



SPRING LOCK WASHER

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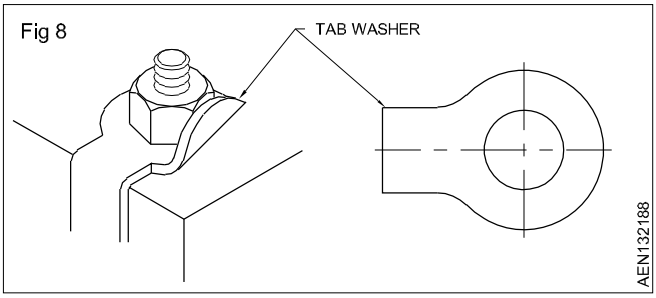
Fig 8



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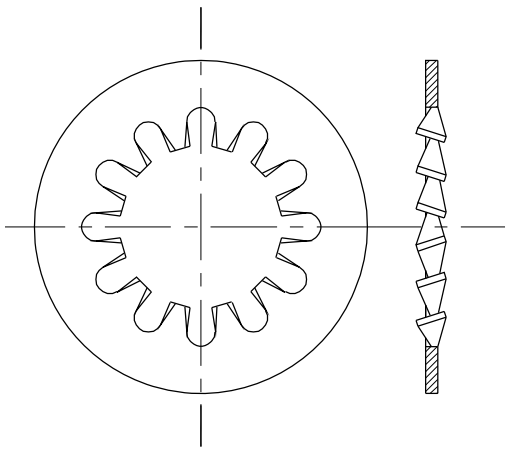
Toothed lock washers (Fig 9): These washers have serrations, cut and twisted. When placed between the nut and the assembly, this washer exerts friction on both the contacting surfaces. This prevents the nuts from slackening.

Specifications

The Indian standard Is:2016-1967 designates a washer by name, type size and number of the standard and material.

Fig 9



INTERNALLY TOOTHED

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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

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, i.e 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

configuration

a single lip b double lip

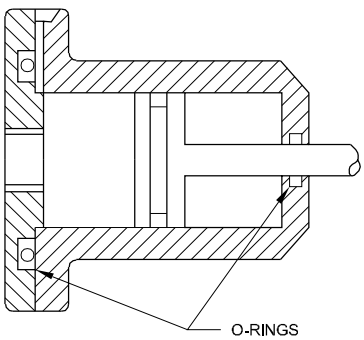
c triple lip d fan lip

Seals capable of sealing two components which move or rotate insulation to each other are called dynamic seals.

The most common dynamic seal is called 'O' rings which are moulded to close tolerances in the cross-sectional areas and to the inner and outer diameters.

Bearing Isolator (Fig 1): Bearing Isolator are dynamicsed designed to protect bearing from outside containant. The contain rotor (rotating) & stater (Stationary) member same bearing Isolator are of labyrinth construction of other use o-rings.

Fig 1



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Specifications

Sealing orientation (Fig 2 & 3)

- Rod seals or shaft seals are type of radial seal.
- Radial seal are 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.

Fig 2

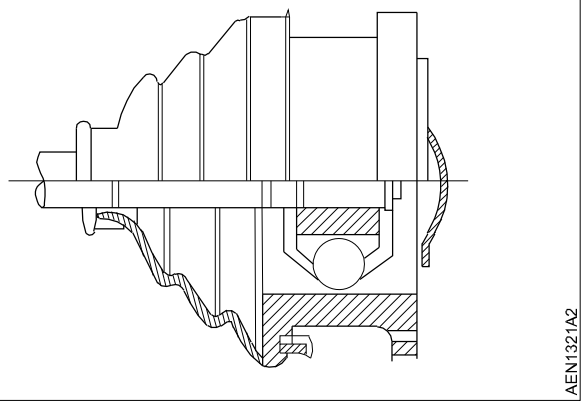
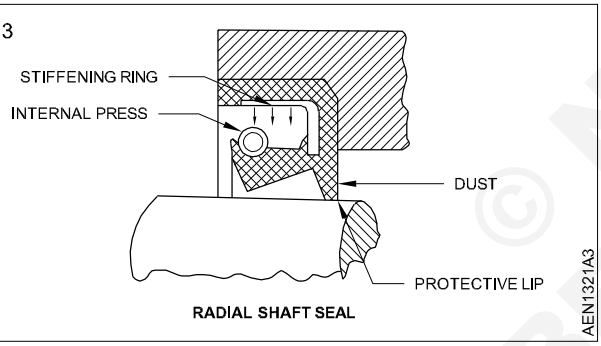


Fig 3



RADIAL SHAFT SEAL

- An axial seals axially against a housing or machine component.
- Material - Nylon, Rubber, polythen, PTFE etc.

Sealants

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

1 The Teflon tape 2 Pipe tape

3 Anaerobic resin compound

1 Teflon tape: The purpose of this Teflon tape is no sticking tape it is 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

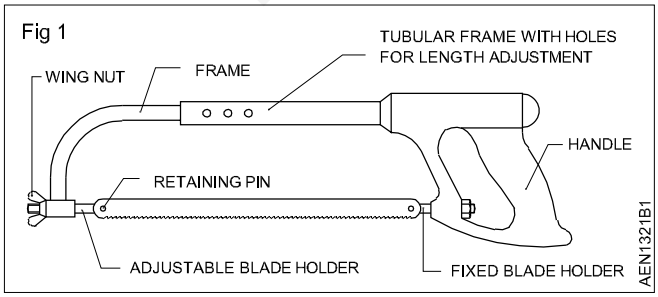
Hacksaw frame and blade

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.

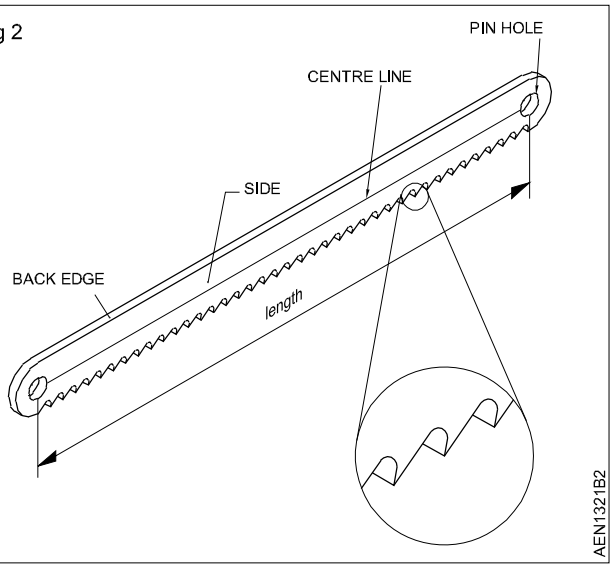
Adjustable frame (Flat type): Different standard lengths of blades can be fitted to this frame.

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): 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 250mm and 300mm.

Fig 2



Types of hacksaw blades: Two types of hacksaw blades are available - all hard blades and flexible blades.

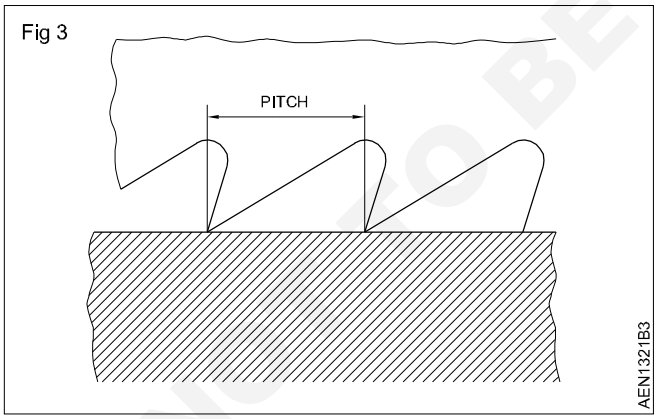
All hard blades: These are hardened to the full width between the pin holes.

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

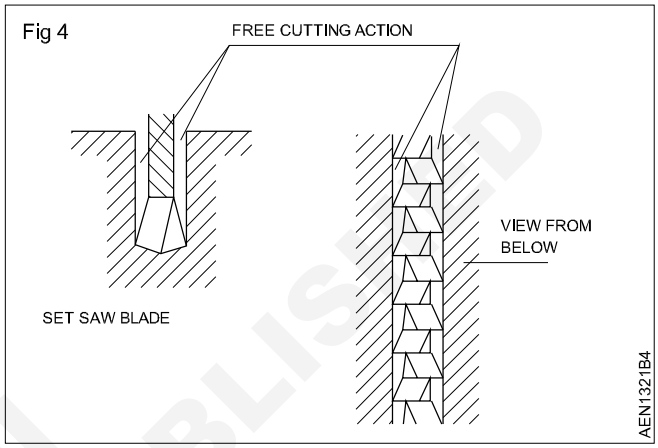
Hacksaw blades are designated according to their length, pitch and type.

To prevent the saw blade binding when penetrating into the material and to allow free movement of the blade, the cut is to be border 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.

Fig 4



Wave set (Fig 5)

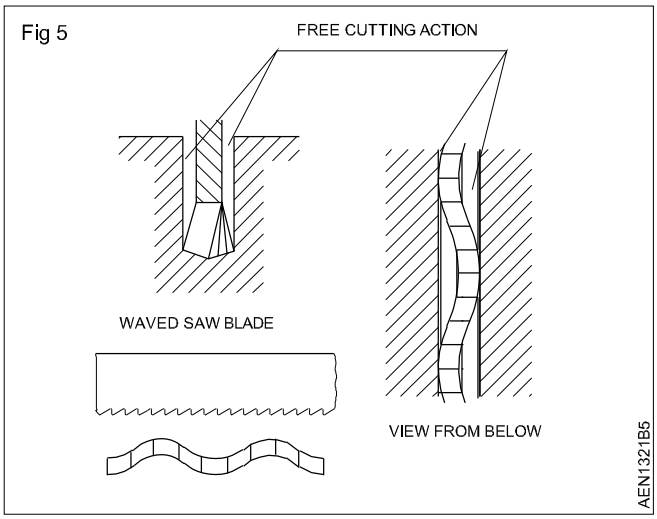
In this, the teeth of the blade are arranged in a wave form.

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.

Fig 5



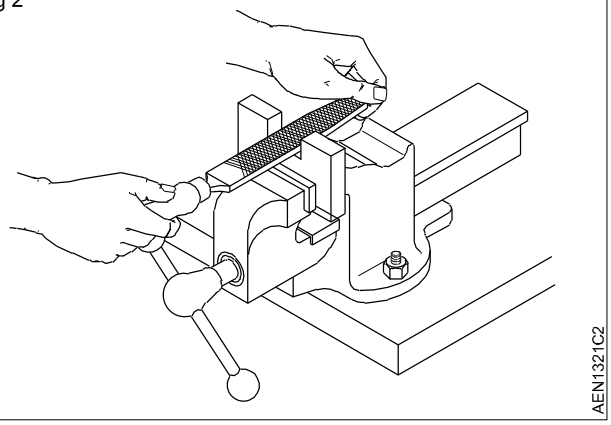
Elements of a file

Objective: 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).

Fig 2



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. The parts are given below;

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

Parts of a file (Fig 3)

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 hardended and tempered. The tang is however not hardended.

Fig 1

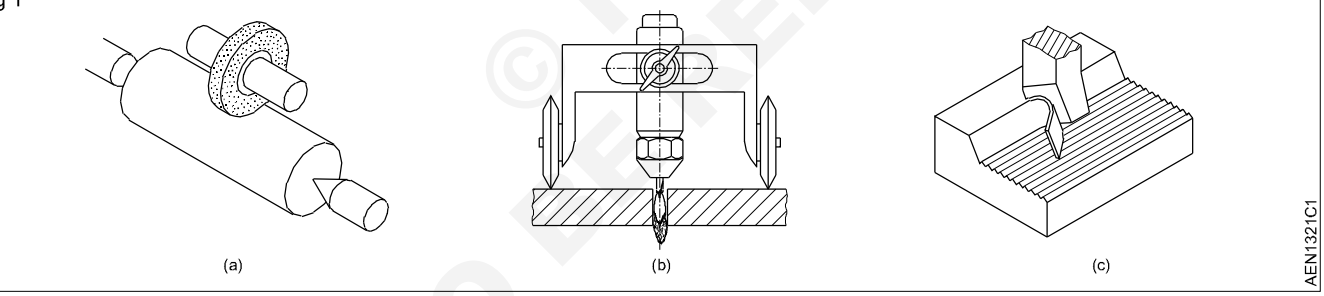
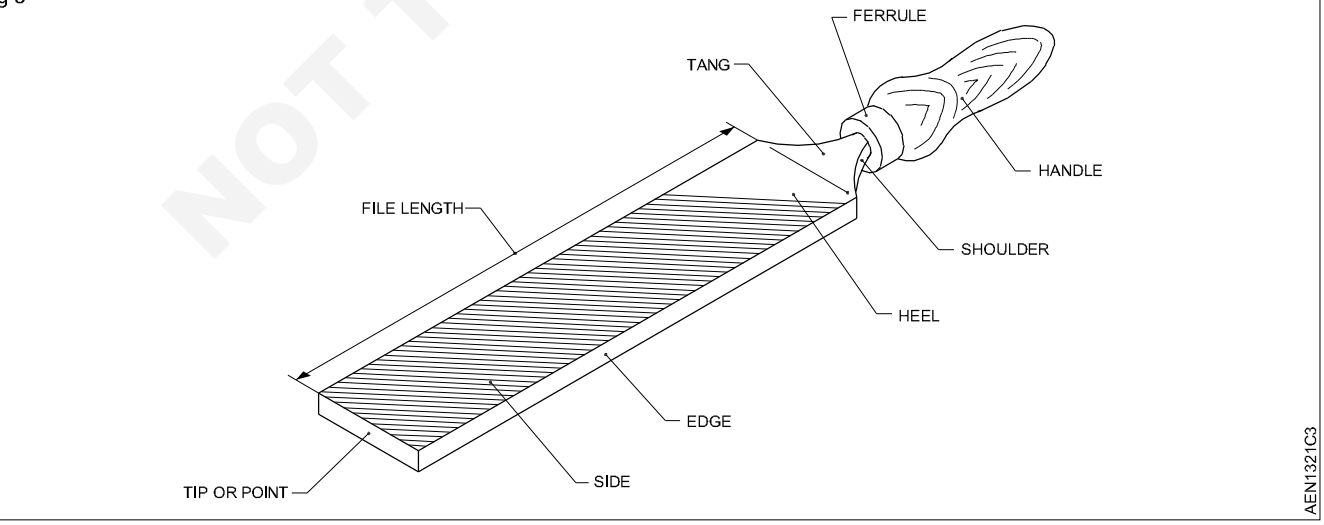


Fig 3



Cut of files

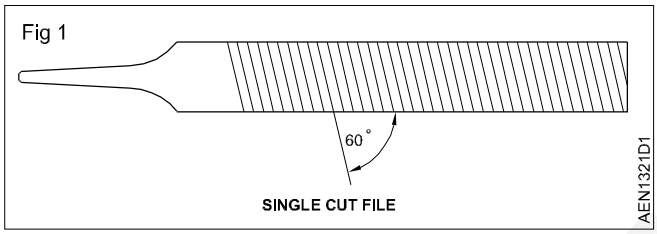
Objectives: At the end of this lesson you shall be able to
- **name the different cuts of files**
- **state the uses of each type of cut.**

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.

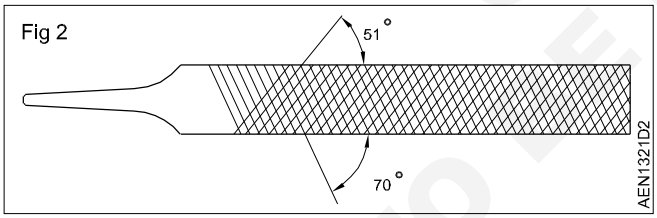
Types of cuts: Basically there are four types.

1 **Single cut 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.

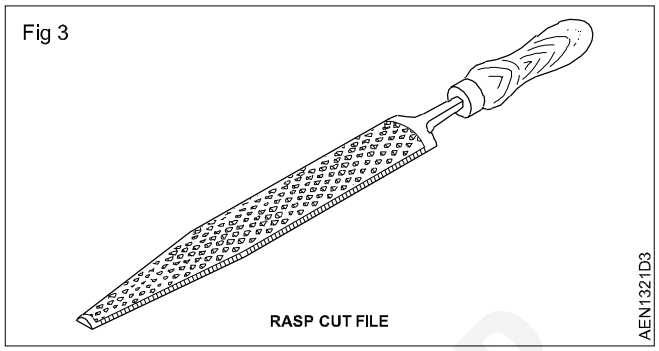
Single cut files do not remove stock as fast as double cut files, but the surface finish obtained is much smoother.



2 **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 known 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.

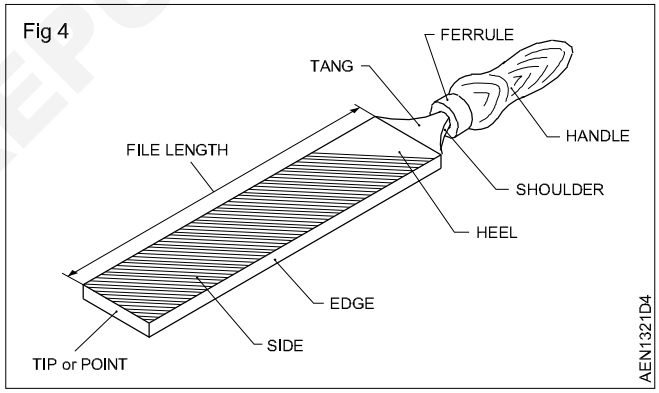


3 **Rasp cut file (Fig 3):** The rasp cut has individual sharp pointed teeth in a line and is useful for filing wood, leather and other soft materials. These files are available only in half round shape.



4 **Curved cut file (Fig 4):** These files have deeper cutting action and are useful for filing soft materials like - aluminium, tin, copper and plastic. The curved cut files are available only in a flat shape.

The selection of a file with a particular type of cut is based on the material to be filed. Single cut files are used for filing soft materials. But certain special files, for example, those used for sharpening saws are also of single cut.



File specifications and grades

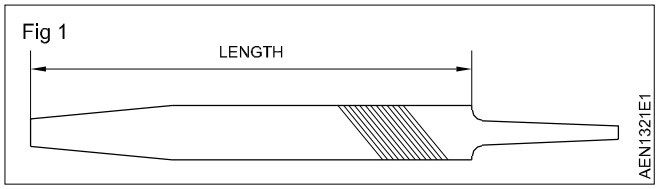
Objectives: At the end of this lesson you shall be able to
- **state how files are specified**
- **name the different grades of files**
- **state the application of each grade of file.**

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

Files are specified according to their length, grade, cut and shape.

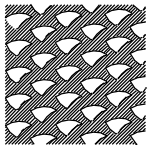
Length is the distance from the tip of a file to the heel. (Fig 1)

File grades are determined by the spacing of the teeth.



A round file (Fig 2) is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.

Fig 2



AEN1321E2

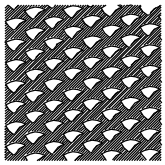
A bastard file (Fig 3) is used in cases where there is a heavy reduction of material.

Fig 3

AEN1321E3

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



AEN1321E4

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

Fig 5

AEN1321E5

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

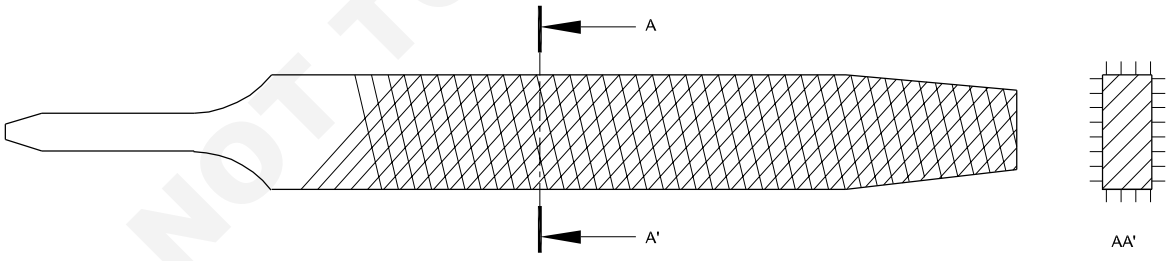
The shape of files is usually specified by their cross section.

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 towards 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



AEN1321F1

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

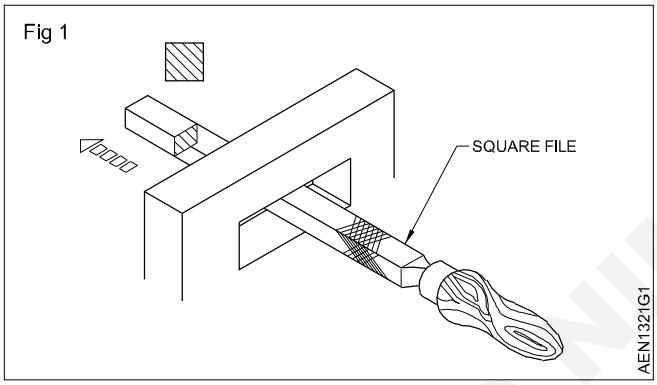
Half found file, Triangular file and Knife-edge file.

(Flat and hand files have already been discussed).

Square File

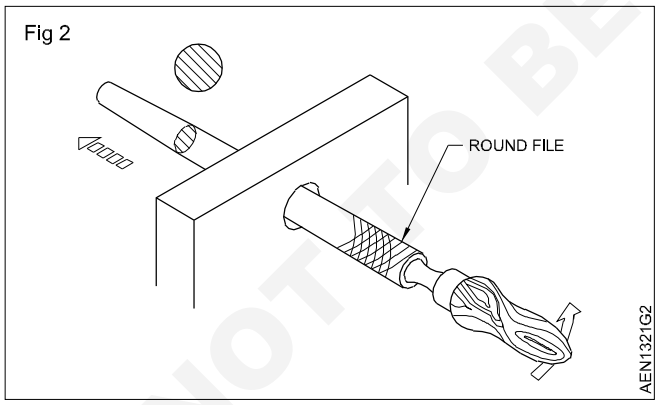
The square file is square in its cross section. It is used for filling square holes, internal square corners, rectangular opening, keyways and spines. (Fig 1)

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

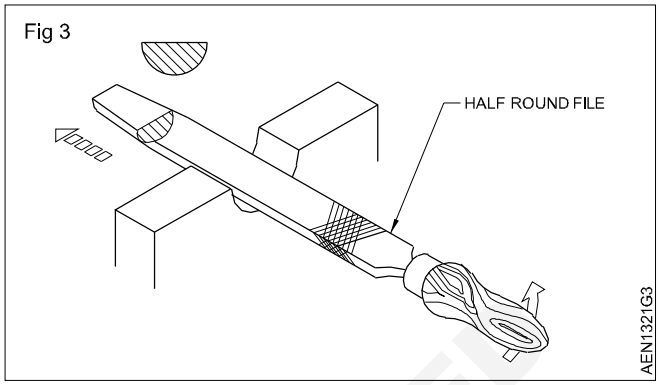
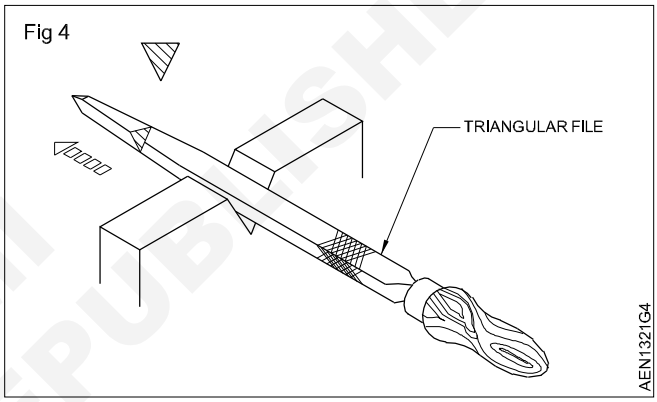


Fig 4

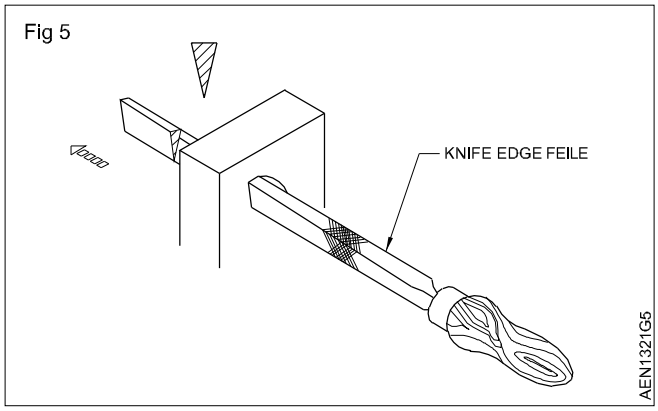


Knife-edge File: A knife-edge file has the cross section of a sharp triangle. It is used for filing narrow grooves and angles above 10^0. (Fig 5)

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



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

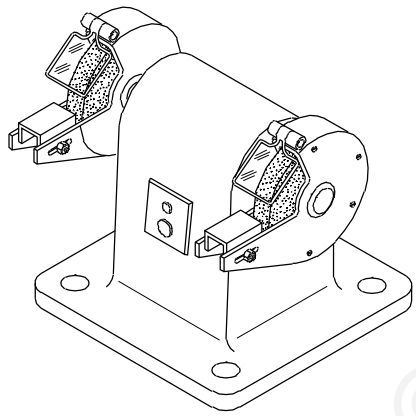
scribers, punches, chisels, twist drills

single point cutting tools etc.

Off-hand grinding is performed with a bench or pedestal grinder (Fig 1 and 2)

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

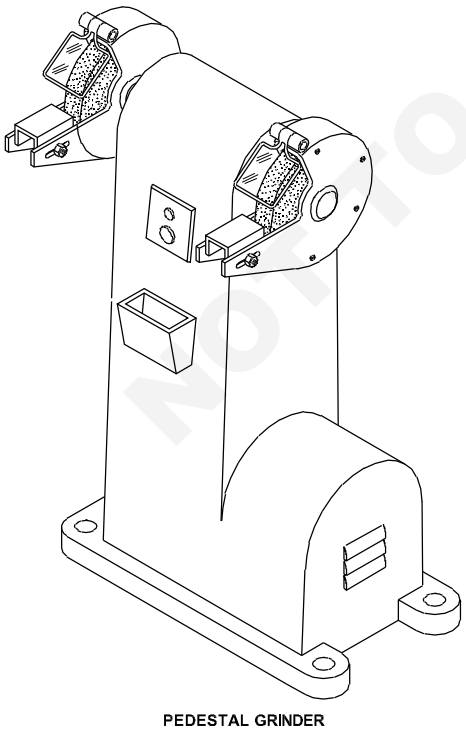
Fig 1



BENCH GRINDER

AEN1321H1

Fig 2



PEDESTAL GRINDER

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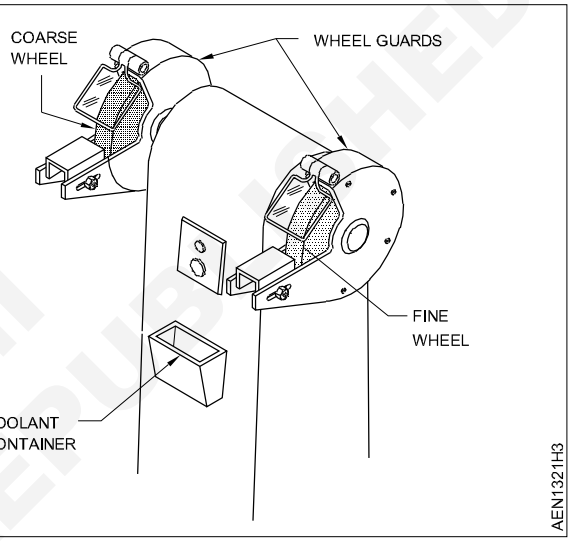
Pedestal grinders: Pedestal grinders are mounted on a base (pedestal), which is fastened to the floor. They are used for heavy duty work.

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)

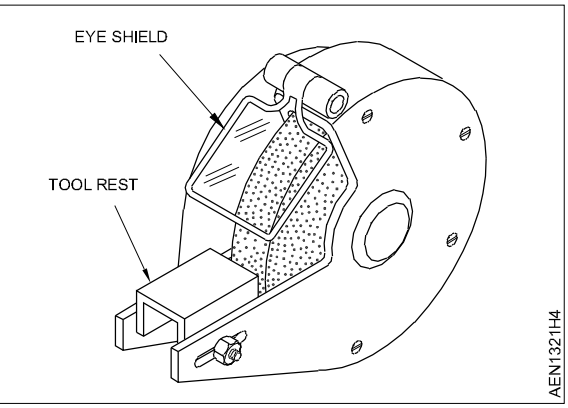
Fig 3



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

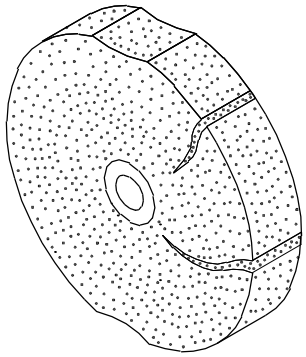


While grinding

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)

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

Fig 5



AEN1321H5

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

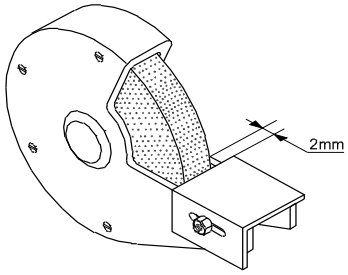


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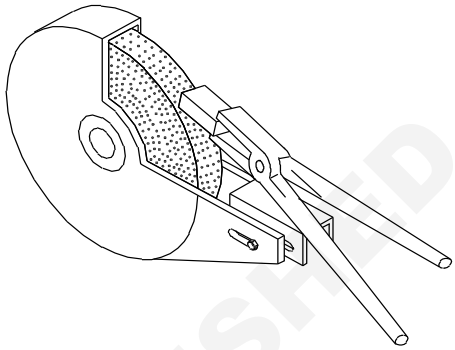
Fig 7



AEN1321H7

Safe working on off - hand grinders

Objectives: At the end of this lesson you shall be able to
- **work safety on an off-hand grinder.**

How to work on an off-hand grinder?

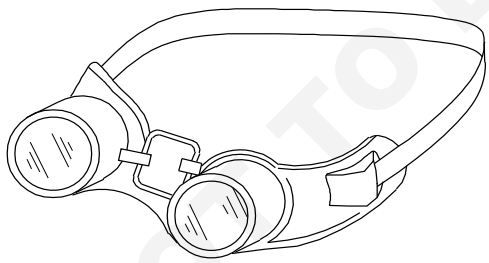
While working on off-hand grinders, it is important to observe the following safety measures.

Before starting

Make sure the grinding wheel guards are in place.

Wear safety goggles while grinding. (Fig 1)

Fig 1



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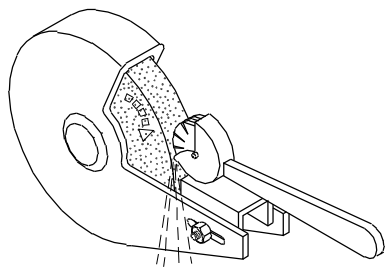
Do not work on grinding wheels which are loaded or glazed. Dress and true wheels whenever necessary. (Fig 2)

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



AEN132I2

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.**

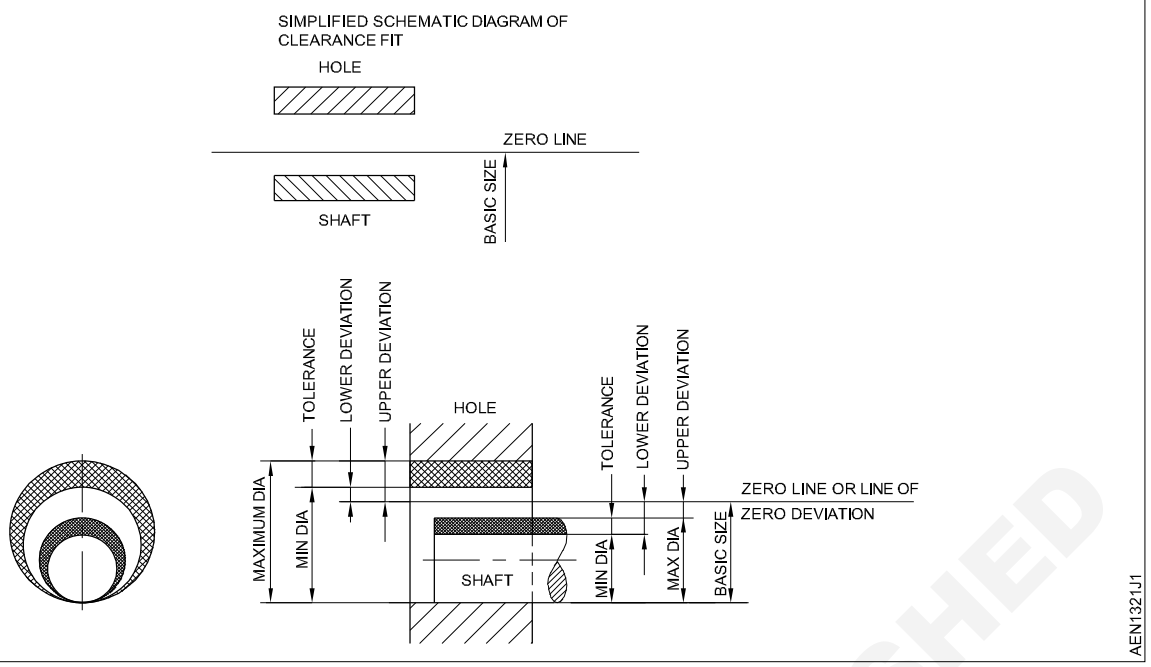
Size: It is a number expressed in a particular unit in the measurement of length.

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)

Fig 1

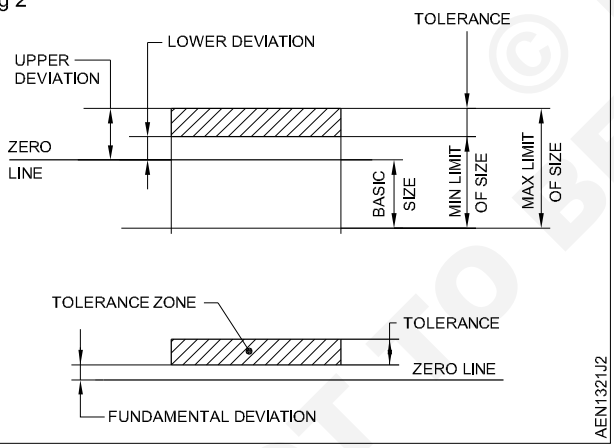


Maximum limit of size: It is the greater of the two limit sizes. (Fig 2) (Table 1)

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)

Fig 2



Shaft: In the BIS system of limits & fits, all external features of a component including those which are not cylindrical are designated as shaft. (Fig 3)

Deviation: It is the algebraic difference between a size, to its corresponding basic size. It may be positive, negative or zero. (Fig 2)

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)

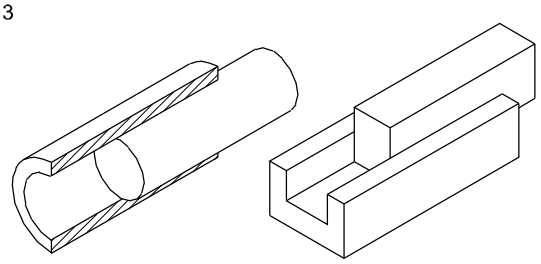
Upper deviation is the deviation which gives the maximum limit of size. Lower deviation is the deviation which gives the minimum limit of size.

Actual deviation: It is the algebraic difference between the actual size and its corresponding basic size (Fig 2)

Table 1 (Examples)

Sl.No	Size of Component	Upper Deviation	Lower Deviation	Max-Limit of size	Min-Limit of Size
1	+.008 20-.005	+0.008	-0.005	20.008	19.995
2	+.028 20+.007	+0.028	+0.007	20.028	20.007
3	-.012 20-.021	-0.012	-0.021	19.988	19.979

Fig 3



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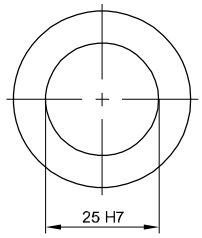
Tolerance: It is the difference between the maximum limit of size and the minimum limit of size. It is always positive and is expressed only as a number without a sign. (Fig 2)

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



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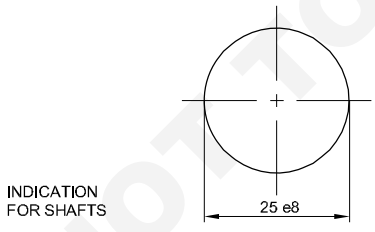
In addition to the above, four sets of letters, JS, ZA, ZB & ZC are included. For fine mechanisms CD, EF and FG are added. (Ref. IS:919 Part II - 1979)

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

Fig 5



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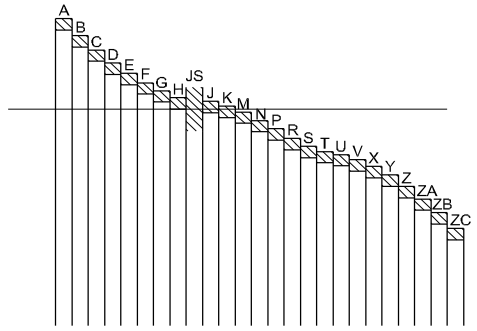
The position of tolerance zone with respect to the zero line is shown in Fig 6 and 7.

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

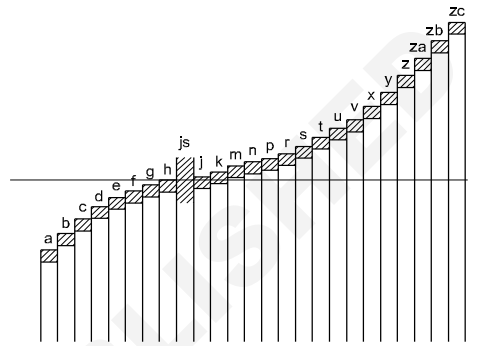
Fundamental tolerance: This is also called as 'grade of tolerance'. In the Indian Standard System, there are 18 grades of tolerances represented by number symbols, both for hole and shaft, denoted as IT01, IT0, IT1.... to IT16. (Fig 10) A high number gives a large tolerance zone.

Fig 6



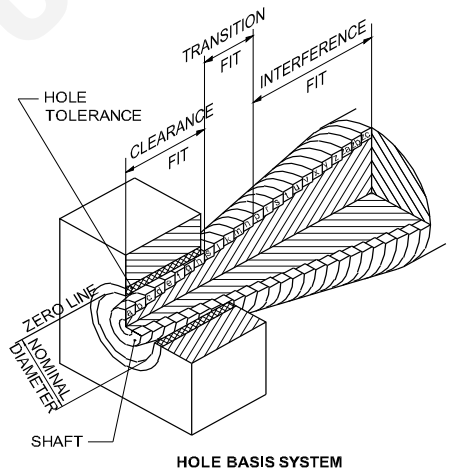
AEN1321J6

Fig 7



AEN1321J7

Fig 8



AEN1321J8

Fig 9

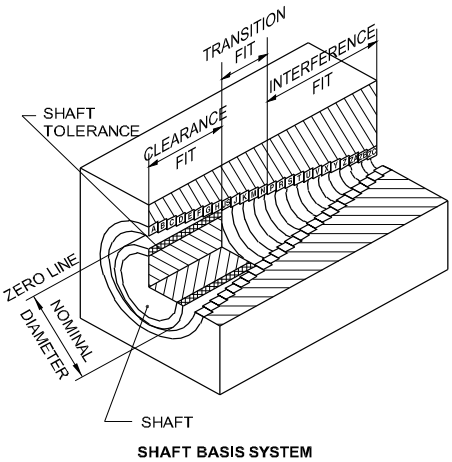


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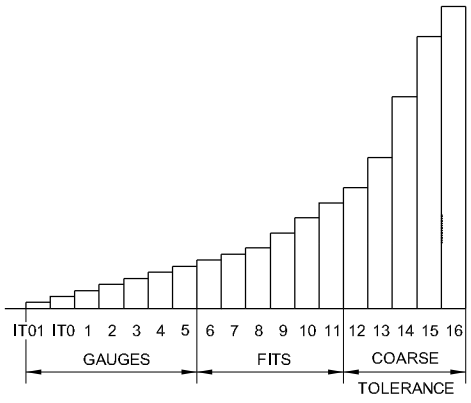
Fig 10



The grade of tolerance refers to the accuracy of manufacture.

In a standard chart, the upper and lower deviations for each combination of fundamental deviation and fundamental tolerance are indicated for sizes ranging upto 500 mm. (Refer to IS 919)

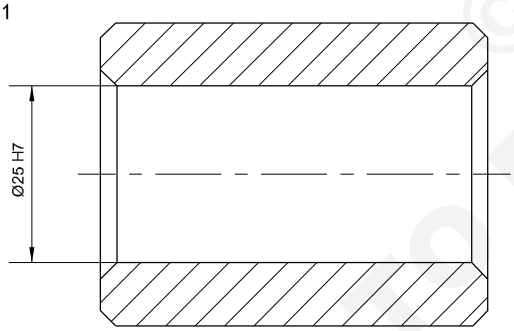
Toleranced size

This includes the basic size, the fundamental deviation and the grade of tolerance.

Example

25H7 - toleranced size of a hole whose basic size is 25. The fundamental deviation is represented by the letter symbol H and the grade of tolerance is represented by the number symbol 7. (Fig 11)

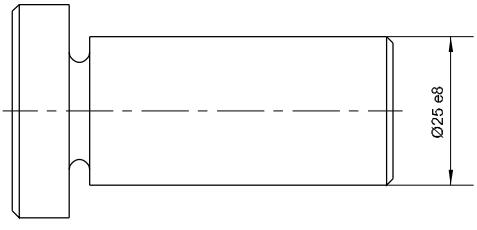
Fig 11



25 e8 - is the toleranced size of a shaft whose basic size is 25. The fundamental deviation is represented by the letter symbol e and the grade of tolerance is represented by the number 8. (Fig 12)

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

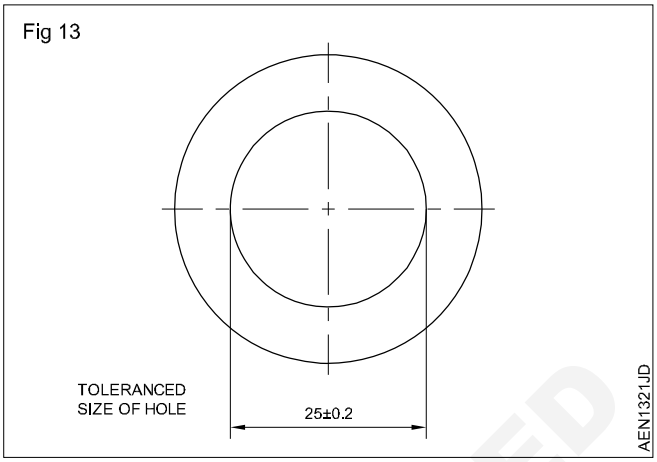
Fig 12



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.

Fig 13



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

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

In the example 25 ± 0.2, ± 0.2 is the deviation of the hole of 25 mm diameter. (Fig 13) This means that the hole is of acceptable size if its dimension is between

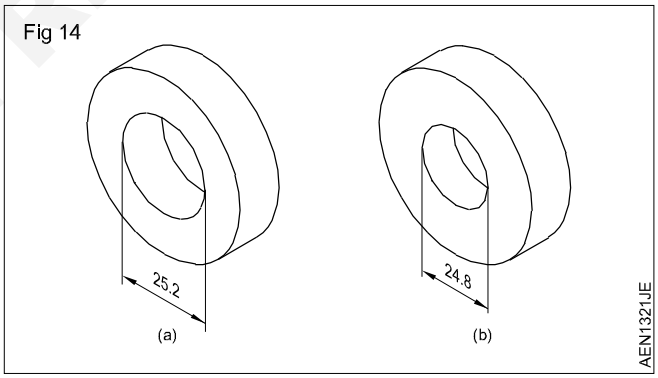
25 + 0.2 = 25.2 mm

or 25 - 02 = 24.8 mm.

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

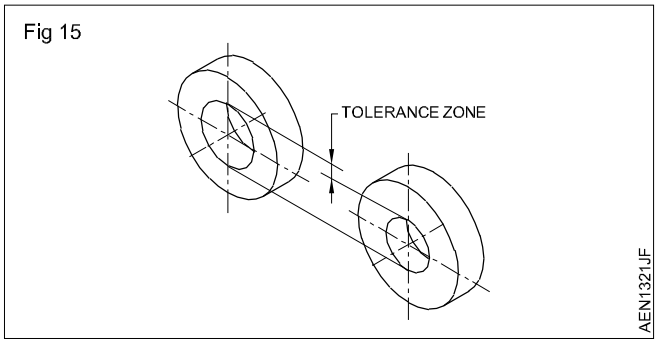
24.8 mm is known as the minimum limit. (Fig 14b)

Fig 14



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

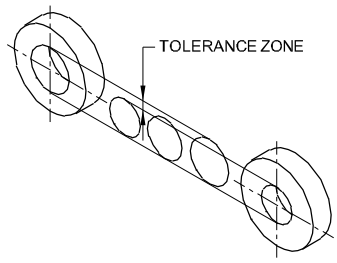
Fig 15



All dimensions of the hole within the tolerance zone are of acceptable size as in Fig 16.

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

Fig 16



Fits and their classification as per the indian standard

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

- **define 'Fit' as per the Indian Standard**
- **list out the terms used in limits and fits as per the Indian Standard**
- **state examples for each class of fits**
- **Interpret the graphical representation of different classes of fits.**

Fit: It is the relationship that exists between two mating parts, a hole and a shaft, with respect to their dimensional difference before assembly.

Expression of a fit: A fit is expressed by writing the basic size of the fit first, (the basic size which is common to both the hole and the shaft) followed by the symbol for the hole, and by the symbol for the shaft.

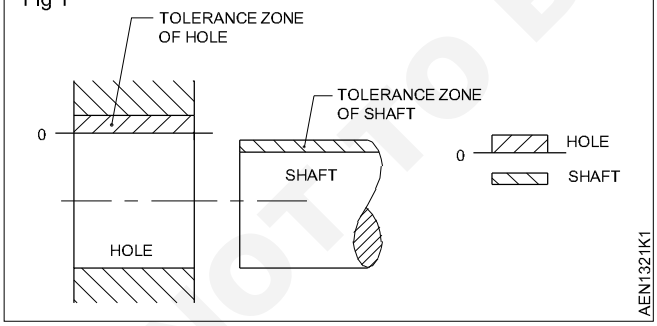
Example

30 H7/g6 or 30 H7 - g6 or 30

Clearance: In a fit the clearance is the difference between the size of the hole and the size of the shaft which is always positive.

Clearance fit: It is a fit which always provides clearance. Here the tolerance zone of the hole will be above the tolerance zone of the shaft. (Fig 1)

Fig 1



Example 20 H7/g6

With the fit given, we can find the deviations from the chart.

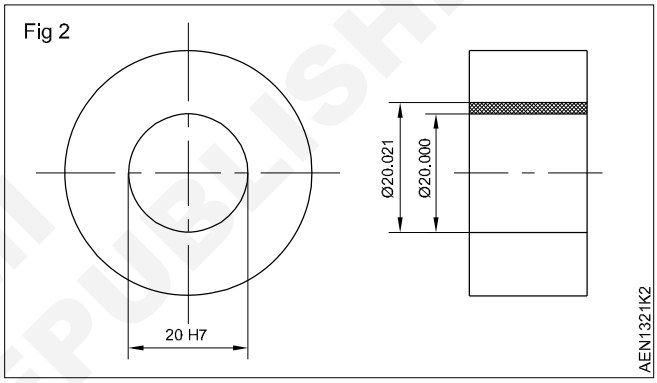
For a hole 20 H7 we find from the table +21mm.

These numbers indicate the deviations in microns.

(1 micrometre = 0.001 mm)

The limits of the hole are 20 = 0.021 = 20.021 mm and 20 + 0 = 20.000 mm. (Fig 2)

Fig 2



For a shaft 20 g6 we find in the table - 7mm

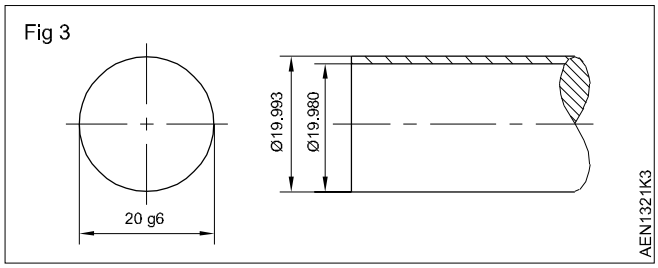
- 20mm

So the limits of the shaft are

20 - 0.007 = 19.992 mm

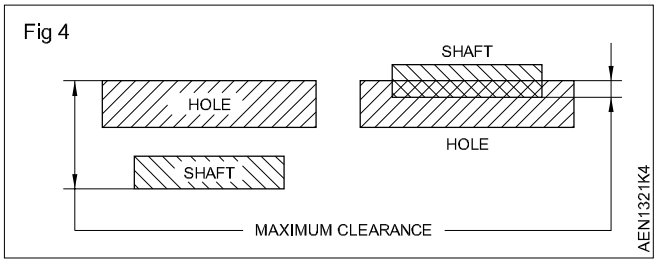
and 20 - 0.020 = 19.980 mm. (Fig 3)

Fig 3

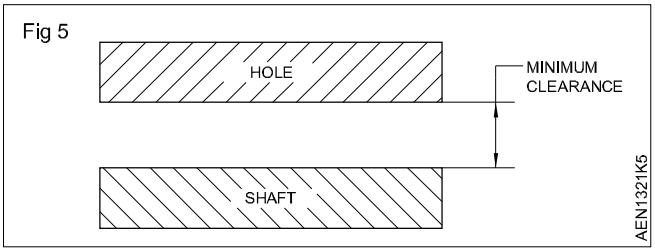


Maximum clearance: In a clearance fit or transition fit, it is the difference between the maximum hole and minimum shaft (Fig 4).

Fig 4

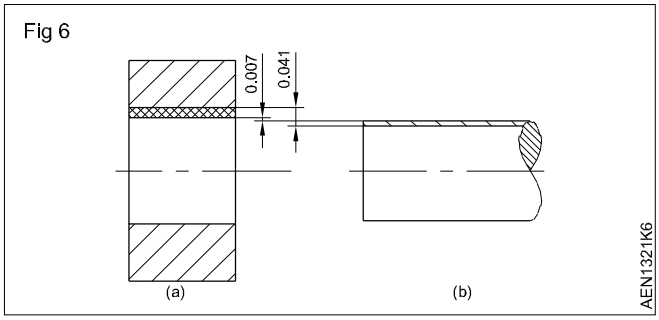


Minimum Clearance: In a clearance fit, it is the difference between the minimum hole and the maximum shaft (Fig 5).



The minimum clearance is 20.000 - 19.993 = 0.007 mm. (Fig 6a)

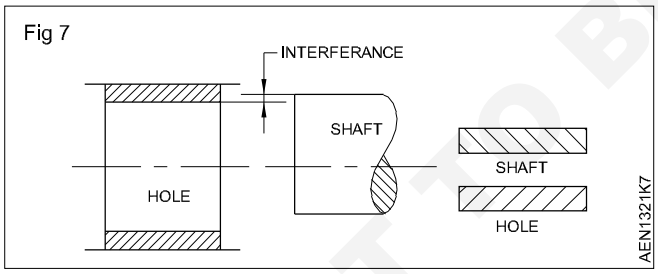
The maximum clearance is 20.021 - 19.980 = 0.041 mm. (Fig 6b)



There is always a clearance between the hole and the shaft. This is the clearance fit.

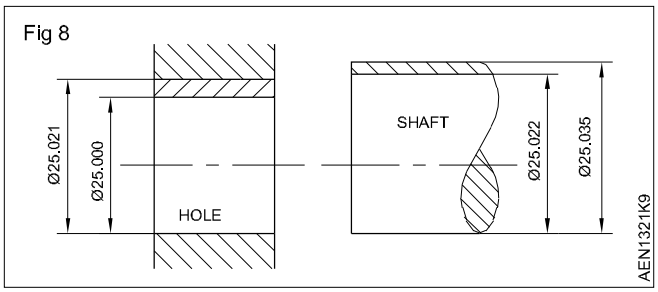
Interference: It is the difference between the size of the hole and the shaft before assembly, and this is negative. In this case, the shaft is always larger than the hole size.

Interference Fit: It is a fit which always provides interference. Here the tolerance zone of the hole will be below the tolerance zone of the shaft. (Fig 7)

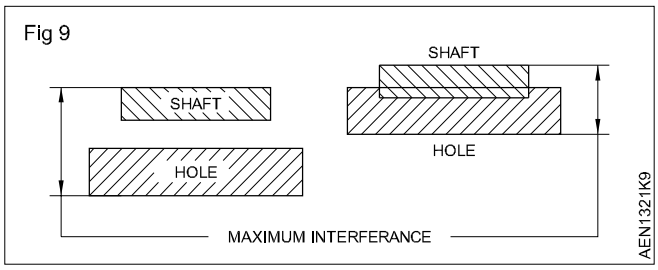


Example Fit 25 H7/p6 (Fig 8)

The limits of hole are 25.000 and 25.021 mm and the limits of the shaft 25.022 and 25.035 mm. The shaft is always bigger than the hole. This is an interference fit.



Maximum interference: In an interference fit or transition fit, it is the algebraic difference between the minimum hole and the maximum shaft. (Fig 9)



Minimum interference

In an interference fit, it is the algebraic difference between the maximum hole and the minimum shaft. (Fig 10)

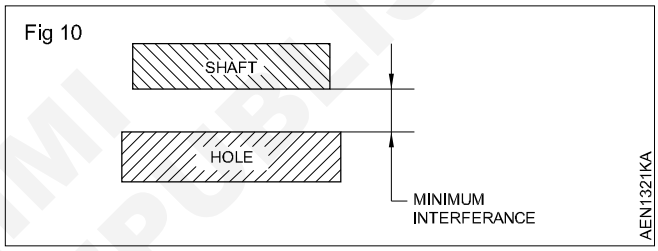
In the example (Fig 8)

The maximum interference is = 25.035 - 25.000

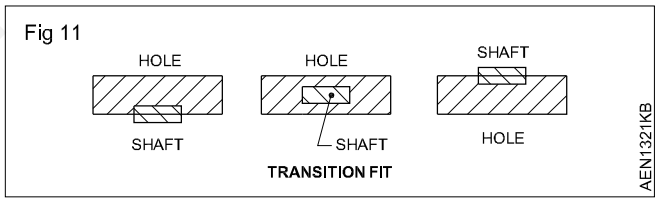
= **0.035**

The minimum interference is = 25. 022 - 25.021

= **0.001**



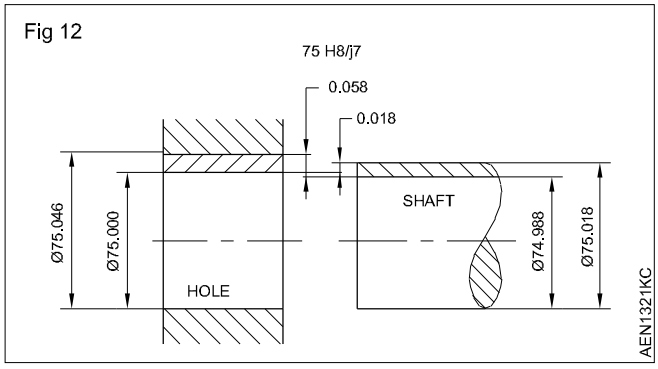
Transition fit: it is a fit which may sometimes provide clearance, and sometimes interference. When this class of fit is represented graphically, the tolerance zones of the hole and shaft will overlap each other. (Fig 11)



Example Fit 75 H8/j7 (Fig 12)

The limits of the hole are 75.000 and 75.046 mm and those of the shaft are 74.018 and 74.988 mm.

Maximum Clearance = 75.046 - 74.988 = 0.058 mm.

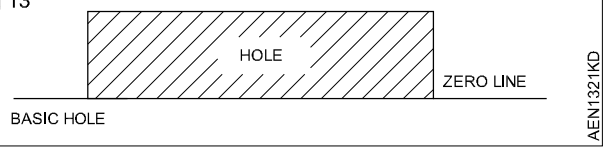


If the hole is 75.000 and the shaft 75.018 mm, the shaft is 0.018 mm, bigger than the hole. This results in interference. This is transition fit because it can result in a clearance fit or an interference fit.

Hole basis system: In a Standard system of limits and fits, where the size of the hole is kept constant and the size of the shaft is varied to get the difference class of fits, then it is known as, the hole basis system.

The fundamental deviation symbol 'H' is chosen for the holes, when the hole basis system is followed. This is because the lower deviation of the hole 'H' is zero. It is known as 'basic hole'. (Fig 13)

Fig 13



Shaft basis system: In a standard system of limits and fits, where the size of the shaft is kept constant and the variations are given to the hole for obtaining different class of fits, then it is known as shaft basis. The fundamental deviation symbol 'h' is chosen for the shaft when the shaft basis is followed. This is because the upper deviation of the shaft 'h' is zero. It is known as 'basis shaft'. (Fig 14)

The hole basis systems followed mostly. This is because, depending upon the class of fit, it will be always easier to alter the size of the shaft because it is external, but it is difficult to do minor alternations to a hole. Moreover the hole can be produced by using standard toolings.

The three classes of fits, both under hole basis and shaft basis, are illustrated in (Fig 15)

Fig 14

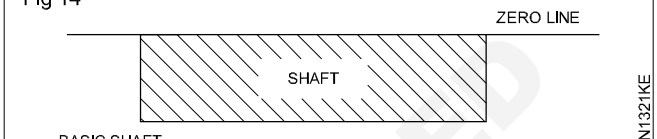
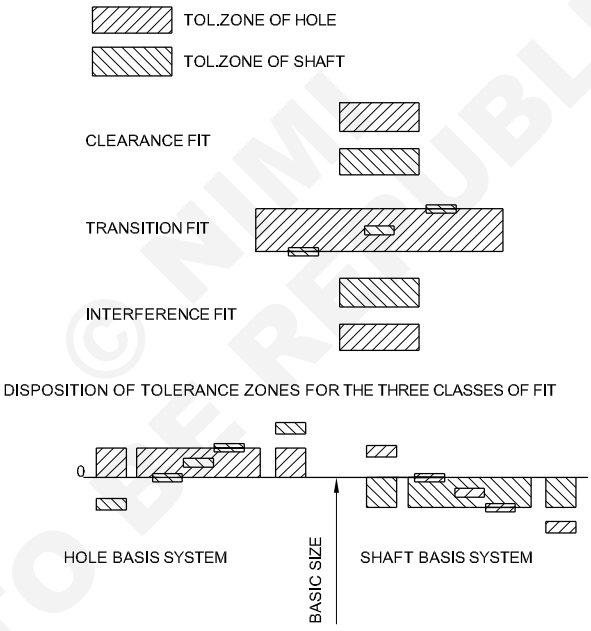


Fig 15



EXAMPLES ILLUSTRATING THE HOLE BASIS AND SHAFT BASIS SYSTEM

Drilling machine (portable type)

Objectives: At the end of this lesson you shall be able to
- **name the different types of portable drilling machines**
- **state their distinctive features and uses.**

Necessity

Portable hand drills of different types are used for certain jobs which cannot be handled on stationary drilling machines.

Types: There are two types of portable drilling machines,

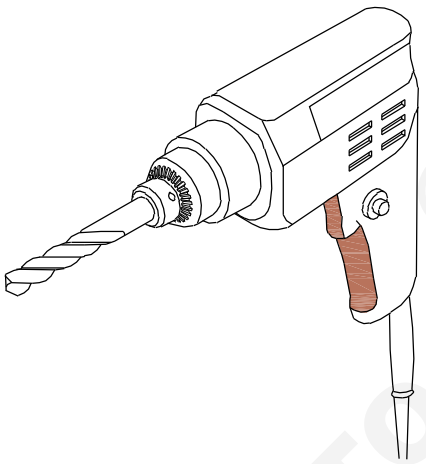
1 Power operated 2 hand operated.

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) (Figs 2 and 3)

This drill has an additional feature by which the drill speed can be varied through a system of gears. This is particularly useful for drilling larger diameter holes.

Fig 2

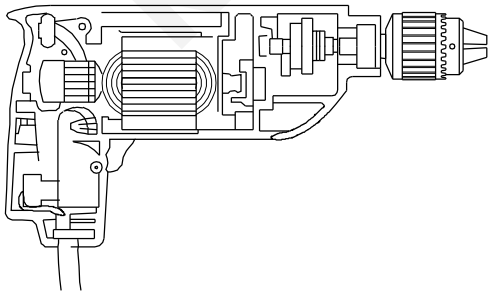

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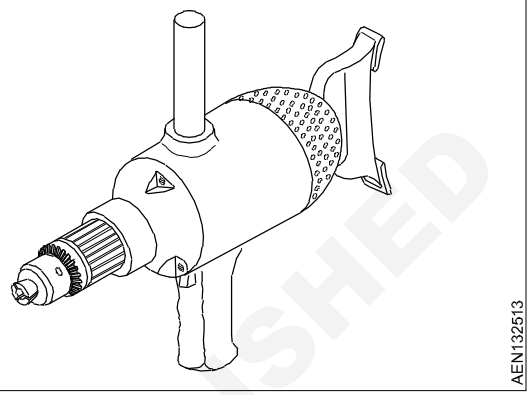
Fig 3



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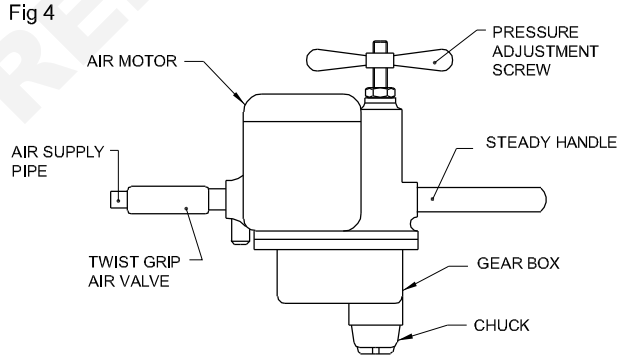
Pneumatic hand drill (Fig 4): This type of drill is operated by compressed air. An air driven motor is housed in the casing, and a handle is fitted along with an air pipe to operate the drill conveniently.

This drill is used where electrically operated drills are prohibited i.e. explosives factories, petroleum refineries etc.

Fig 4



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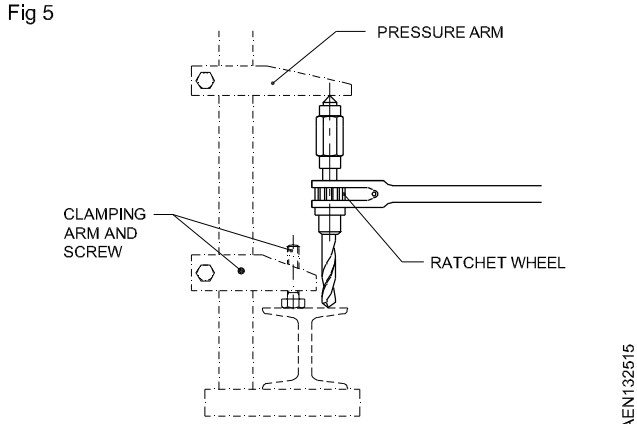
Hand operated drilling machines (Fig 5)

Fig 5



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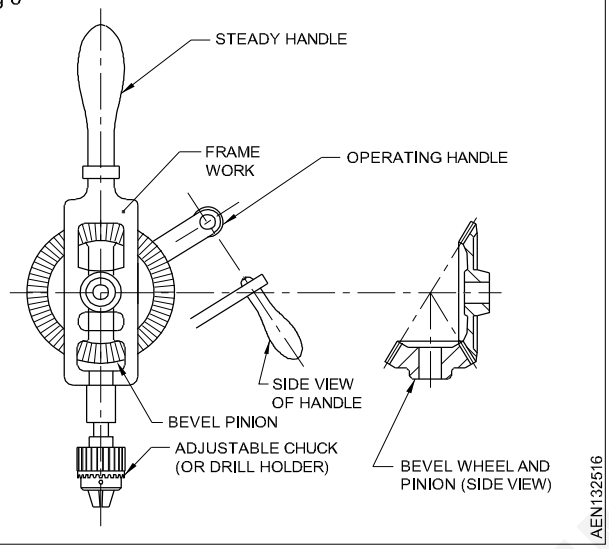
Different types of hand operated drilling machines are shown below. They are used in structural fabrication, sheet metal and carpentry, particularly where electricity or pneumatic supply is not available.

The ratchet drilling machine (Fig 5) is commonly used in structural fabrication. Square head, taper shank drills are used on these machines.

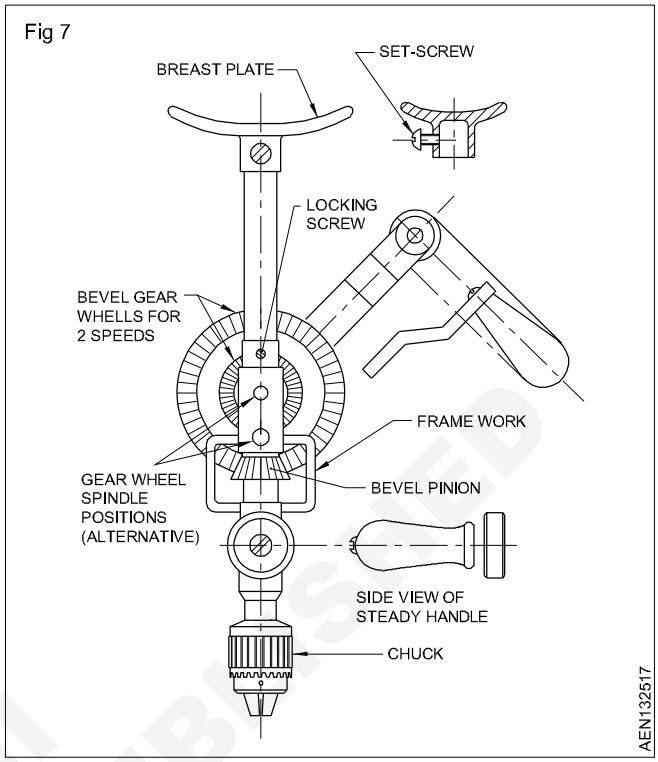
The bevel gear type drilling machine (Fig 6) is used for drilling small diameter holes up to 6mm.

Fig 6



The breast drilling machine (Fig 7) is used for drilling holes of larger diameter as more pressure can be exerted. Drills between 6 mm to 12 mm can be used on these machines.

Fig 7



Drilling machines (bench and pillar type)

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

- **name the types of drilling machines**
- **list out the parts of bench type, pillar type and radial drilling machines**
- **compare the features of the bench type, pillar type and radial drilling machines.**

The principal types of drilling machines are :

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

(You are not likely to use the column and radial types of drilling machines now. Therefore, only the sensitive and pillar type machines are explained here.)

The sensitive bench drilling machine (Fig 1)

The simplest type of sensitive drilling machines is shown in the figure with its various parts marked. This is used for light duty work.

This machine is capable of drilling holes upto 12.5 mm diameter. The drills are fitted in the chuck or directly in the tapered hole of the machine spindle.

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)

Fig 1

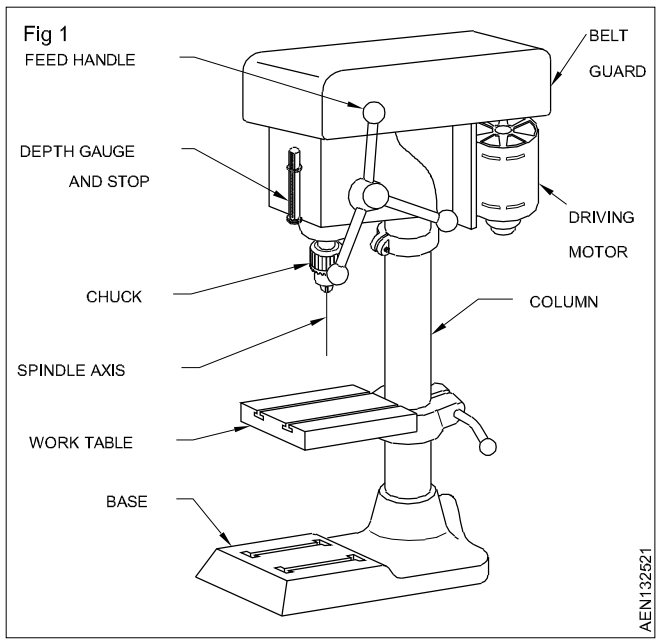
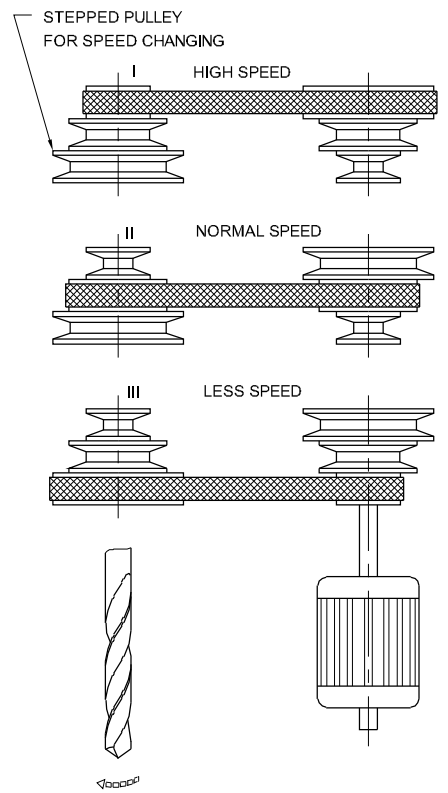


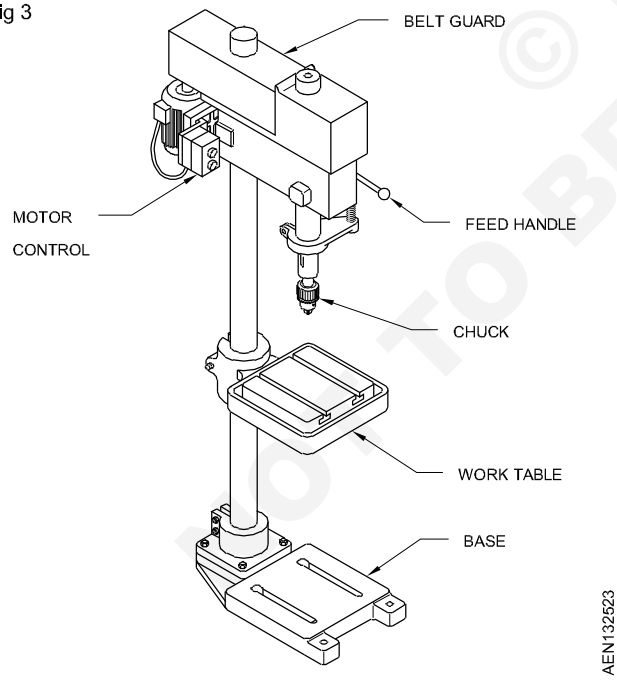
Fig 2



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.

Fig 3

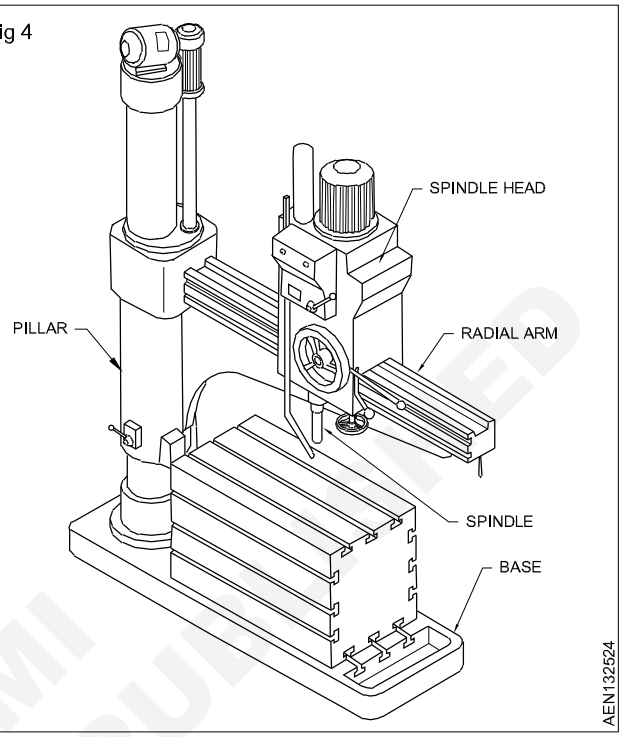


They are used for heavy duty work. Pillar drilling machines are available in different sizes.

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

Radial drilling machines (Fig 4)

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.

Cutting speed and RPM

Objectives: At the end of this lesson you shall be able to
- **define cutting speed**
- **state the factors for determining the cutting speed**
- **differentiate between cutting speed and r.p.m.**
- **determine r.p.m. spindle speed**
- **select r.pm. for drill sizes from tables.**

For a drill to give satisfactory performance, it must operate at the correct cutting speed and feed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting, and is expressed in metres per minute.

Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the recommended cutting speed for drilling depends on the materials to be drilled, and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in the table. Based on the cutting speed recommended, the r.p.m. at which a drill has to be driven, is determined.

Calculate r.p.m

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

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

n = r.p.m

v = cutting speed in m/min

d = diameter of drill in mm

Π = 3.14

Material being drilled for HSS	Cutting speed (m/min)
Aluminium	70 -100
Brass	35-50
Bronze (Phosphor)	20-35
Cast Iron (grey)	25-40
Copper	35-45
LC/MC steel/ Alloy steel	20-30
Thermosetting plastic (low speed due to abrasive properties)	5-8

Work - holding devices

Objectives: At the end of this lesson you shall be able to
- **state the purpose of work-holding devices**
- **name the devices used for holding work**
- **state the precautions to be observed while using.**

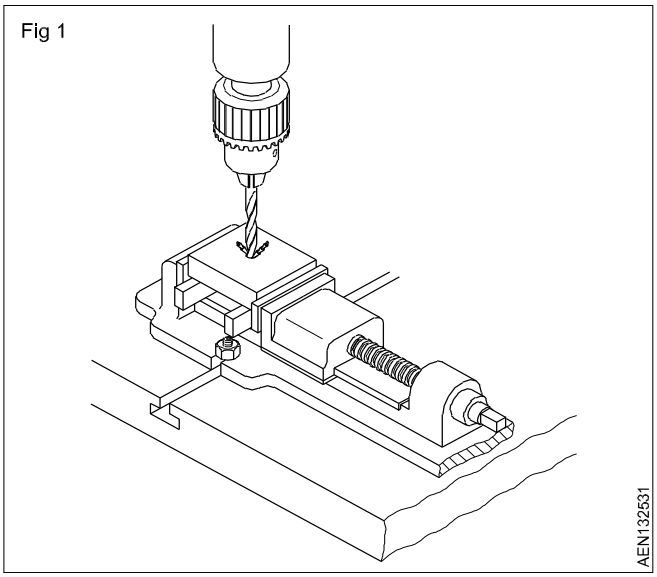
Workpieces to be drilled should be properly held or clamped to prevent them from rotating along with the drill. Improperly secured work is not only a danger to the operator but can also cause inaccurate work, and breakage to the drill. Various devices are used to ensure proper holding.

The machine vice (Fig 1)

Most of the drilling work can be held in a machine vice. Ensure that the drill does not drill through the vice after it has passed through the work. For this purpose, the work can be lifted up and secured on parallel blocks providing a gap between the work and the bottom of the vice.

Workpieces which are not accurate may be supported by wooden pieces.

Fig 1



Clamps and bolts (Fig 2 to 5)

Fig 2

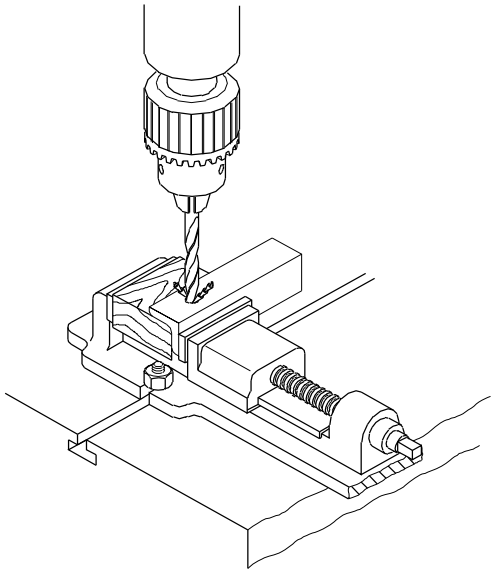
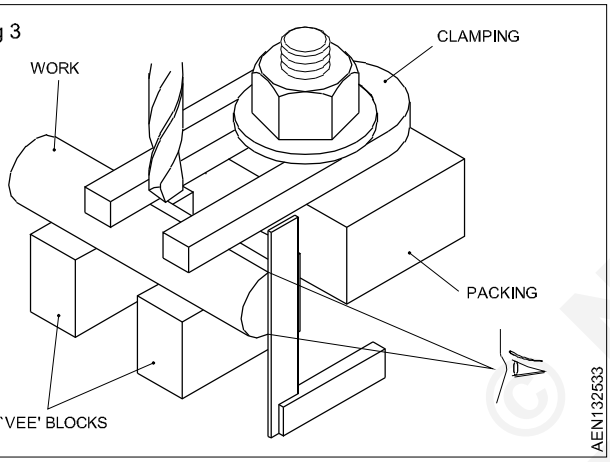


Fig 3



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 and it is necessary to determine the clamping method according to the work.

Fig 4

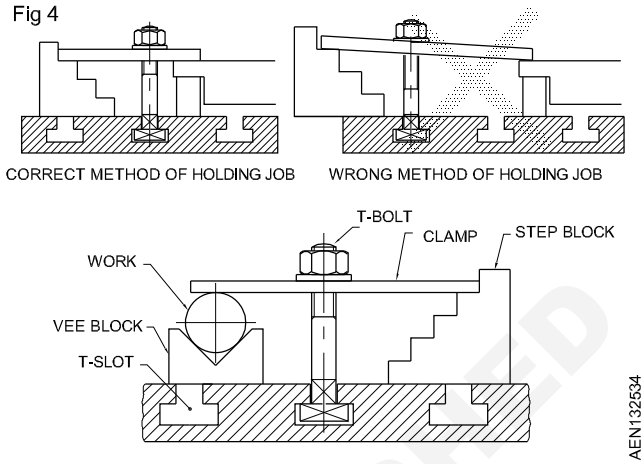
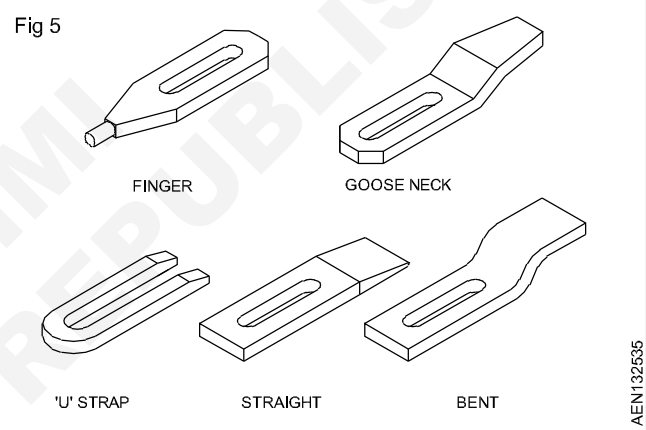


Fig 5



Drill - holding devices

Objectives: At the end of this lesson you shall be able to
- **name the types of drill-holding devices**
- **state the features of drill chucks**
- **state the functions of drill sleeves**
- **state the function of drift.**

For drilling holes of material, the drills are to be held accurately and rigidly on the machines.

The common drill-holding devices are drill chucks and sleeves and sockets.

Drill Chuck: Straight shank drills are held in drill chucks. For fixing and removing drills, the chucks are provided either with a pinion and key or a knurled ring.

The drill chucks are held on the machine spindle by means of an arbor fitted or the drill chuck. (Fig 1)

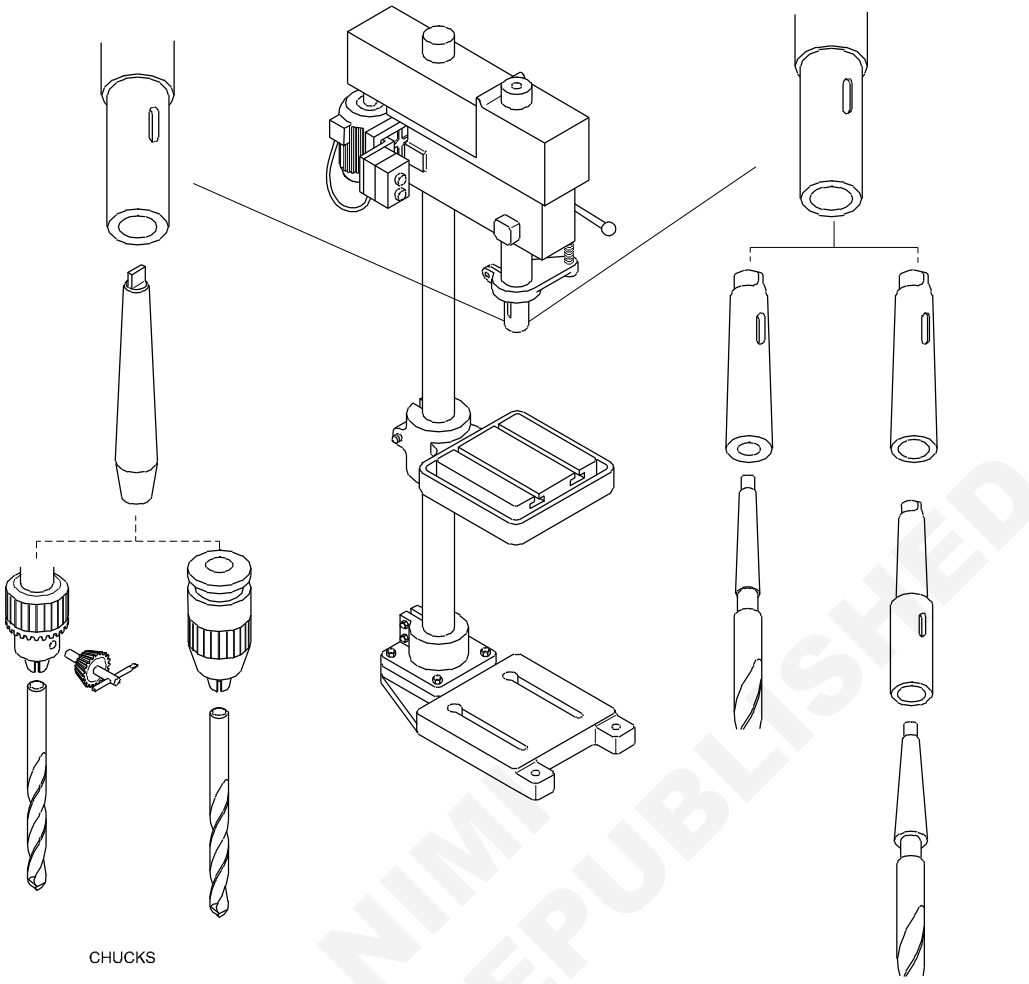
Taper Sleeves and Sockets (Fig 1): Taper shank drills have a morse taper.

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.

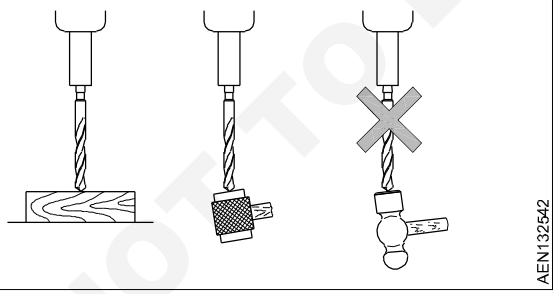
In order to make up the difference in sizes between the shanks of the drills and the type of machine spindles, sleeves of different sizes are used. When the drill taper shank is bigger than the machine spindle,taper sockets are used. (Fig 1)

Fig 1



While fixing the drill in a socket or sleeves the tang portion should align in the slot (Fig 2). this will facilitate the removal of drill or sleeve from the machine spindle.

Fig 2



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

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

Fig 3

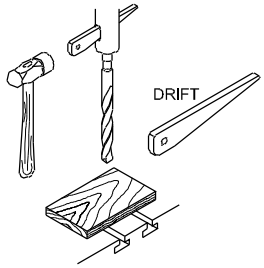
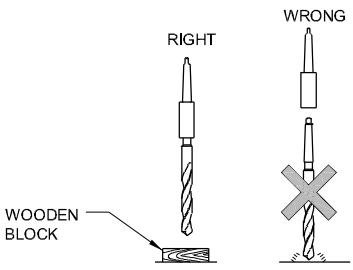


Fig 4

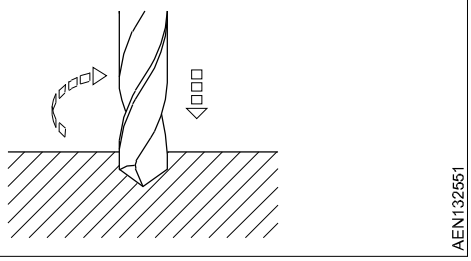


Drill bits

Objectives: At the end of this lesson you shall be able to
- **state the functions of drills**
- **name the parts of a drill**
- **state the functions of each part of a drill.**

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

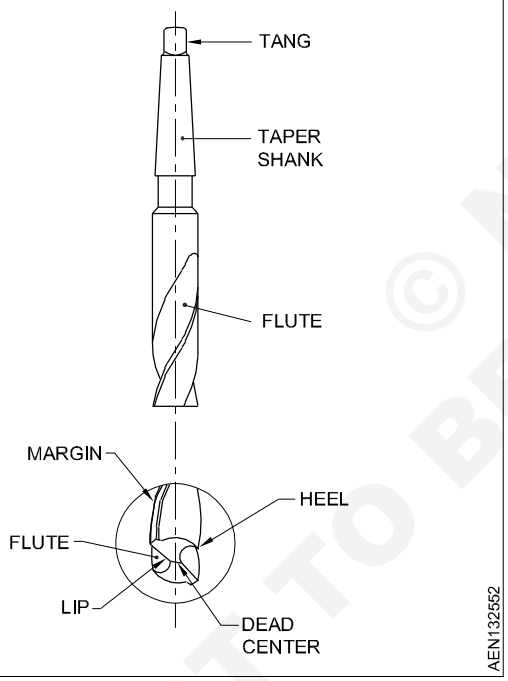
Fig 1



Parts of a Drill (Fig 2)

The Various parts of a drill can be identified from Fig 2

Fig 2



Point: The cone shaped end which does the cutting is called point. It consists of a dead centre, lips or cutting edges and a heel.

Shank: This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

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

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

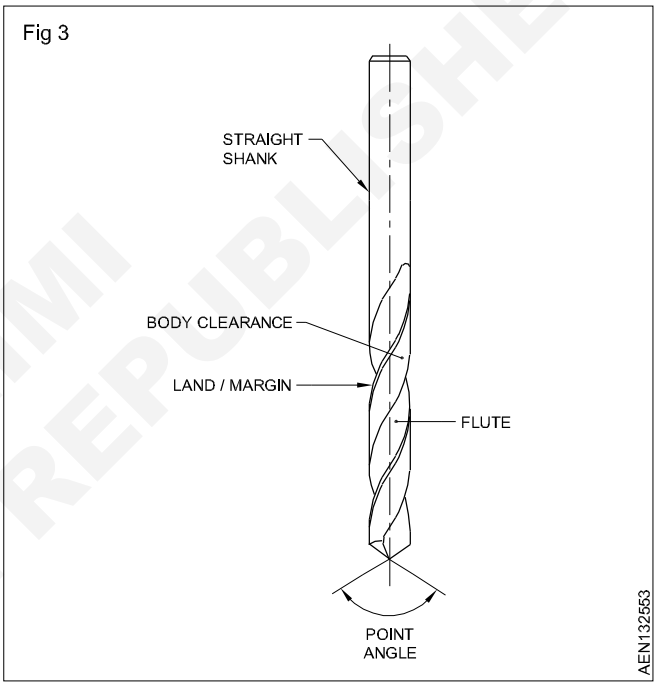
Body (Fig 3): The portion between the point and the shank is called the body of a drill.

The parts of the body are flute, land/margin, body clearance and web.

Flutes: Flutes are the spiral grooves which run to the length of the drill. The flutes help,

- to form the cutting edges
- to curl the chips and alow these to come out
- the coolant to flow to the cutting edge.

Fig 3



Land/Margin

The land/margin is the narrow strip which extends to the entire length of the flutes.

The diameter of the drill a measured across the land margin.

Body Clearance

Body clearance is the part of the body which is reduced in diameter to cut down the function between the drill and the hole being drilled.

Web

Web is the metal column which separates the flutes. It gradually increases in thickness towards the shank.

Drill angles

Objectives: At the end of this lesson you shall be able to
- **list the various angles of a twist drill**
- **state the functions of each angle**
- **list the tool types for drill as per IS**
- **distinguish the features of different types of drills**
- **designate drills as per ISI recommendations.**

Angles

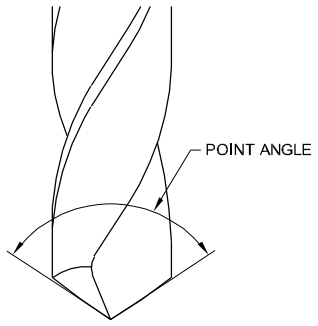
They are different angles for different purposes. They are listed below.

Point Angle, Helix angles, Rake angle, Clearance angle and chisel edge angle.

Point Angle/Cutting Angle

The point angle of a general purpose (standard) drill is 118°.This is the angle between the cutting edges (lips). This angle according to the hardness of the material to be drilled (Fig 1)

Fig 1



Helix Angle (Figs 2a,2b & 2c)

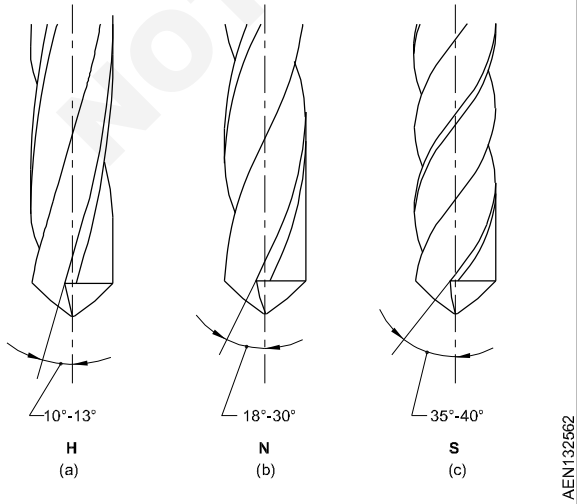
Twist drills are made with different helix angles. The helix angle determines the rake angle at the cutting edge of the twist drill.

The helix angles vary according to the material being drilled. According to Indian Standards, three types of drills are used for drilling various materials.

- Type N-for normal low carbon steel
- Type H-for hard and tenacious materials
- Type S- for soft and tough materials.

The type N drill is used for general purpose drilling work.

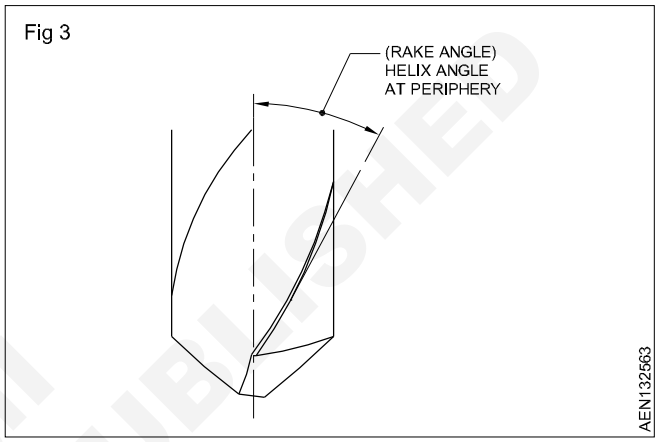
Fig 2



Rake Angle (Fig 3)

Rake angle is the angle of flute (helix angle)

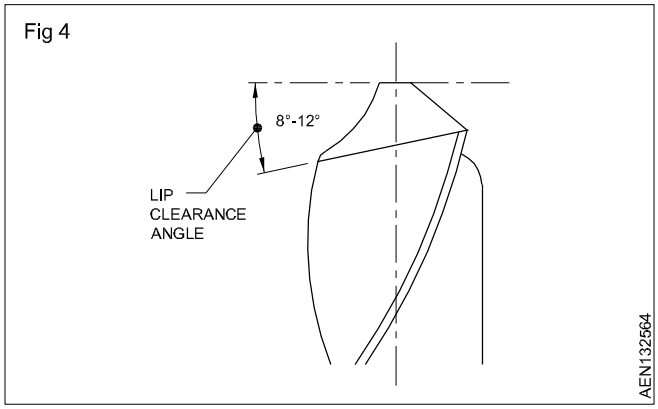
Fig 3



Clearance Angle (Fig 4)

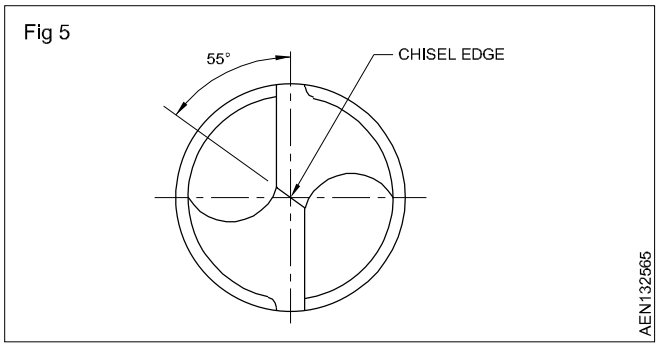
The clearance angle is to prevent the friction of the tool behind the cutting edge. This will help in the penetration of the cutting edges into the material. If the clearance angle is too much the cutting edges will be weak, and if it is too small the drill will not cut.

Fig 4



Chisel Edge Angle/ Web Angle (Fig 5)

Fig 5



This is the angle between the chisel edge and the cutting lip.

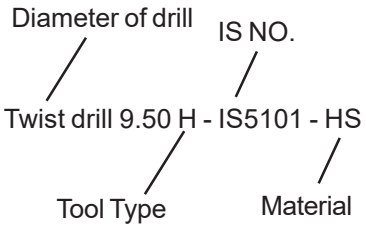
Designation of drills

Twist drills are designated by the

- diameter
- tool type
- material

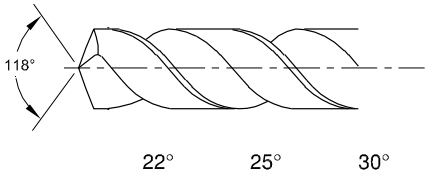
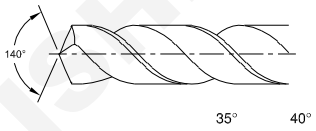
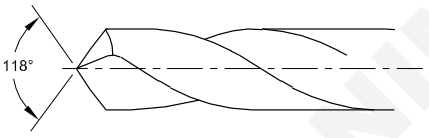
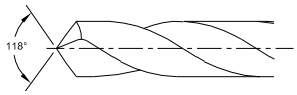
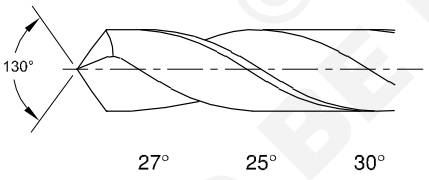
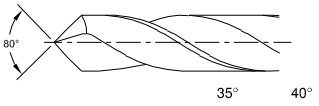
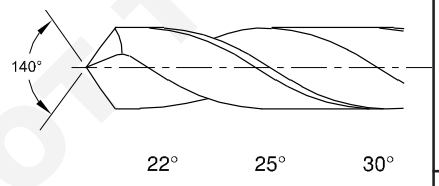
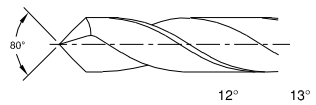
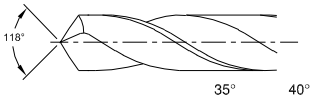
Example

A twist drill of 9.50mm dia of tool type “H’ right hand cutting and made from HSS is designated.



If the tool type is not indicated in the designation, it should be taken as type ‘N’ tool.

Drills for different materials

Recommended drills				
Material to be drilled	Point angle	Helix angle d=3.2-5 5-10	Material to be drilled	Point angle Helix angle d=3.5 -5
Steel and cast steel up to 70 kgf/mm^2 strength Gray cst iron Malleable cast iron Brass German silver, nickel			Copper (up to 30 mm drill diameter) Al-alloys, forming curly chips celluloid	
Brass, CuZn 40			Austentic steels	
Steel and cast steel 70.... 120 Kgfmm^2			Moulded plastics (with thickness s>d)	
Stainless steel; Copper (drill diameter) more than 30 mm) Al-alloy, forming short - broken chips			Moulded plastics, with thickness s<d Laminated plastics. hard rubber (ebonite) marble, state, coal	
			Zinc alloys	

Hand taps and dies

Objectives: At the end of this lesson you shall be able to
- **state the uses of threading hand taps**
- **state the features of hand taps**
- **distinguish between different taps in a set**
- **name the different types of tap wrenches**
- **state the uses of different types of wrenches.**

Use of Hand Taps

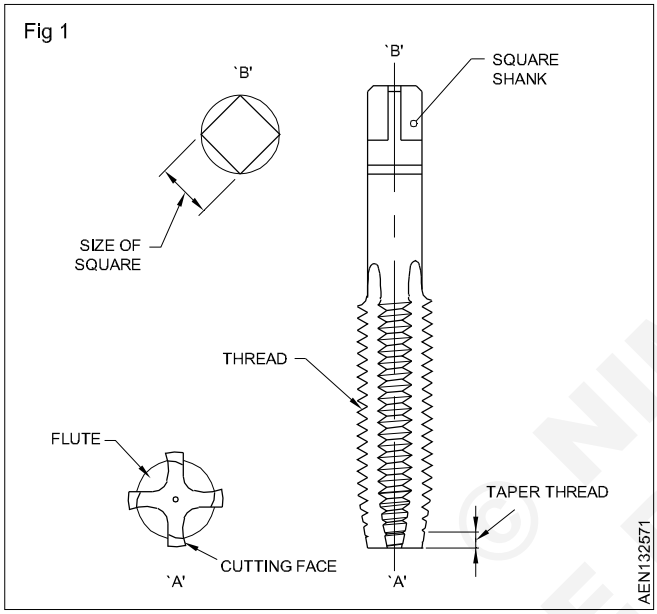
Hand taps are used for internal threading of components.

Features (Fig 1)

They are made from high carbon steel of high speed steel handened and ground

Threads are cut on the surface and are accurately finished.

Fig 1



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

For holding and turning the taps while cutting threads the ends of the shanks are squared.

The ends of the taps are chamfered (taper lead) for assisting aligning and starting of the thread.

The size of the taps and the type of the thread are usually marked on the shank.

In certain cases the pitch of the thread will also be marked.

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

Types of Taps in a set

Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2)

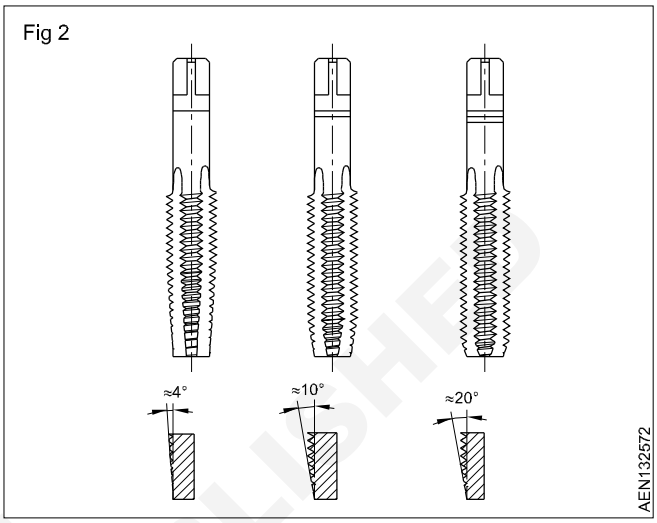
These are

first tap or taper tap

second tap or intermediate tap

plug or bottoming tap

Fig 2



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

The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep.

The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth.

for identifying the type of taps quickly - the taps are either numbered as 1,2 and 3 or rings are marked on the shank.

The taper tap has one ring the intermediate tap has two rings and the bottoming tap has three rings (Fig 2)

Tap Wrenches

Tap Wrenches are used to align and drive the hand taps correctly into the hole to be threaded.

Tap Wrenches are of different types.

Double ended adjustable wrench, T handle tap wrench and solid type tap wrench.

Double ended adjustable tap Wrench or Bar Type Tap Wrench (Fig 3)

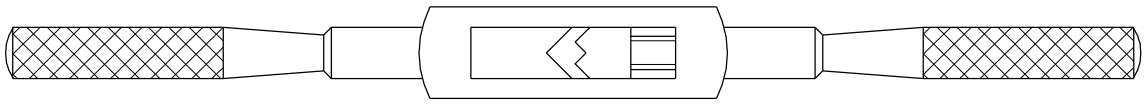
This is the most commonly used type of tap wrench. It is available in various sizes. These tap wrenches are more suitable for large diameter taps and can be used in open places where there is no obstruction to turn the tap. It is important to select the correct size of wrench.

T- Handle Tap Wrench (Fig 4)

These are small adjustable chucks with two jaws and a handle to turn the wrench.

This tap wrench is useful to work in restricted places and is turned with one hand only.

Fig 3



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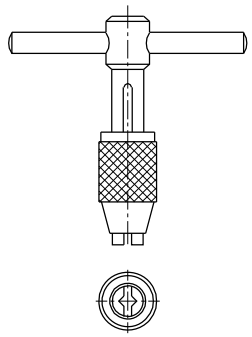
This is not suitable for holding large diameter taps.

Fig 4



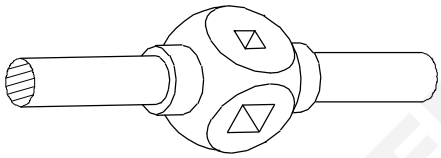
AEN132574

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



AEN132575

Tap drill size

Objectives: At the end of this lesson you shall be able to
- **state the tap drill size**
- **choose the tap drill sizes for different threads from tables**
- **calculate the tap drill sizes for ISO metric and ISO inch.**

Tap drill Size

Before a tap is used for cutting internal threads, a hole is to be drilled. The diameter of the hole should be such that it should have sufficient material in the hole for the tap to cut the thread.

Tap Drill Sizes for Different Threads

ISO Metric Thread

Tapping drill size

for M10 x 1.5 thread

Minor diameter = Major diameter – 2 x depth

depth of thread = 0.6134 x pitch of a screw

2 depth of thread = 0.6134 x 2 x pitch

=1.226 x 1.5 mm = 1.839 mm

Minor dia (D1)=10 mm – 1.839 mm

=8.161mm or 8.2 mm

This tap drill will produce 100% thread because this is equal to the minor diameter of the thread. For most fastening purposes a 100% formed thread is not required.

A standard nut with 60% thread is strong enough to be tightened until the bolt breaks without stripping the thread. Further it also requires a greater force for turning the tap if a higher percentage formation of thread is required.

Considering this aspect, a more practical approach for determining the tap drill sizes is

Tap drill size = Major diameter – pitch

= 10 mm - 1.5 mm

= 8.5 mm.

Compare this with the table of tap drill sizes for ISO metric threads.

ISO Inch (Unified) threads Formula

$$\text{Tap Drill size} = \text{Major diameter} - \frac{1}{\text{Number of thread per inch}}$$

For calculating the tap drill size for 5/8" UNC thread

Tap drill size = 5/8" – 1/11"

= 0.625" – 0.091"

= 0.534"

The next drill size is 17/32" (0.531 inches)

Compare this with the table of drill sizes for unified inch threads.

What will be the tapping size for the following threads?

a M 20

b UNC 3/8

Refer to chart for determining the pitches of the thread.

TABLE FOR TAP DRILL SIZES - ISO METRIC

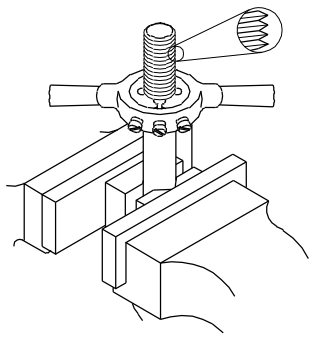
PITCH /	0.25	0.3	0.35	0.4	0.45	0.5	0.6	0.7	0.75	0.8	1	1.25	1.5	1.75		2.5	3	3.5	4	4.5	5	5.55
1	0.85																					
1.1	0.95																					
1.2	0.96																					
1.4		1.10																				
1.6			1.25																			
1.8			1.45																			
2				1.60																		
2.2			2.15		1.75																	
2.5			2.65		2.05																	
3			3.15			2.50																
3.5							2.90															
4						3.50		3.30														
4.5						4.00			3.70													
5						4.50				4.20												
5.5						5.00																
6									5.20		5.00											
7									6.20		6.00											
8									7.20		7.00	6.80										
9									8.20		8.00	7.80										
10									9.20		9.00	8.80	8.50									
11									10.20		10.00		9.50									
12											11.00	10.80	10.50	10.20								
14											13.00	12.80	12.50		12.00							
15											14.00		13.50									
16											15.00		14.50		14.00							
17											16.00		15.50									
18											17.00		16.50		16.00	15.50						
20											19.00		18.50		18.00	17.50						
22											21.00		20.50		20.00	19.50						
24											23.00		22.50		22.00		21.00					
25											24.00		23.50		23.00							
26													24.50									
27											26.00		25.50		25.00		24.00					
28											27.00		26.50		26.00							
30											29.00		28.50		28.00		27.00	26.50				
32													30.50		30.00							
33													31.50		31.00		30.00	29.50				
35													33.50									
36													34.50		34.00		33.00		32.00			
38													36.50									
39													37.50		37.00		36.00		35.00			
40													38.50		38.00		37.00					
42													40.50		40.00		39.00		38.00	37.50		
45													43.50		43.00		42.00		41.00	40.50		
48													46.50		46.00		45.00		44.00		43.00	
50													48.50		48.00		47.00					
52													50.50		50.00		49.00		48.00		47.00	
56																						50.50

Die and die stock

Objectives: At the end of this lesson you shall be able to
- **name the different types of dies**
- **state the features of each type of die**
- **state the use of each type of die**
- **name the type of diestock for each type of die.**

Uses of dies: Threading dies are used to cut external threads on cylindrical workpieces. (Fig 1)

Fig 1



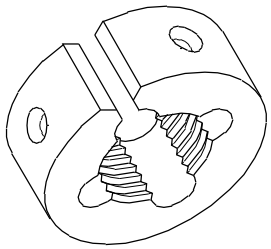
Types of Dies: The following are the different types of dies.

- 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



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.

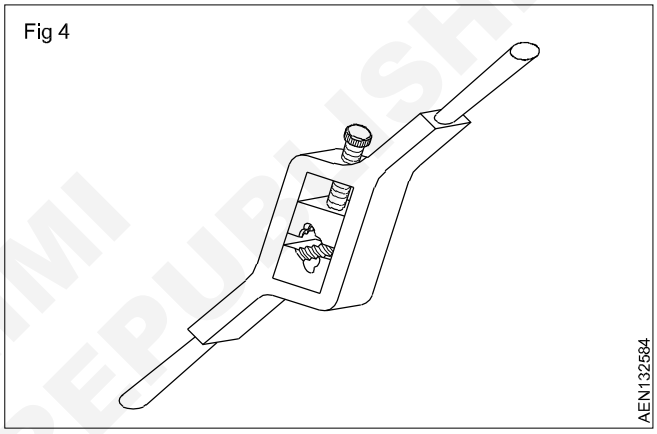
Adjustments can be made easily to increase or decrease the depth of cut.

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



Adjustable Screw Plate Die (Fig 5)

This is another type of a two piece die similar to the half die.

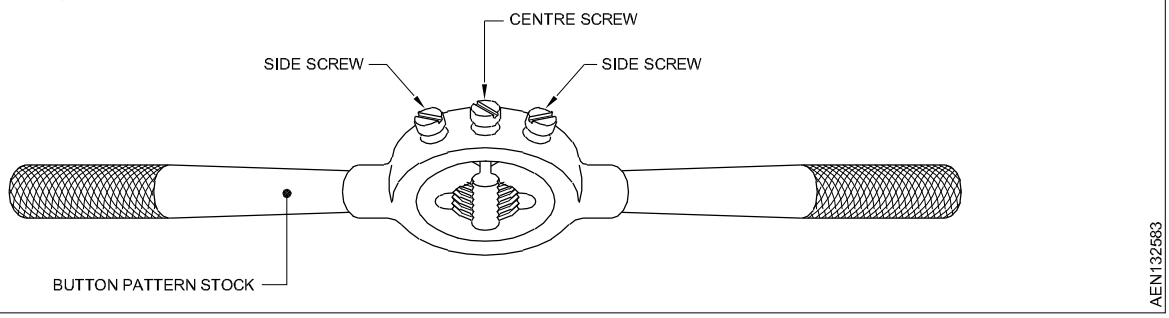
This provides greater adjustment than the split die.

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.

When the guide plate is tightened after placing the die pieces in the collar, the die pieces are correctly located and rigidly held. (Fig 5)

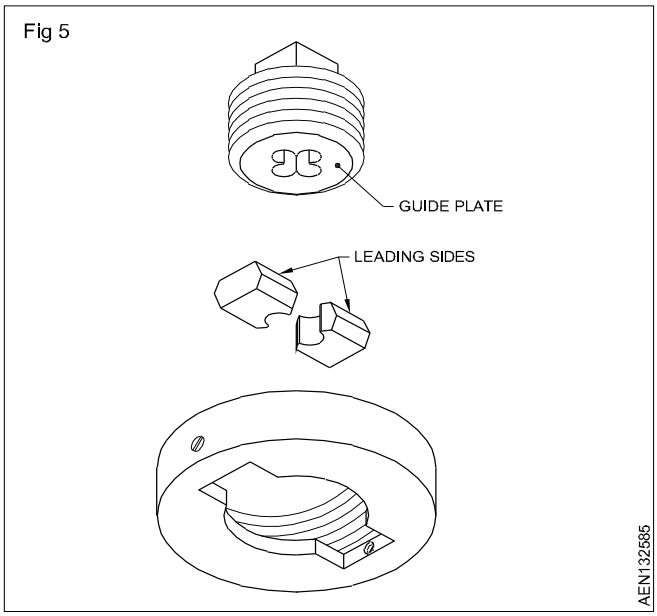
The die pieces can be adjusted, using the adjusting screws on the collar. This type of die stock used is called quick cut diestock. (Fig 6)

Fig 3



The bottom of the die halves is tapered to provide the lead for starting the thread. On one side of each die head, the serial number is stamped. Both pieces should have the same serial numbers.

Fig 5



Die Nut (Solid Die) (Fig 7)

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

The die nut is turned with a spanner.

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

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

Fig 7

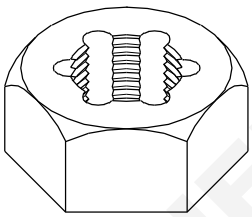
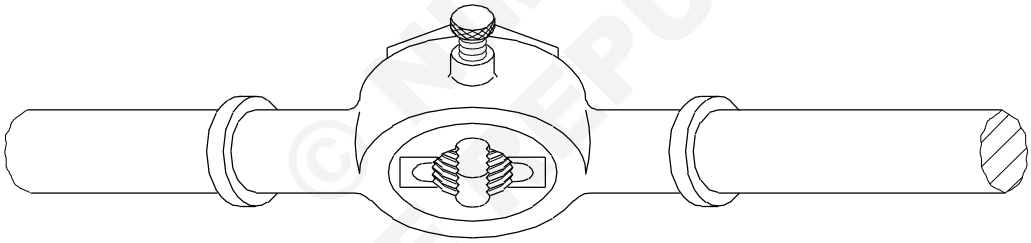


Fig 6



Methods of removing broken studs

Objectives: At the end of this lesson you shall be able to
- **state the reasons for breakage of studs**
- **state the different methods for removing broken studs.**

The stud is used in the place of a bolt. Where hole cannot be had for the bolt to pass through or to avoid the use of an unnecessarily long bolt. Studs are generally used to fix up cover plates or to connect cylinder covers to engine cylinders.

Reasons for breakage of stud/bolt

Excessive torque is applied while screwing the stud into the hole/tightening the nut.

Threads are corroded excessively.

Matching threads are not of proper formation.

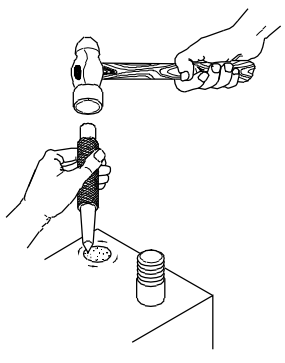
Threads are seized.

Methods of removing broken studs

Prick punch method (Fig 1)

If the stud is broken very near to the surface, drive it in an anticlockwise direction, using a prick punch and hammer to remove it.

Fig 1

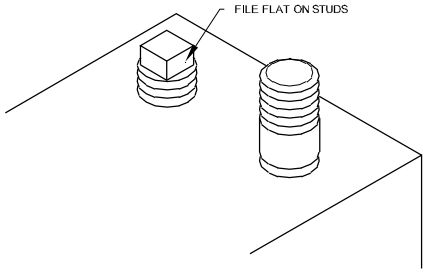


Filing square form (Fig 2)

When the stud is broken a little above the surface, form a

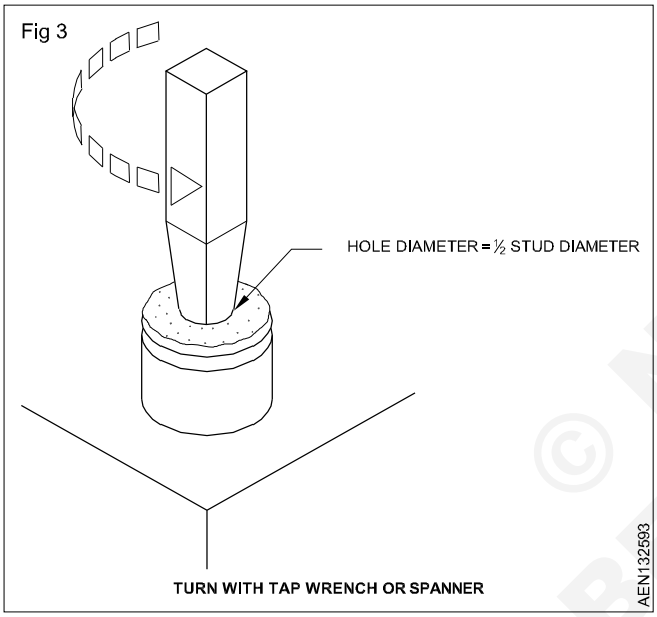
square on the projecting portion to suit a standard spanner. Then turn it anticlockwise using a spanner to remove stud.

Fig 2



Using square taper punch (Fig 3): Broken studs can also be removed by drilling a blind hole (hole diameter equal to half of stud diameter) and driving a square taper punch into the hole as shown Fig 3. Turn the punch using a suitable spanner in an anticlockwise direction to unscrew the stud.

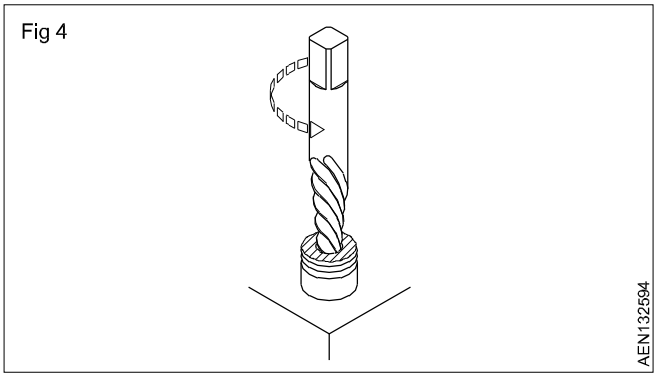
Fig 3



Ezy-out method (Fig 4): Ezy-out or a stud extractor is a hand tool, some what similar to the form of a taper reamer but it has left hand spiral. It is available in a set of 5 pieces. The recommended drill size is punched on each ezy-out.

Drilling the hole, the recommended ezy-out is set on and turned in an anticlockwise direction by a tap wrench. As it is rotated it penetrates into the hole increasing its grip and in the process the broken stud gets unscrewed.

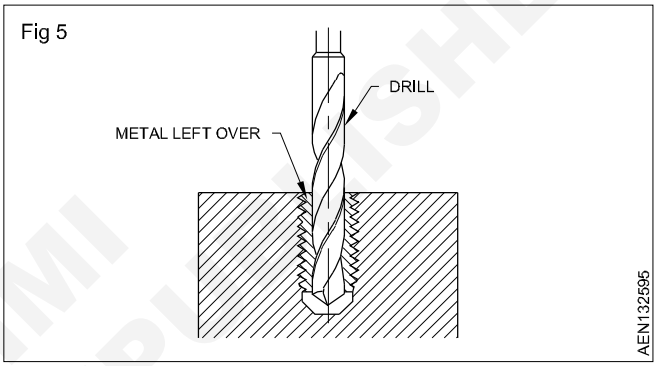
Fig 4



Making drill hole (Fig 5)

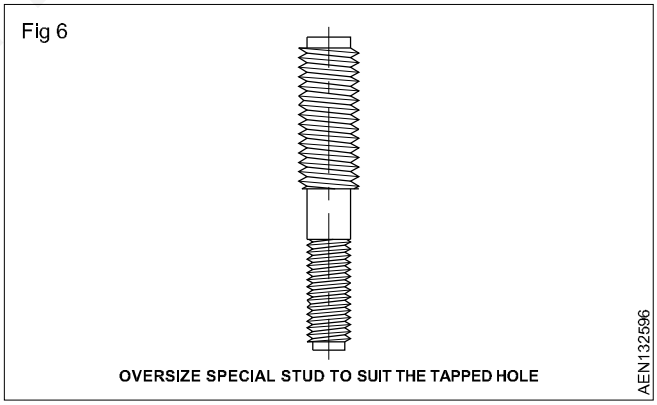
Correctly find out the centre of the broken stud and drill a hole nearly equal to the core diameter of the stud down the centre so that the threads only remain (Fig 5). Remove the thread portion by the point of a scriber in the form of broken chips. Re-tap the drill hole to clear the threads.

Fig 5



If all other methods fail drill a hole equal to the size of the stud size or a little over and tap the hole with an oversize tap. Now a special oversize stud as shown in figure 6 is to be made and fitted in position. (Fig 6)

Fig 6



Hand reamers

Objectives: At the end of this lesson you shall be able to
- **state the uses of reamers**
- **state the advantages of reaming**
- **distinguish between hand and machine reaming**
- **name the elements of a reamer.**

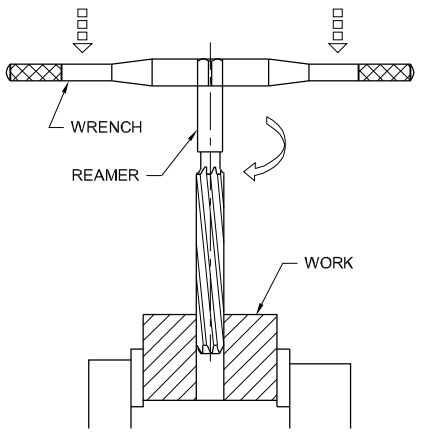
What is reamer?

A reamer is a multi-point cutting tool used for enlarging and finishing previously drilled holes to accurate sizes. (Fig 1)

Advantages of 'reaming'

Reaming produces high quality surface finish and dimensional accuracy to close limits.

Fig 1



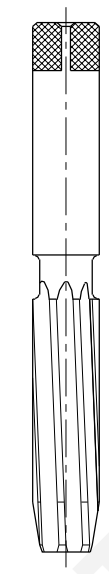
Also small holes which cannot be finished by other processes can be finished.

Classification of reamers

Reamers are classified as hand reamers and machine reamers. (Fig 2 and 3)

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

Fig 2



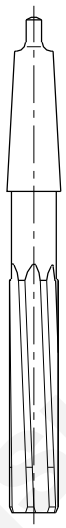
HAND REAMER

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)

Fig 3

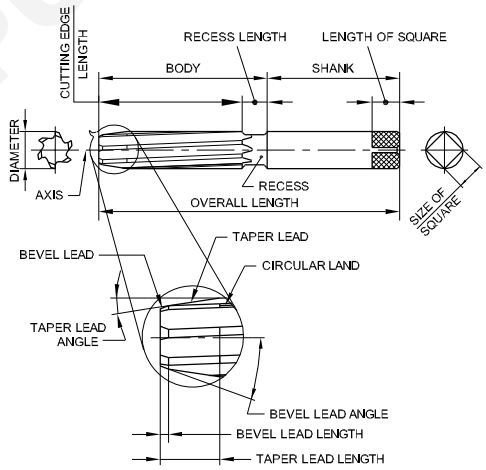


MACHINE REAMER

Parts of a hand reamer

The parts of a 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. (see Table)

TABLE 1

Undersizes for reaming

Diameter of ready reamed hole (mm)	Undersizes of rough bored hole (mm)
under 5	0.1...0.2
5....20	0.2...0.3
21....50	0.3....0.5
over 50	0.5....1

Oversize of drilled hole

It is generally considered that a twist drill will make a hole larger than its diameter. The oversize for calculation purposes is taken as 0.05 mm, for all diameters of drills.

For light metals the undersize will be 50% larger.

Example

A hole is to be reamed on mild steel with a 10mm reamer. What will be the diameter of the drill for drilling the hole before reaming?

Drill size = Reamed size - (undersize + oversize) (finished size) = 10mm

Undersize as per table = 0.2 mm

Oversize = 0.05 mm, finished size = 0.05+0.2=0.25mm

Drill size = 10mm-0.25mm

= 9.75mm

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 - causes and remedies

Reamer hole undersize

If a worn out reamer is used, it may result in the reamed hole being undersize. Do not use such reamers.

Always inspect the condition of the reamer before using.

Surface finish rough

The causes may be anyone of the following ara combination there of.

- incorrect application
- Swarf accumulated in reamer flutes
- in adequate flow of coolant
- feed rate too fast

While reaming apply a steady and slow feed rate.

Ensure a copious supply of the lubricant.

Do not turn the reamer in the reverse direction.

Lapping

Objectives: At the end of this lesson you shall be able to
- **state the purpose of lapping**
- **state the features of a flat lapping plate**
- **state the use of changing a flat lapping plate**
- **state the method of charging a cast iron plate**

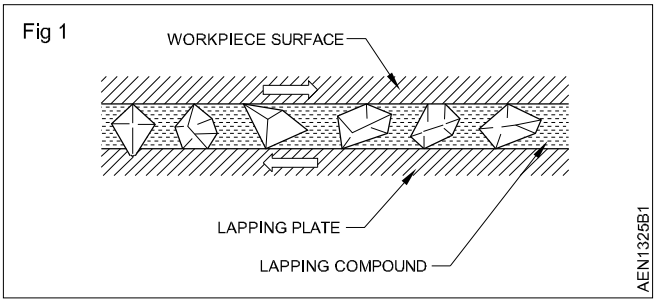
Lapping is a precision finishing operation carried out using line abrasive materials.

Purpose: This process

- improves geometrical accuracy
- refines surface finish
- assists in achieving a high degree of dimensional accuracy.
- improves the quality of fit between the mating components.

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)

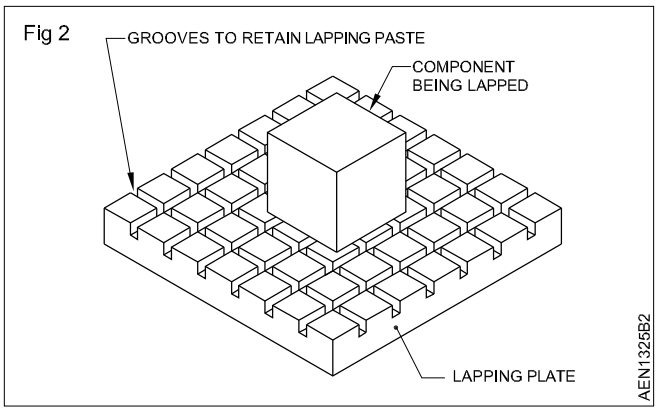
Fig 1



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.



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
- **name the different types of lap materials**
- **state the qualities of different lap materials**
- **name the different types of abrasive materials used for lapping**
- **distinguished between the application of different lapping abrasives**
- **state the function of lapping vehicles**
- **name the solvents used in lapping.**

The material used for making laps should be softer than the workpiece being lapped. This helps to charge the abrasives on the lap. If the lap is harder than the workpiece, the workpiece will get charged with the abrasives and cut the lap instead of the workpiece being lapped.

Laps are usually made of

- close grained iron
- copper
- brass or lead.

The best material used for making lap is cast iron, but this cannot be used for all applications.

When there is excessive lapping allowance, copper and brass laps are preferred as they can be charged more easily and cut more rapidly than cast iron.

Lead is an in expensive form of lap commonly used for holes. Lead is cast to the required size on steel arbor. 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 soluble oil, bentonite 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 and structure of matter**
- **describe atomic structure**
- **describe the energy shell and electron distribution**
- **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.

Examples of Electric current

- Domestic electric supply, industrial electric supply.

Examples of static electricity

Shock received from door knobs of a carpeted room. Attraction of paper of the comb.

Structure of matter

To understand electricity, one must understand the structure of matter. Electricity is related to some of the most basic building blocks of matter that are atoms (electrons and protons). All matter is made of these electrical building blocks, and, therefore, all matter is said to be 'electrical'.

Matter is defined as anything that has mass and occupies space. A matter is made of tiny, invisible particles called molecules. A molecule is the smallest particle of a substance that has the properties of the substance. Each molecule can be divided into simpler parts by chemical means. The simplest parts of a molecule are called atoms.

Atomic Structure

Basically, an atom contains three types of sub-atomic particles that are of relevance to electricity. They are the electrons, protons and neutrons. The protons and neutrons are located in the centre, or nucleus, of the atom, and the electrons travel around the nucleus in orbits.

The Nucleus

The nucleus is the central part of the atom. It contains the protons and neutrons of an atom as shown in Fig 1

Protons

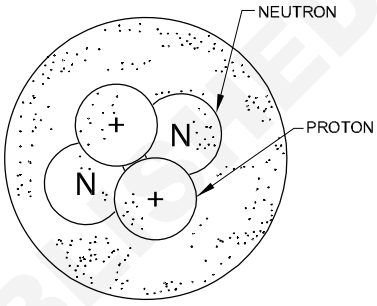
The proton has a positive electrical charge. (Fig 1) It is almost 1840 times heavier than the electron and it is the permanent part of the nucleus; protons do not take an active part in the flow or transfer of electrical energy.

Electron

It is a small particle revolving round the nucleus of an atom as shown in Fig 2. It has a negative electric charge.

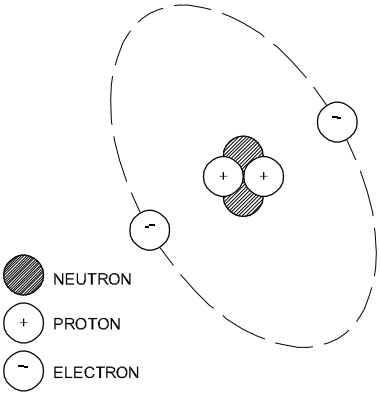
The electron is three times larger in diameter than the proton. In an atom the number of protons is equal to the number of electrons.

Fig 1



NUCLEUS OF AN ATOM

Fig 2



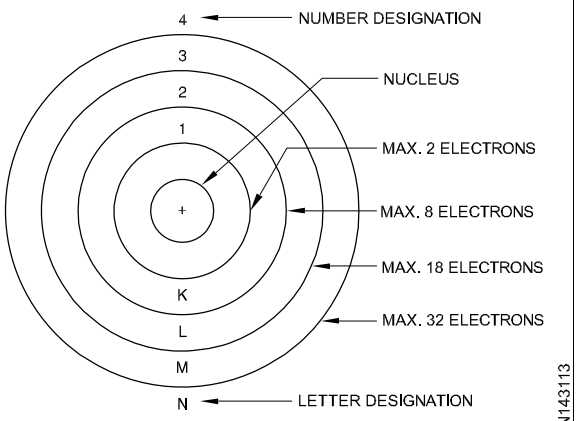
Neutron

A neutron is actually a particle by itself, and is electrically neutral. Since neutrons are electrically neutral, they are not too important to the electrical nature of atoms.

Energy Shells

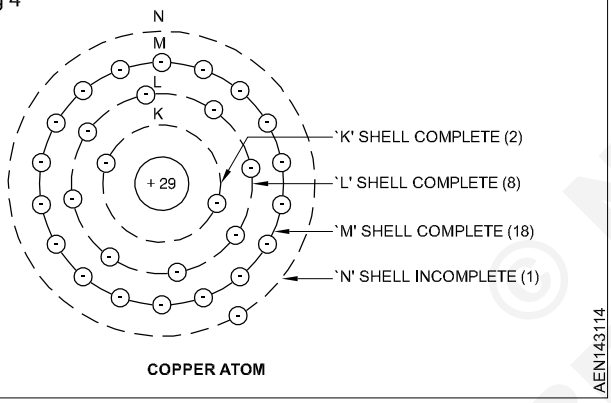
In an atom, electrons are arranged in shells around the nucleus. A shell is an orbiting layer or energy level of one or more electrons. The major steel layers are identified by numbers of by letters starting with 'K' nearest the nucleus and continuing alphabetically outwards. There is a maximum number of electrons that can be contained in each steel. Fig 3 illustrates the relationship between the energy shell level and the maximum number of electrons it can contain.

Fig 3



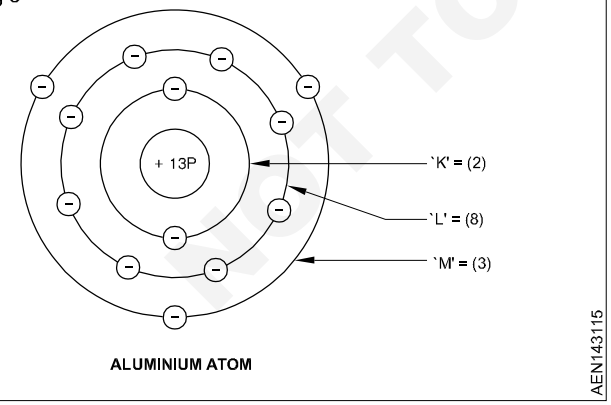
If the total number of electrons for a given atom is known, the placement of electrons in each shell can be easily determined. Each shell layer, beginning with the first, is filled with the maximum number of electrons in sequence. For example, a copper atom which has 29 electrons would have four wheels with a number of electrons in each shell as shown in Fig 4.

Fig 4



Similarly an aluminium atom which has 13 electrons has 3 shell as shown in Fig 5.

Fig 5



Electron distribution

The chemical and electrical behaviour of atoms depends on how completely the various shell and sub-shells are filled.

Atoms that are chemically active have one electron more or one less than a completely filled shell. Atoms that have the outer shell exactly filled are chemically inactive. They are called inert elements. All inert elements are gases and do not combine chemically with other elements.

Metals possess the following characteristics

- They are good electric conductors.
- Electrons in the outer shell and sub-shells can move more easily from one atom to another.
- They carry charge through the material.

The outer shell of the atom is called the valence shell and its electrons are called valence electrons. Because of their greater distance from the nucleus, and because of the partial blocking of the electric field by electrons in the inner shells, the attracting force exerted by nuclues on the valence electrons is less. Therefore, valence electrons can be set free most easily. Whenever a valence electron is removed from its orbit it becomes a free electron. Electricity is commonly defined as the flow of these free electrons through a conductor. Though electrons flow from negative terminal to positive terminal, the conventional current flow is assumed as from positive to negative.

Conductors Insulators and 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.

Earthing and its importance

Objectives : At the end of this lesson you shall be able to
- **describe the necessity of earthing**
- **explain the reasons for system and equipment earthing**
- **describe the shielding**
- **state the power, energy, fuse, circuit breakers and wire colour codes.**

Necessity of earthing

While working in electrical circuits, the most important consideration for an Electrician is the safety factor - safety not only for himself but also for the consumer who uses the electricity.

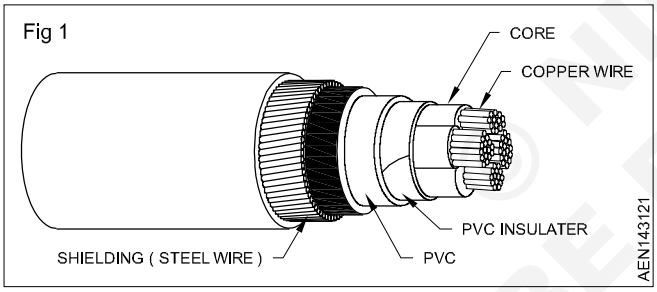
Reasons for earthing

An electric shock is dangerous only when the current through the body exceeds beyond certain milliampere value. In general any current flowing through the body beyond 5 milliamperes is considered dangerous.

Shielding

Shielding is the (Fig 1) protective device layer over the insulated cable. Shielded cable or screened cable is an electrical cable one or more insulated conductors enclosed by a common conductive layer. The shield may be composed of braided strands of copper (or other metal - braided spiral winding of copper tape, or a layer of conducting polymer.

Fig 1



Fuses: Fuses are used to protecting the electrical equipment and circuit against the effect of excessive currents. Fuse has to protect a group of electrical items, it is used between the circuit, it is operative whether the ignition switch is ON or OFF position.

Circuit breakers: Circuit breakers are used in the automotive lighting circuit, the lamp will light and then go out. This giving and indication of a faulty circuit.

Cable colour codes: The automotive wires colour coding system provides to easy tracing the electrical circuits. There are seven main colours used in feed wires in automotive electrical circuit.

Ballast resistor: A ballast resistor is a resistor inserted into a circuit to compensate for different changes or a resister that has the property of increasing in resistance as current decreases. This resistor is used in car engines produced with breaker points type ignition primary circuit, between battery and ignition coil.

Uses

- It act as earth / ground for the electrical appliances.
- It protect the cables from moisture entering as well as flexible.
- It also act as mechanical strength as well as flexible to the cables.
- It protect the cable from all weather condition like water, oil, gases and heat.

Electrical measuring instruments and electrical circuits

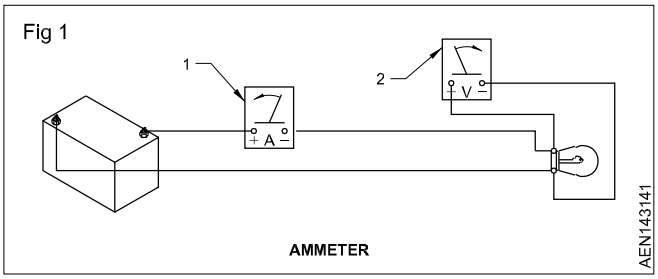
Objectives: At the end of this lesson you shall be able to
- **explain the connection of an ammeter in the circuit**
- **state the use of an ammeter**
- **explain the care to be taken of an ammeter, voltmeters and ohmmeters**
- **explain the connection of a voltmeter**
- **explain the use of a voltmeter**
- **explain the connection of an ohmmeter**
- **state the use of an ohmmeter**
- **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 Fig1



Uses of ammeter

An ammeter is used to measure the amount of current flowing in the circuit.

This is connected in series with the load.

It is used to indicate the rate at which the battery is being charged or discharged.

Care

Do not connect an ammeter in parallel in the circuit.

Take care of "+" and "-" mark on terminals.

Use DC meter for automobile charging system.

Select and use an ammeter as per the required range.

Voltmeter

A voltmeter (2) is used to measure electrical voltage. It is not fitted permanently on the vehicle but used separately whenever required. It is connected in parallel with the circuit. Use DC voltmeter for automobiles.

Uses of a voltmeter

To measure the voltage at any point of circuit.

To measure the voltage drop in the circuit.

To check the condition of the battery.

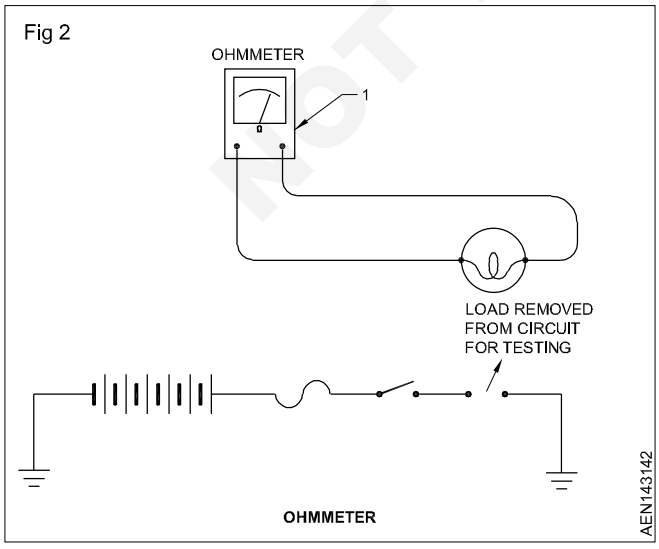
Care

Select the voltmeter as per the required range.

Do not connect the voltmeter in series in the circuit.

Ohmmeter (Fig 2)

An ohmmeter (1) is also known as resistance meter.



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

It has its own built-in power source. Hence the device/ circuit being checked with the ohmmeter should be disconnected from the power supply as shown in the figure, to prevent damage to the ohmmeter.

The unit of resistance is an ohm.

Uses of ohmmeter: An ohmmeter is used:

– to measure the resistance of any conductor

– to measure the resistance of any load

– to check the continuity of the field coils.

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.

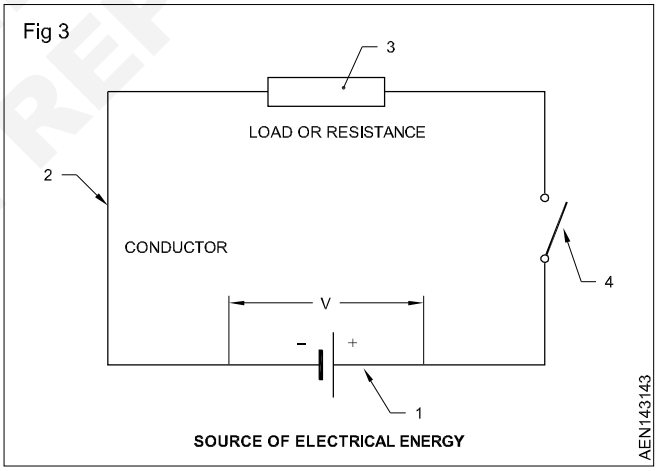
Keep the connections tight while the meters are in use.

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)

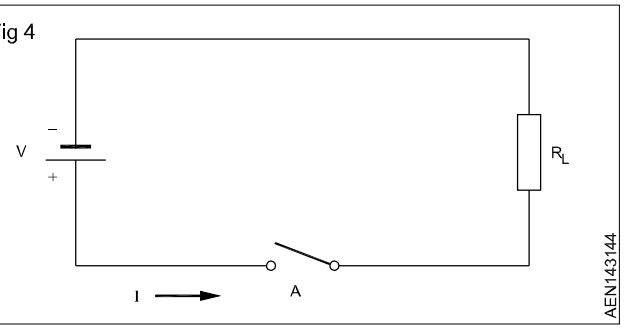
– connecting wires (conductors) (2)

– a load (lamp or motor) (3)

– switch (4).

Open circuit (Fig 4): In an open circuit, an infinite resistance is provided, most of the time by the open switch (A). Therefore no current can flow.

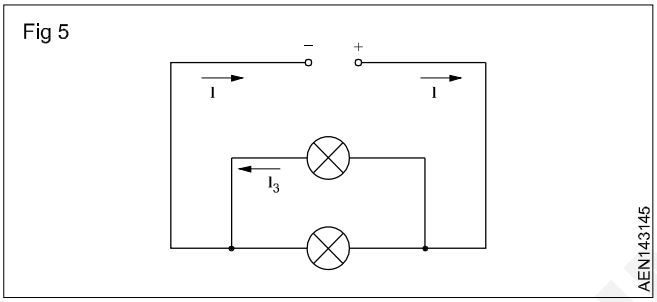
Fig 4



Short circuit: A short circuit will occur when two terminals of the same circuit touch each other. A short circuit may also occur if the insulation between the two cores of the cable are defective. This results in a lower resistance. This causes a large current to flow which can become a hazard.

Parallel circuit (Fig 5): In this circuit two or more loads are connected. Each load is provided with its own path to the source of supply.

Fig 5



Example

A pair of head lights is connected in parallel circuit. When wired in parallel the failure of one bulb will not effect the operation of the other bulb. Each load receives full system voltage.

The formula to calculate resistance in a parallel circuit is:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

where

I = current

R = resultant resistance

R_1, R_2, R_3 = resistance of each load.

Series circuit : This circuit consists of only one load and one source of supply. It has one continuous path for the flow of current. Hence the current flows through all the load in a sequence in circuit. If any of the parts fails the circuit breaks and the current stops flowing. 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 ohm value of resistance it is grouped as low, medium and high resistance.

Low resistance

Range : 1 Ohm and below.

Uses : Armature winding, ammeter.

Medium resistance

Range : Above 1 Ohm up to 1,00,000 Ohm.

Uses : Bulbs, heaters, relay starters.

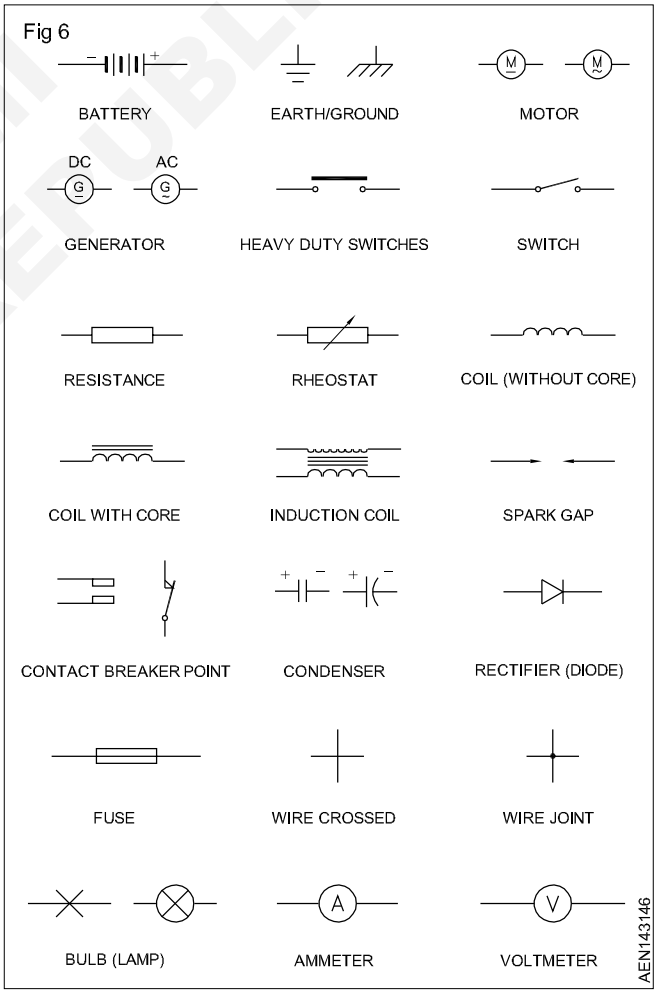
High resistance

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

Use : Lamps.

Electrical symbols used in a wiring diagram (Fig 6): Automotive circuits are generally shown by wiring diagrams. The parts in those diagrams are represented by symbols. Symbols are codes or signs that have been adopted by various automobile manufacturers as a convention.

Fig 6



Multimeter

Objectives : At the end of this lesson you shall be able to
- **state the function of multimeter controls**
- **explain about the dial (scale) of the multimeter**
- **explain about zero adjustment during ohmmeter function**
- **state the function of digital multimeter**
- **state the application of the multimeter**
- **state the precautions to be followed while using a multimeter.**

A multimeter is an instrument in which the functions of an ammeter, voltmeter and ohmmeter are incorporated for measurement of current, voltage and resistance respectively. Some manufacturers call this a VOM meter as this meter is used as volt, ohm and milli ammeter, Multimeters use the basic d' Arsonval (PMMC) movement for all these measurements. This meter has facilities through various switches to change the internal circuit to convert the meter as voltmeter, ammeter or ohmmeter.

There are two major types of multimeters

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.

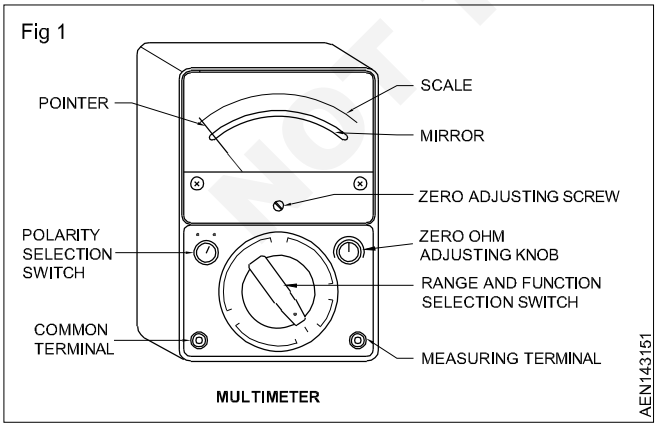
There are several types of multimeters available in the market, manufactured by various manufactures. Each model differs from the others by the extra facilities available. It is a versatile tool for all automobile. With proper usage and care, it could give service for many years.

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

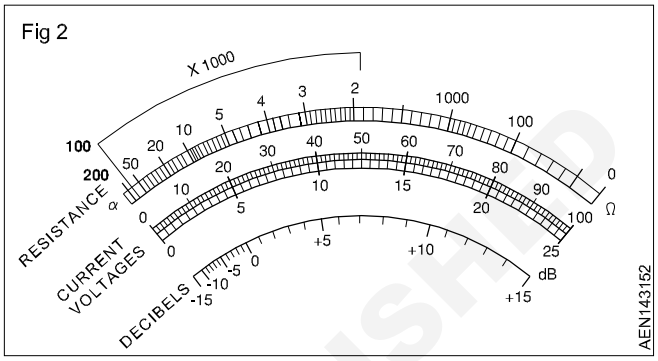
Scale of multimeter

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.

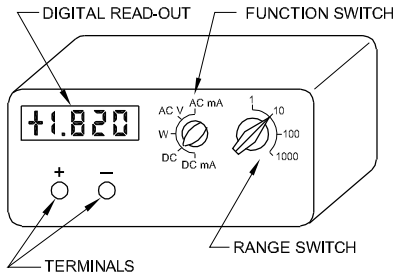
Digital multimeter (DMM)

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

AEN143153

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.**

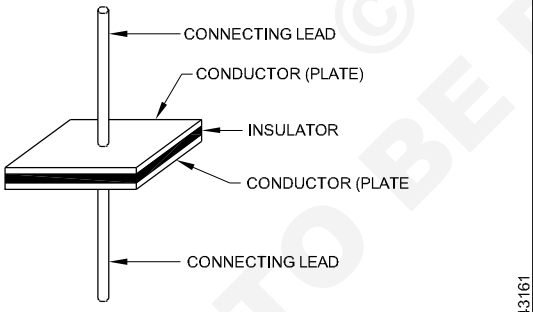
Capacitors

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

AEN143161

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'.

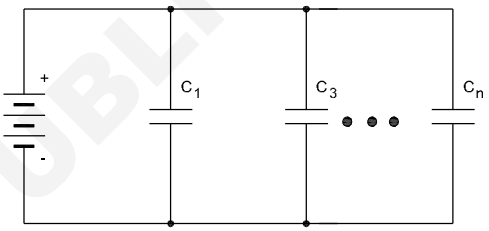
Capacitance

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).

Fig 2



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A farad is the unit of capacitance (C), and a coulomb is the unit of charge(Q), and a volt is the unit of voltage(V).

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.

Series Capacitors

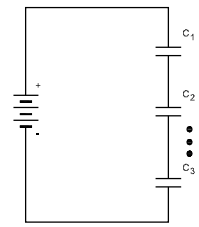
Capacitors connected in series will have a lower total capacitance than any single one in the circuit.

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

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.

Fig 3



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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.**

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): This battery is an electrochemical device for converting electrical energy into chemical energy and vice versa. The main purpose of the battery is to store electrical energy in the form of chemical energy. It provides supply of current for operating various electrical accessories, when the engine is not running. When the engine is running it gets electric supply from the dynamo/alternator. It is also known as accumulator and storage battery.

Fig 1

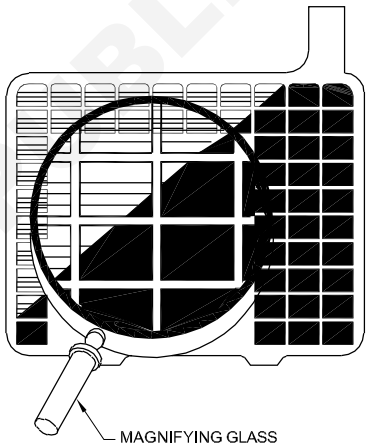

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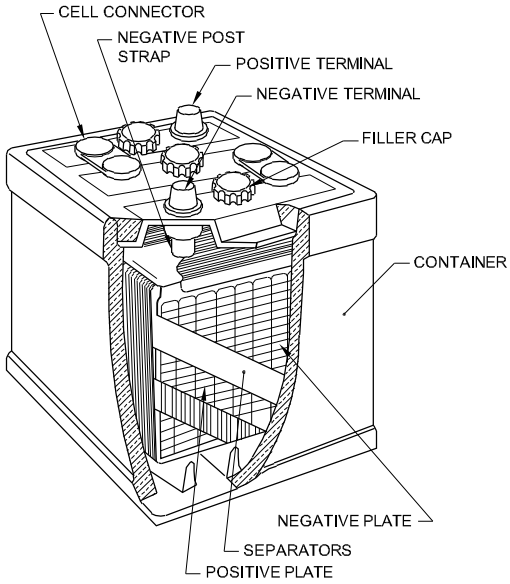
Fig 2



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Construction: The automobile battery's plates are rectangular. They are made of lead. Antimony alloy is used to provide them strength.

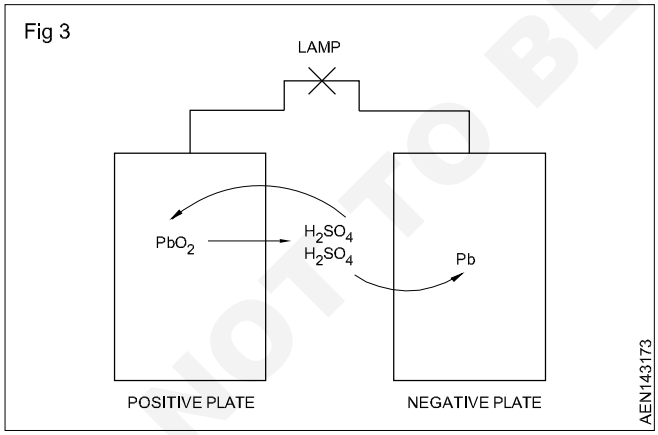
The group of plates, which are connected to the positive terminal of the cell, consists of grids filled with a paste of lead peroxide. This lead is brown in colour. The group of plates, which are connected to the negative terminal of the cell, consists of grids filled with metallic lead which is spongy 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.

Fig 3



PbO_2 + $2H_2SO_4$ + Pb $\quad$ $PbSO_4$ + $2H_2O$ + $PbsO_4$

(+ve) (electrolyte) (-ve) $\quad$ (+ve) (water) (-ve)

Charging (Fig 4)

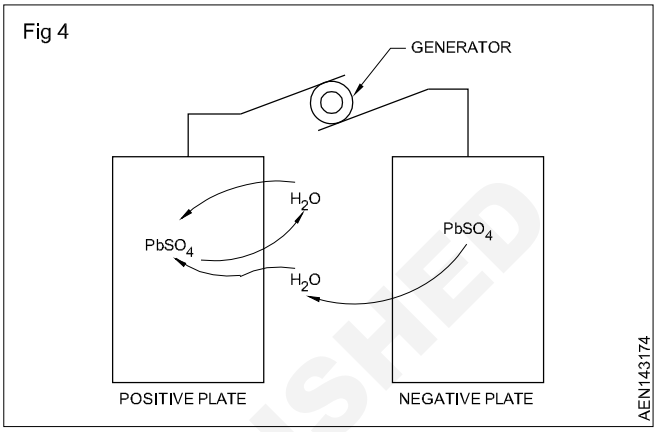
When the battery is charged by passing current through a dynamo or charger in the opposite direction, the reverse chemical reaction takes place. The lead sulphate on one plate becomes lead peroxide (+ve plate). The lead sulphate on the other plate (-ve plate) becomes spongy lead and the electrolyte becomes more concentrated because of the increased amount of sulphuric acid.

$PbSO_4$ + $2H_2O$ + $PbSO_4$ $\quad$ PbO_2 + $2H_2SO4$ + Pb

(+ve) (water) (-ve) $\quad$ (+ve) (Electrolyte) (-ve)

Maintenance of battery: Batteries are expensive items to replace. They should be serviced regularly as recommended by the manufacturer. If maintained properly, they can be used for longer periods. The following aspects are to be checked to maintain the battery in good condition.

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.

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.

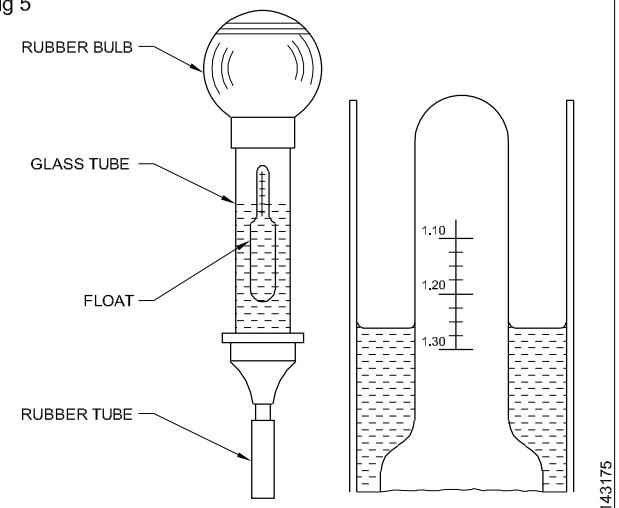
While charging do not overcharge the battery.

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

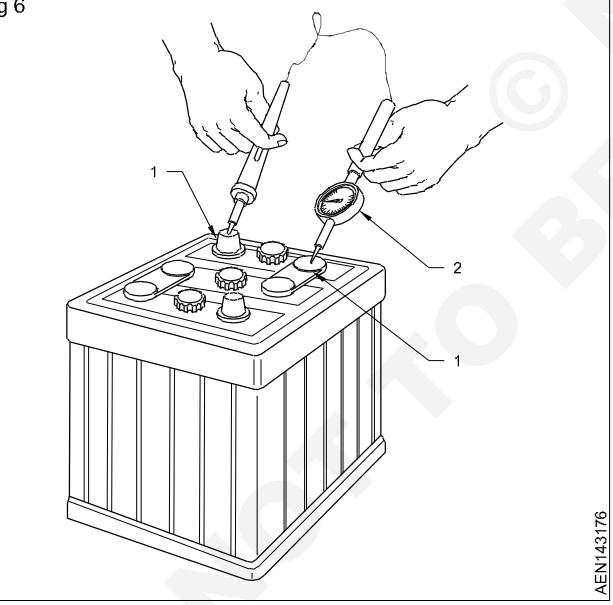
Fig 5



HYDROMETER

Battery selection (Fig 6) : Most cars in current production are equipped with a 12V battery. When a manufacturer installs a battery in a new car that battery is chosen to meet the requirements of that particular car. Prime importance is the battery's ability to crank and start the engine. The current required to crank on engine can range from 150A to over 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.

Fig 6



The lead acid batteries are made for different vehicle application to suit the electrical demands, while the voltage of the battery remains same for all application, the ampere-hour rate changes as per demand.

The following examples reveal the 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.

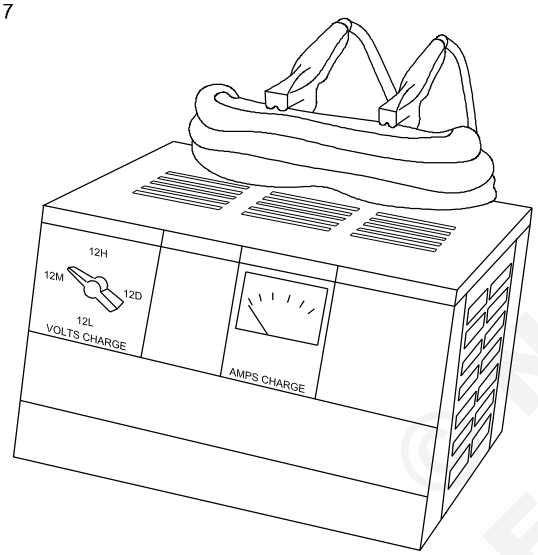
2 Violent gassing or spewing of electrolyte occurs.

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.

Fig 7



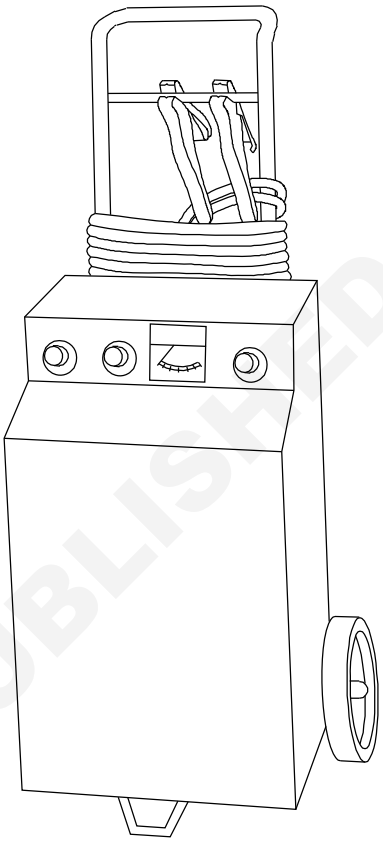
A TYPICAL SLOW CHARGER

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.

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

Benefits

- Saving of 100 litres of distilled water through out its life time as compared to convention batteries.
- Saving of man power for regular topping up & cleaning corroded terminals as in conventional batteries.
- No damage of flooring by spoilage of batteries acid or water during maintenance.
- No need of separate battery room.

Electricity effects

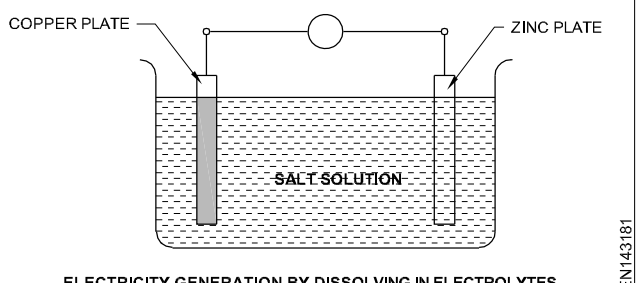
Objectives: At the end of this lesson you shall be able to
- **state electro chemical process**
- **state the effect of an electric currents.**
- **state thermo couple**
- **state thermo electric energy**
- **state piezo electric energy.**

Chemical sources (Electro chemical process) (Fig 1)
If two electrically conducting materials (metals) are immersed in salt solutions, an electric charge is produced between the two metals (electrodes, poles). Two examples are given below.

1 Copper and Zinc in salt solution is one combination

2 Lead and sulphuric acid is another combination.

Fig 1



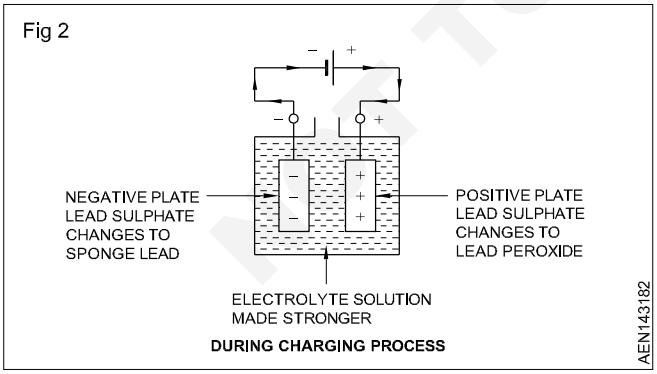
ELECTRICITY GENERATION BY DISSOLVING IN ELECTROLYTES

This arrangement is known as wet cell and gives direct current. The second combination is used in a Lead Acid Battery for Motor vehicles.

Dynamic electricity (Fig 2)

The current is produced by A/C or D/C generators, by conversion of mechanical energy into electrical energy. The generation of electric current is based on the fact when a conductor is moved in a magnetic field an E.M.F is set up in the conductor. When a large number of conductors are moved in a powerful magnetic field, high voltages and current are produced. This is the Principle of Dynamo.

Fig 2



DURING CHARGING PROCESS

The effect of an electric current

Let us now study effects of an electric current. When an electric current flows through a circuit, its presence could be analysed by its effects. They are stated below.

This can be seen by connecting a “Galvanometer”. The current, will flow only when the bar magnet is moving actually. Because, the turns of coil of wire should cut the lines of force.

Shock effect

If the current flow through Human body, it may give a severe stock or cause even death of the individuals so everyone must be careful in dealing with electrical current during work.

Note

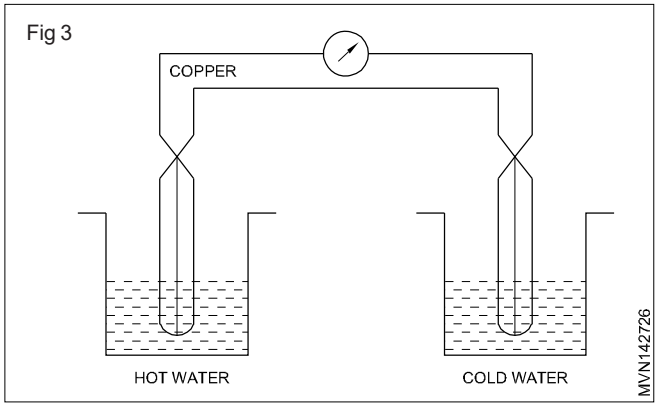
In motor vehicle trade application, the following effect electric current are widely used

- Chemical effect-for battery.
- Heating effect-Head lamp bulbs for lighting.
- Magnetic effect-Electro magnets in relays and cuts.

Thermocouple (Fig 3)

This is such an arrangement where circuit is closed by wires of different metals. One metal wire is kept at low temperature and the other at high temperature. In this way thermo-electro motive force is created which can be seen by galvanometer. This works on the effect of see back.

Fig 3



Solenoid and 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 and 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.

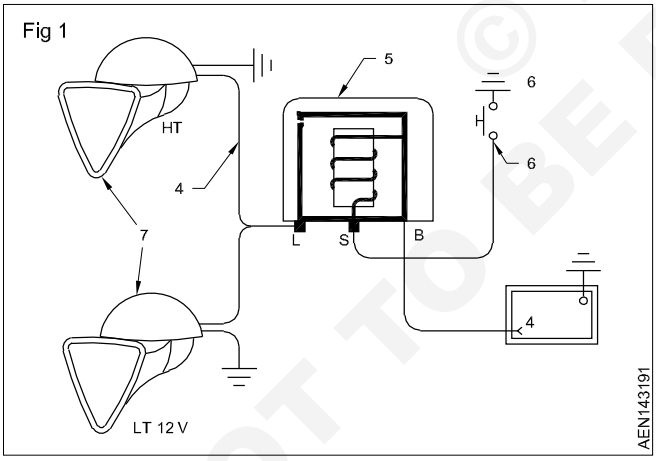
Classification of relays

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.

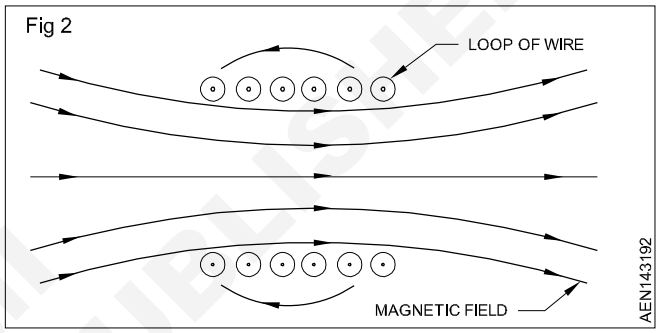
Current sensing relay: A current sensing relay functions whenever the current the coil reaches an upper limit. The difference between the current specified for pick up (must operate) and non - pick up (must non operate) is usually closely controlled. The difference in current may also be closely controlled 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 metalic core, which produces a uniform magnetic field in a volume of space. (Fig 2)

Fig 2

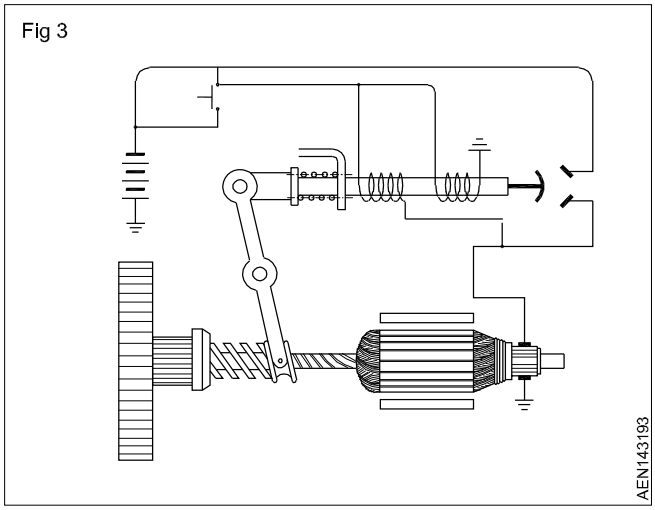


Application

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.

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.

Fig 3



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.

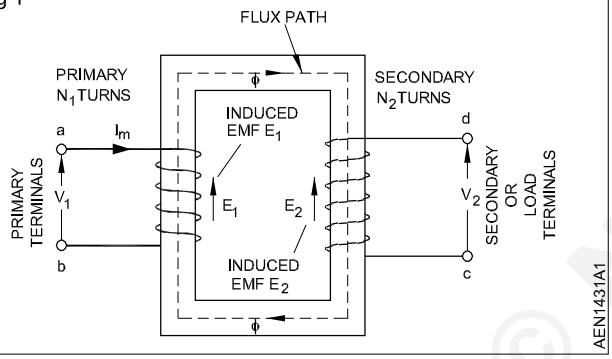
Transformers and alternators

Objectives: At the end of this lesson you shall be able to
- **describe a two winding transformer**
- **explain the ignition coil as a step up transformer**
- **state the function of a transformer**
- **describe a function of a alternator and its parts.**

Two- winding transformers

A transformer in its simplest form consists of two stationary coils coupled by a mutual magnetic flux (Fig 1). The coils are said to be mutually coupled because they link a common flux.

Fig 1



Laminated steel core transformers are used in power applications. As shown in Fig 1, the current flowing in the coil connected to the AC source is called the primary winding or simply primary. The primary is the input to a transformer. It sets up the flux in the core, which varies periodically both in magnitude and direction. The flux links the second coil, called the secondary winding or simply the secondary.

The flux is changing; therefore, it induces a voltage in the secondary by electromagnetic induction. Thus the primary receives its power from the source while the secondary supplies this power to the load. This action is known as transformer action. There is no electrical connection between these two coils.

Transformers are efficient and reliable devices used mainly to change voltage levels. Transformers are efficient because the rotational losses are absent; so little power is lost when transforming power from one voltage level to another. Typical efficiencies are in the range of 92 to 99%. The higher values apply to the large power transformers. There is no change in frequency of voltage.

Transformer

A transformer is an electrical device that transforms the AC voltage between two circuit through an electromagnetic induction.

A transformer may be used as a safe and efficient voltage convertor to change the AC/DC voltage and its to a higher / lower voltage its output without changing the frequency and power.

Types

1 Step up transformer 2 Step down transformer

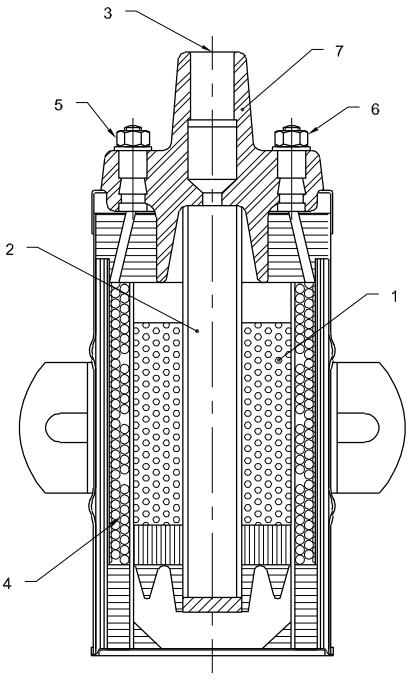
Application

Transformer is used in (1) ignition coil in petrol engine ignition system.

Ignition coil (Fig 2)

It is used to step up low voltage to high voltage to generate sparks. In 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. 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

Fig 2



to the external terminal (5,6) of coil. The bakelite cap (7) insulates the secondary terminal from the container and primary terminals.

Alternator: Alternators are used in cars trucks tractors and two wheelers.

Alternators has two main functions

1 To charge the battery.

2 To supply current to the vehicle while it is running.

Description

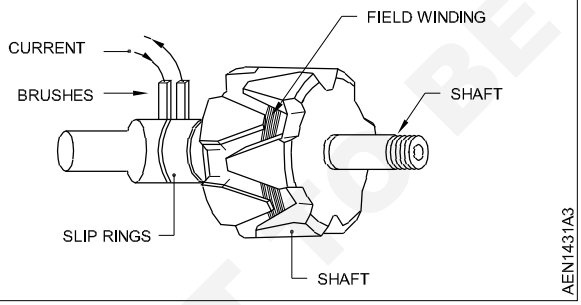
The alternator is a 3 phase machine of the revolving field and stationary armature type. Its output from the stator windings is rectified by means of built in silicon diodes in heat sinks mounted within the slip diodes in heat sinks mounted within the slip ring end shield. Output control is effected by varying the rotor excitation. The machine is self limiting in terms of output current. Cooling is provided by a radial fan mounted on the drive end of the rotor shaft. The standard machine is insulated return version. The regulator is housed in the alternator itself.

Terminal arrangement: The alternator has three terminals i.e. positive terminal, negative terminal and warning lamp terminal 'WL'.

Rectifier: The rectifier pack comprises of nine silicon diodes, six main output diodes and three field diodes .

Rotor: Forged claw or pressed claw rotors are used. A pair of four fingered claws envelope the field shaft from the 8 pole imbricated rotor. The ends of the windings are brought out an connected to two slip rings at the end of the rotor assembly. The rotor is supported by bearings housed on the two end brackets (Fig 3).

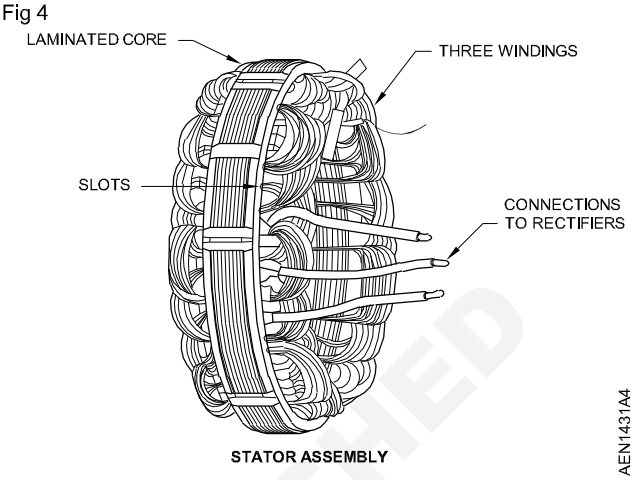
Fig 3



Stator

The stator assembly comprises of a pack of laminations housing a three phase winding in the slots. The stator is held in position by the Drive End (DE) and Slip Ring End (SRE) shields (Fig 4).

Fig 4



In-built regulator: This is a fully transistorised device with no moving parts, requiring no service attention. The transistors, diodes and resistors are fixed on a printed circuit base and then encapsulated.

No cutout relay is necessary as the diodes in the alternator prevent reverse currents from the battery flowing through the stator when the machine is stationary or when generating less than the battery voltage.

As the alternator is self limiting in current output, the regulator has only to control voltage which it does by regulating the alternator field current.

The regulator is housed in then alternator in between SRE shield and cowl by means of three studs.

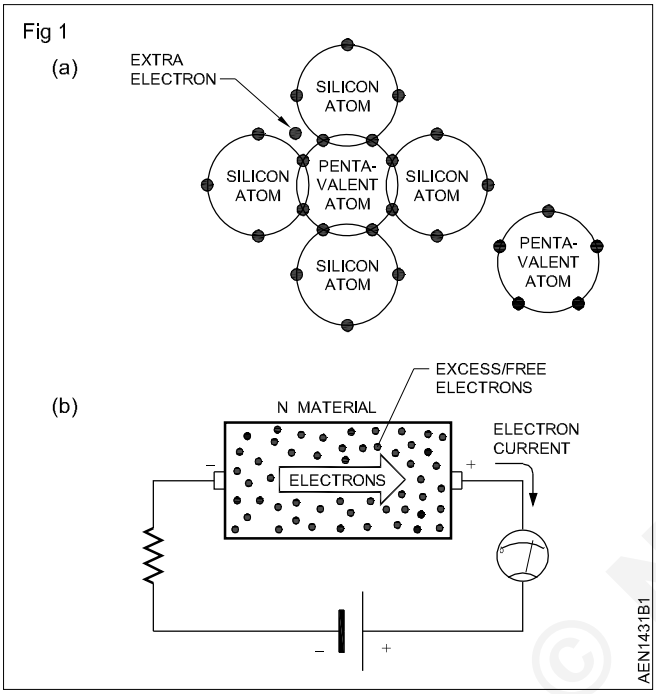
Diodes

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.

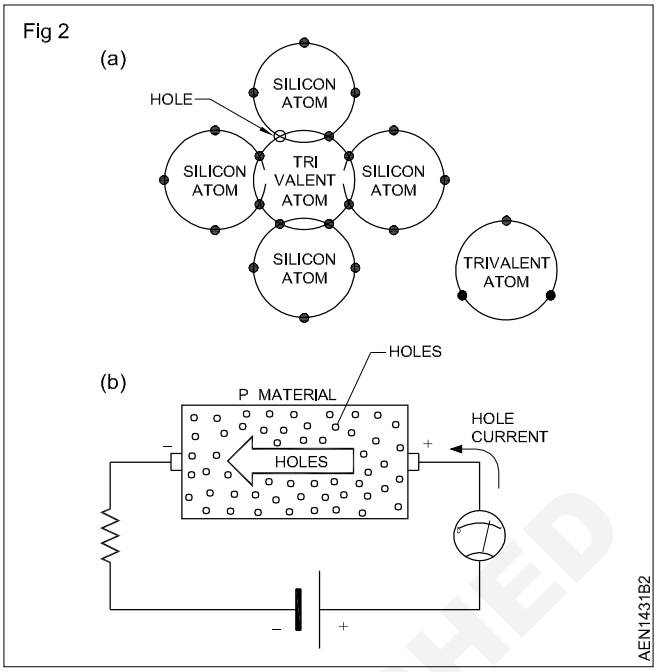


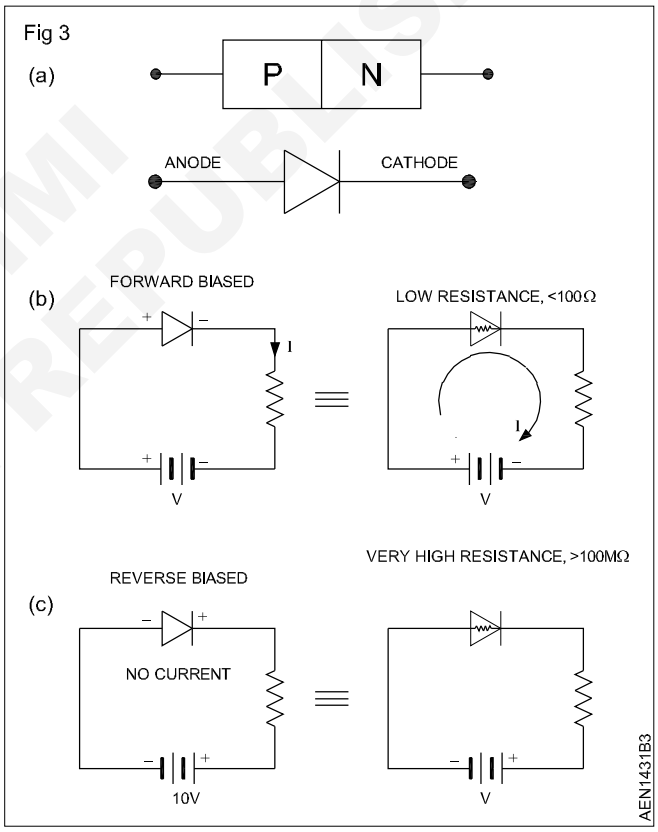
2 **P-type semiconductors:** When a trivalent material like Gallium(Ga) is added to a pure Germanium or pure Silicon crystal, one vacancy or deficit of electron results per bond as shown in Fig 2a. As every gallium atom creates one deficit of electron or hole, the material is ready to accept electrons 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.

P-N junction

When a P-type and a N-type semiconductors are joined, a contact surface between the two materials called PN-junction is formed. This junction has a unique characteristic. This junction, has the ability to pass current in one direction and stop current flow in the other direction. To make use of this unique property of the PN junction, two terminals one on the P side and the other on the N side are attached. Such a PN junction with terminals attached is called a **Diode.** The typical symbol of a PN-junction diode is shown in Fig 3a.





Types of diodes: The PN junction diodes discussed so far are commonly referred to as *rectifier diodes.* This is because these diodes are used mostly in the application of rectifying AC to DC.

Classification of Diodes

1 **Based on their current carrying capacity/power handling capacity, diodes can be classified as**

– **low power diodes**

can handle power of the order of several milliwatts only

– **medium power diodes**

can handle power of the order of several watts only

– **high power diodes**

can handle power of the order of several 100's of watts.

2 Based on their principal application, diodes can be classified as,

– **Signal diodes**

low power diodes used in communication circuits such as radio receivers etc. for signal detection and mixing

– **Switching diodes**

low power diodes used in switching circuits such as digital electronics etc. for fast switching ON/OFF of circuits

– **Rectifier diodes**

medium to high power used in power supplies for electronic circuits for converting AC voltage to DC.

Polarity marking on the diodes: The cathode end of a diode is usually marked by a circular band or by a dot or by plus (+) sign. In some diodes the symbol of the diode, which itself indicates the polarities, is printed on the body of the diode.

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

Hence, instead of printing its specifications on its body, all diodes will have a type number printed on their body. This type number carries a set of specifications which can be found out by referring to a diode data manual. Diode data manuals give data of several thousands of diodes from different manufacturers. Some of the popular type numbers of diodes are

OAxx,	xx - from 70 to 95.	examples: OA79, OA85 etc.,
BYxxx,	xxx- from 100 onwards,	examples: BY127, BY128 etc.
DRxxx,	xxx- from 25 onwards.	examples: DR25, DR150 etc.,
1Nxxxx	examples: 1N917	1N4001, 1N4007 etc.

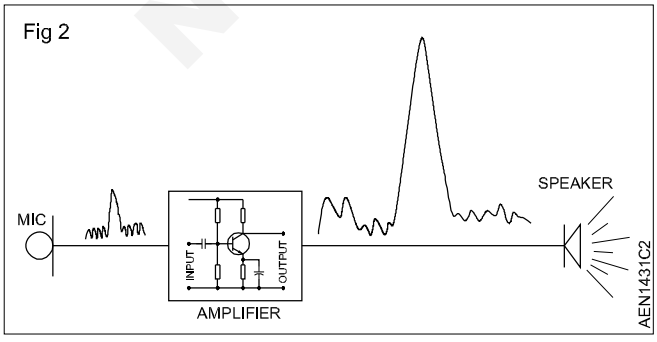
Transistors and classification

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

Introduction to Transistors

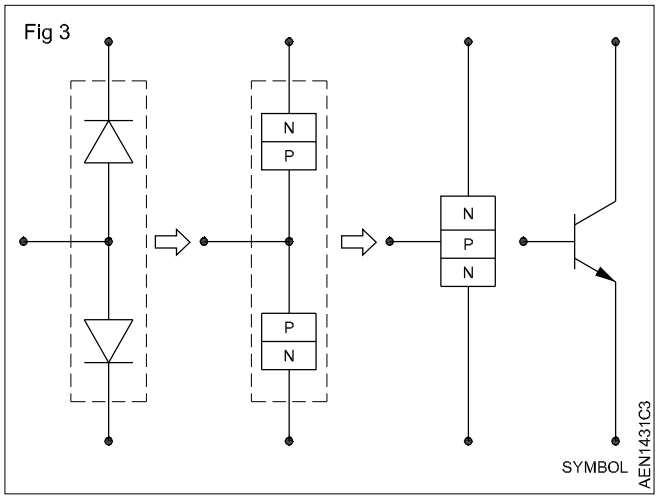
Transistors are the semiconductor devices having three or four leads/terminals. Fig 1a shows some typical transistors. Fig 1b shows the symbols used for different types of transistors.

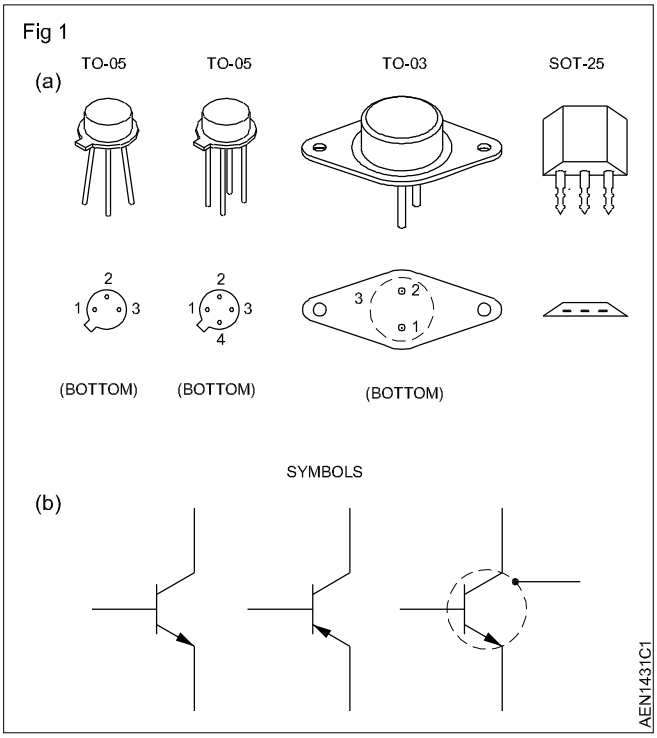
Transistors are mainly used for enlarging or amplifying small electric/electronic signals as shown in Fig 2. The circuit which uses transistors for amplifying is known as a transistor amplifier.



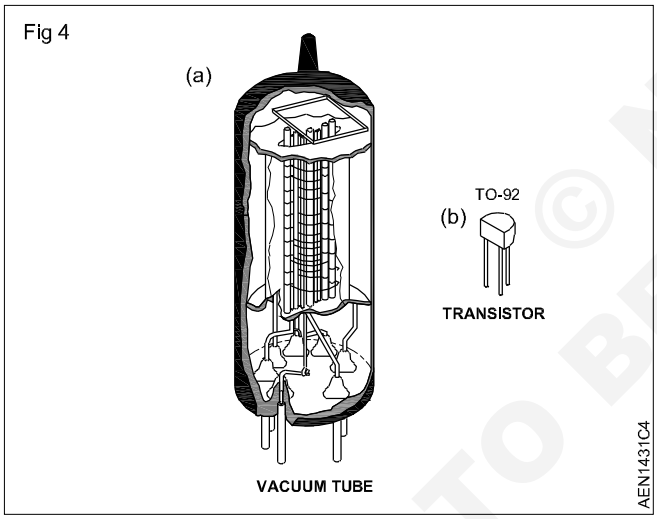
Other important application of transistors is its use as a solid state switch. A solid state switch is nothing but a switch which does not involve any physical ON/OFF contacts for switching.

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.

Classification of Transistors

1 Based on the semiconductor used.

– Germanium transistors

– Silicon transistors

Like in diodes, transistors can be made, using any one of the above two important semiconductors. However, most of the transistors are made using silicon. This is because, silicon transistors work better over a wide temperature range (higher thermal stability) compared to germanium transistors.

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

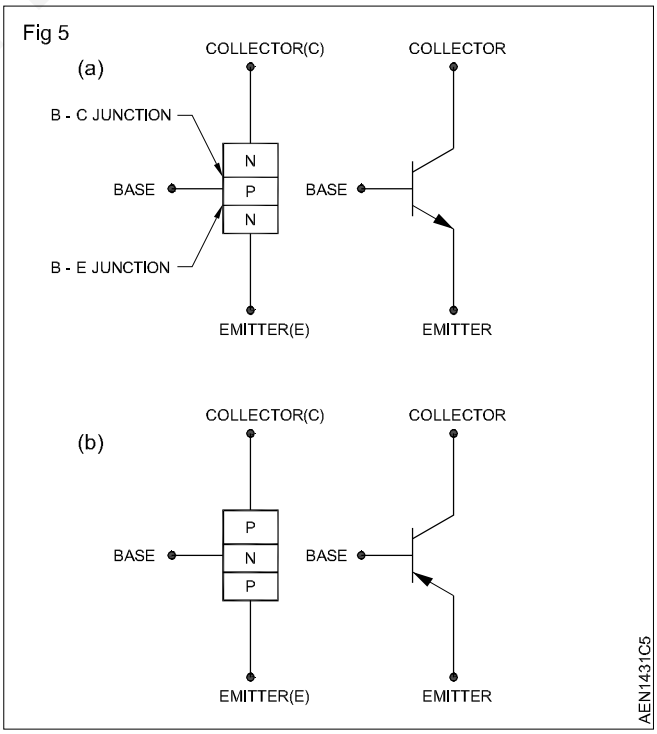
2 Based on the way the P and N junctions are organized as shown in Fig 5.

– NPN transistors

– PNP transistors

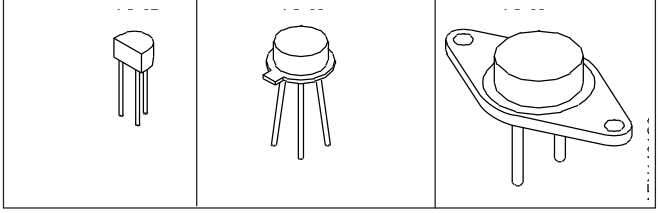
Both NPN and PNP transistors are equally useful in electronic circuits. However, NPN transistors are preferred for the reason that NPN has higher switching speed compared to PNP.

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



3 Based on the power handling capacity of transistors as shown in Table below (Fig 6)

Low power transistors, also known as small signal amplifiers, are generally used at the first stage of amplification in which the strength of the signal to be amplified is low. For example, to amplify signals from a microphone, tape head, transducers etc.,

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

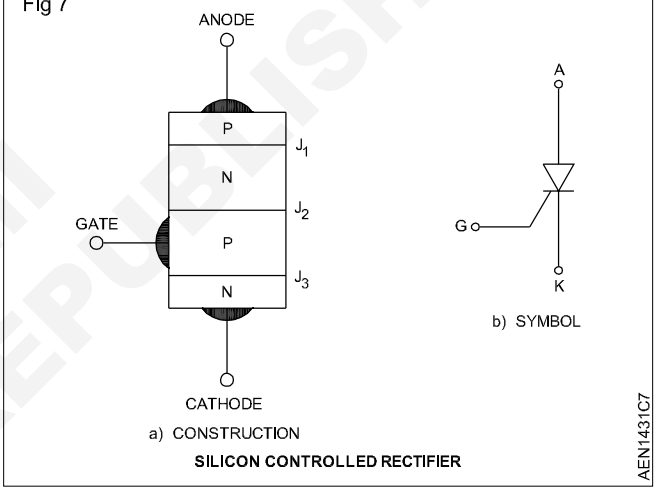
This is the avalanche breakdown. Since the other junctions J_1 and J_3 are forward-biased, there will be free carrier movement across all the three junctions, resulting in a large anode-to-cathode forward current I_F. The voltage drop V_F across the device will be the ohmic drop in the four layers, and the device is then said to be in the conduction state or on-state.

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.

Fig 7



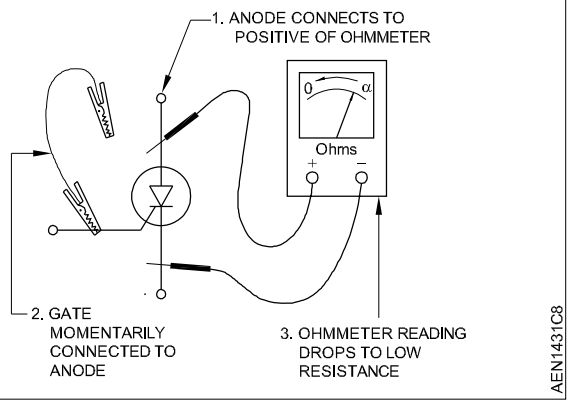
Set the multimeter to a low range. Adjust to zero and infinity with the adjustment knob. Connect the SCR as shown in Fig 8. The meter will not indicate any reading. Even the test prods are interchanged because of the junctions. The multimeter shows infinite resistance. Connect the SCR as shown in Fig 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 40ohm.

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.

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.

Fig 8

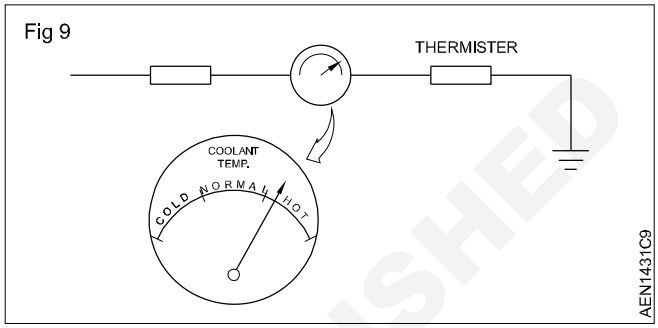


Thermistors are used to detect various temperatures or changes in temperature. Their most frequent use involves the measurement of engine coolant temperature, or inlet air temperature.

In the most common type of thermistor, the resistance decreases as the temperature increases. This type is called a negative temperature coefficient (NTC) thermistor. Some thermistors are of the positive temperature coefficient (PTC) type. This means that the resistance of the thermistor increases with temperature. NTC type thermistors are used in automobiles as engine coolant temperature sensors as shown in Fig 9.

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.

Fig 9



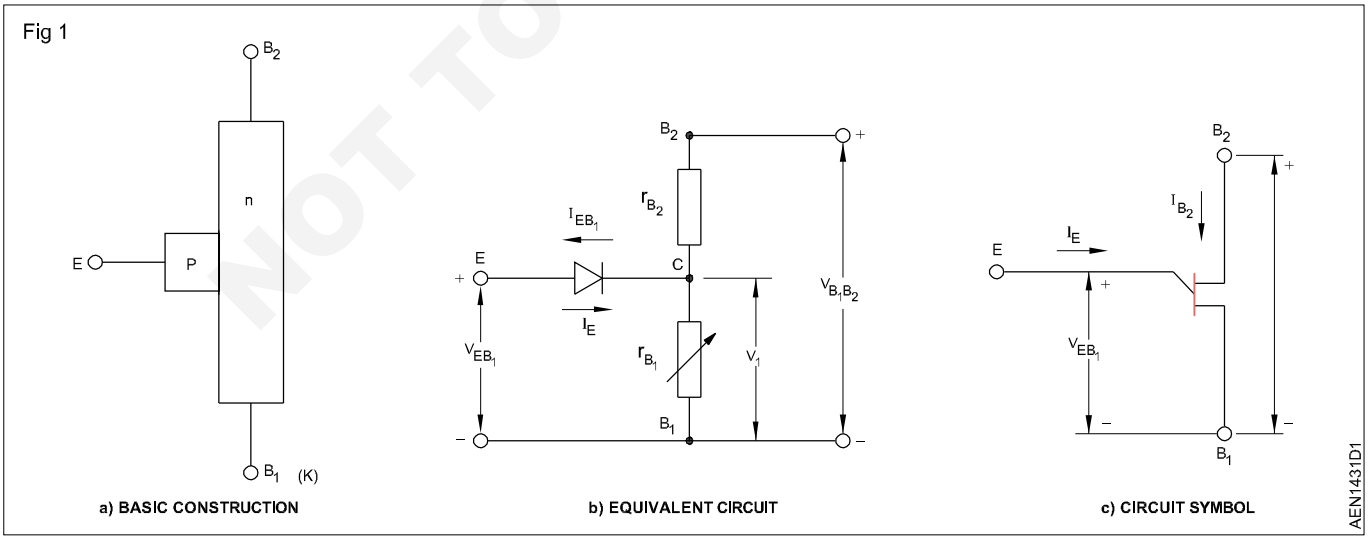
Uni-Junction Transistor (UJT)

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



Metal Oxide Semiconductor Field Effect Transistor (MOSFET)

Objectives: At the end of the lesson you shall be able to
- **state the MOSFET's operation principle and its types**
- **list the special type of MOSFET**
- **explain the features of MOSFET.**

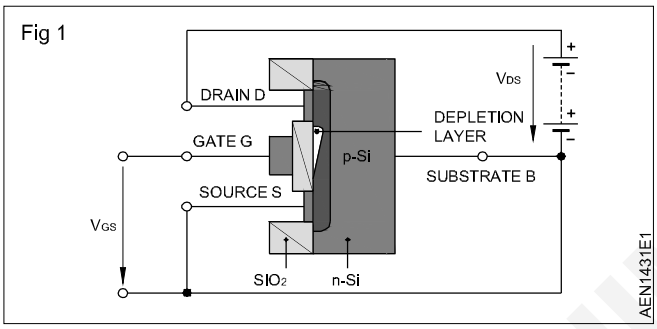
In MOSFETs, control is via an insulating layer instead of a junction (as in JFETS). This insulating layer is generally made of silicon dioxide, from which the very name MOSFET is derived(Metal Oxide Semiconductor). Some times the MOSFETs are also referred to as Insulated-gate FET, for which the abbreviation used are IFET or IGFET.

Type of MOSFET

Depletion-type MOSFET

Construction and mode of operation

Fig 1 shows the construction of a depletion MOSFET of the n-channel type.



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.

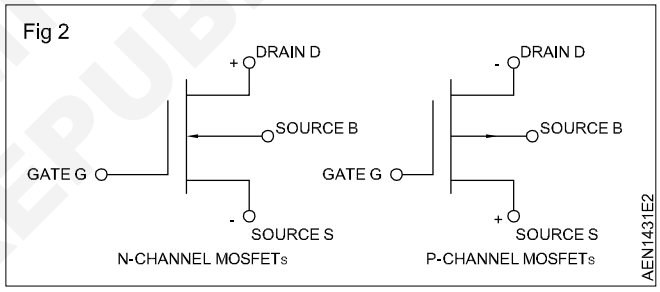
If a voltage U_{DS} is applied between source and drain, at U_{GS} =)V an electron current flows from the source electrode via the n-channel to the drain electrode. If, however, a negative voltage is applied to control electrode G, the electrons present in the n-channel are forced out of the vicinity 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 substrateforms 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.

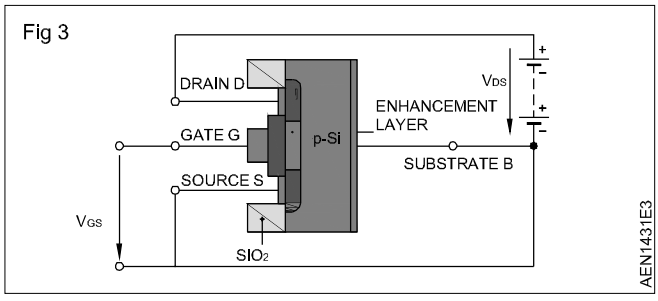
Fig 2 Shows the circuit symbols for depletion- type n-channel MOSFETs and p-channel MOSFETs. For the n-channel type, the arrow points towards the line representing the channel, in the case of the P-Channel type, on the other hand, it points away from the line representing the channel. The continuous 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.

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.

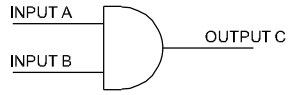


Basic logic gates

Objectives: At the end of this lesson you shall be able to
- **describe the AND, OR, NOT & NAND gate and their applications with simple digital circuits.**

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

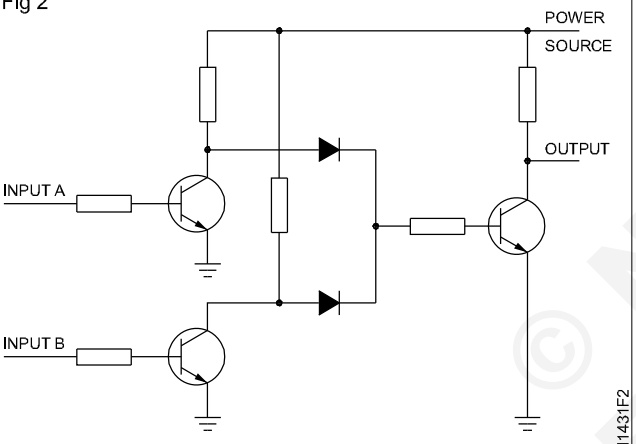
Fig 1



The "AND" Gate:

Logic circuits are usually indicated by a special symbol. Such a circuit, however is actually composed of semiconductor elements as shown in (Fig 2).

Fig 2

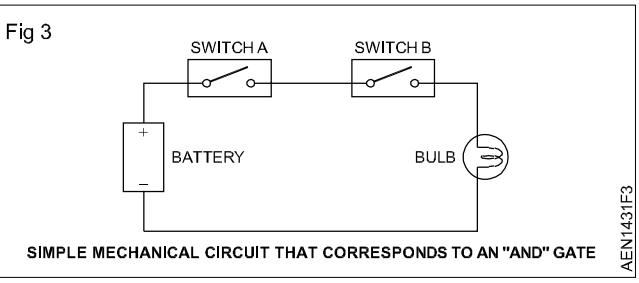


SEMICONDUCTOR CIRCUIT THAT CORRESPONDS TO AN "AND" GATE

To make an AND gate easily understand, a simple mechanical circuit without the use of semiconductors is shown in (Fig 3). In this circuit the switches A and B are equivalent to (C). The light bulb lights only if both switches A and B are closed. If either switch is open, the bulb will (or it both are open), not come on.

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



SIMPLE MECHANICAL CIRCUIT THAT CORRESPONDS TO AN "AND" GATE

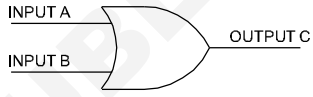
AND - gate truth table		
Inputs		Output
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

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



THE "OR" GATE

Fig 5

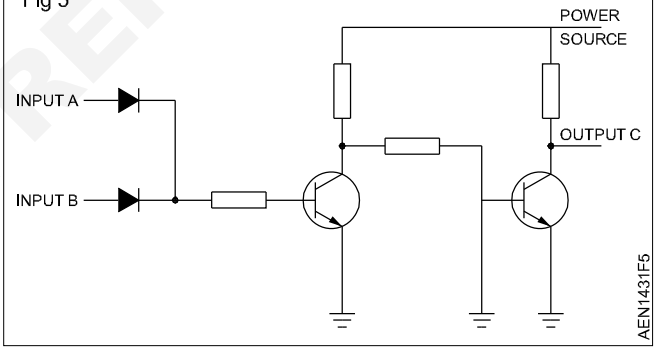
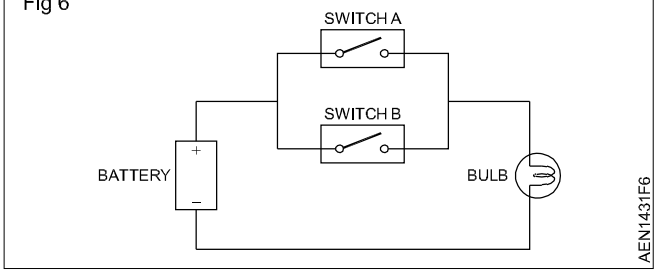


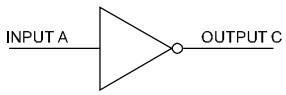
Fig 6



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



"NOT" GATE

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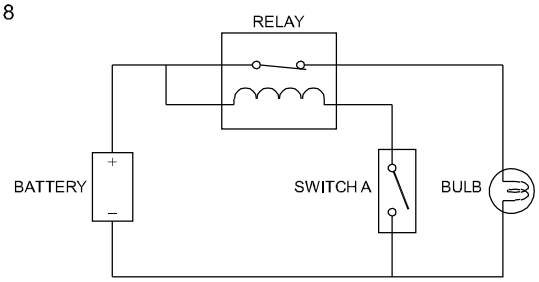
Fig 8



SIMPLE MECHANICAL CIRCUIT THAT CORRESPONDS TO "NOT" GATE

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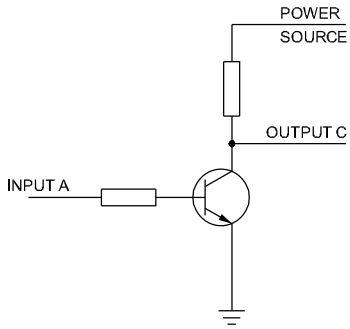
As can be seen in the truth table, the “NOT” gate inverts the signal so that the output is always the opposite of the input. For this reason it is called as “inverter”. (Fig 9)

Fig 9



SEMICONDUCTOR CIRCUIT THAT CORRESPONDS TO "NOT" GATE

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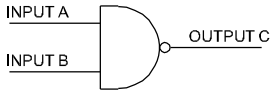
“NAND” is a combination of “AND” gate and a “NOT” gate as shown in (Fig 10).

Fig 10



"NAND" GATE

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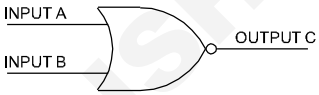
A zero will appear at the output terminal (C) only if there is a voltage at both input terminals (A and B). If there is a zero at either A or B, an “on” signal (number 1) will appear at C.

This can be observed in Truth Table as shown.

A “NOR” gate is a combination of an “OR” gate and a NOT gate (Fig 11). For this reason, an “on” signal will appear at the output terminal only if there is an “off” signal (zero) at both input terminals. If there is an “on” signal at either A or B, terminal C will zero as shown in the truth table.

Fig 11



"NOR" GATE

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Recent trends and developments

Objectives: At the end of this lesson you shall be able to
- **state the history of auto industry**
- **state the leading manufacturers**
- **state the automobile industry, new product.**

Auto industry - History, leading manufacturing

In 1887 first car rolled out in the streets of Calcutta the next year there were four cars in the street of Bombay.

1940 Indian company like Hindustan motors and premier started to manufacture car of other firm, the same decade started Mahindra and Mahindra also started utility vehicle.

1980 Hindustan Motors ambassador and premier were challenged by a new entrant, maruti udyog limited.

The alliance between maruti and Suzuki was first joint venture between an Indian company.

2000-2010, almost every major car company establishing manufacturing facilities across different parts of the country.

Chennai, Mumbai, pune, north NCR are majority of Indian car industry

Top and major manufactures in Automobile industry

- Maruti udyog
- General motors' India
- Ford India
- Eicher motors
- Bajaj Auto
- Daewoo motors India
- Hero motors
- Hindustan motors
- Hyundai Motor India.
- Royal Enfield motors
- Telco
- Swaraj mazda
- BMW

The pioneer Mr. J.R.D. Tata's role in setting up the Tata group (ERC).

In India maruti 800, Car launched by SMT, Indira Gandhi - In 1983.

India in the largest three wheeler and two wheeler market in the world and second largest tractor manufacture in the world , fifth largest commercial vehicle manufacture in the world and second largest producer of motorcycle in the world after china.

In India some Industries are manufacturing the vehicle spare parts and exporting them to other countries.

Example: TATA, Hindustan Motor and ashok leyland etc.

In India some vehicle parts are importing and assembling in the plants

Example: Ford, Hyundai, Audi etc.

Development in automobile industry

Due to the recent developments in electronics and computers lots of changes have come in the automobile also a mini computer named (ECM) electronic control module takes the control of Engine control, transmission control, Brake and steering system controls, Safety controls, and suspension control system.

More number of sensors and transducers are employed in all systems to send information to their corresponding electronic control units to achieve precise control on all activities.

Due to this precise controls we could achieve,

Fuel efficient engines, clean emission engine, Easy steering, and anti locking brakes, keyless entry, Navigation and smart dash board etc.

Gasoline Direct Injection (GDI)

Fuel is injected directly into the cylinders, not mixed with air in the inlet manifold or inlet ports before being drawn into the cylinders. The advantages of direct injection are that the fuel can be placed in the combustion space in a more controlled manner than the conventional inlet injection system.

Hybrid vehicles

Hybrid vehicle that combines a conventional internal combustion engine with an electric propulsion system (hybrid vehicle drive train). The presence of the electric power train is intended to achieve either better fuel economy than a conventional vehicle or better performance.

Electric vehicle (EV)

India has plans to make a major shift to electric vehicles by 2030.E-commerce companies, Indian car manufactures like Rava Electric Car Company (RECC), and Indian app-based transportation network companies like Ola are working on making electric cars in the near future.

The electric cars available in India are:

Mahindra e2oplus

Mahindra e-Verito.

Tata Tiger Electric

Mahindra e-KUV 100

Tata Tiago Electric.

Fuel cells: The fuel cell as used in space-craft, reverses this reaction combining hydrogen and Oxygen to release electrical energy with pure water as a byproduct.

The attraction of using in an internal combustion engine, is that the fuel cell is very efficient indeed, achieving 45 to 60% efficiency versus petrol engine 15 to 35%.

A danger involved in fuel cell is the hydrogen is an explosive gas that is difficult to store and handle.

Lean burn engines: This engine are designed for Lean-burning, They have higher compression ratios and thus provide better performance, efficient fuel usage and low exhaust hydrocarbon emissions compare with the conventional gasoline engines. Lean mixtures with very high air-fuel ratios can only be achieved by direct injection engines.

Driverless cars: This is a vehicle that is capable of sensing its environment and navigating without human input.

Driverless cars combine a variety of techniques to perceive their surroundings, including radar, laser light, GPS and computer vision. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage.

The potential benefits of driverless cars include reduced mobility costs and infrastructure costs, increased safety, increased mobility, increased customer satisfaction, and reduced crime. And also potentially significant reduction in traffic collisions, resulting injuries and related costs, including less need for insurance.

Waymo is a self-driving technology development company and it is a subsidized by Google.

Alternate fuel

Bio fuels are also considered a renewable source. Although renewable energy is used mostly to generate electricity, it is often assumed that some form of renewable energy of a percentage is used to create alternative fuels.

Research is going on the search of more suitable bio fuel crops and improving the oil yields of these crops, Using the current yields, Vast amount of land and fresh water in needed to produce enough oil to completely replace fossil fuel usage.

Alternative fuels, known as non-conventional and advanced fuels, any materials or substances that can be used as fuels, other than conventional feels like; fossil fuels (Petroleum (oil), coal, and natural gas.

Some well-known alternative fuels includes biodiesel, bio alcohol (Methanol, ethanol), vegetable oil, propane and other biomass sources.

Ministry of road transport and highways

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 and 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

It deals with road transport relating matters

Main Responsibilities of transport wing

- 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.

Classification of vehicles

Objective: At the end of this lesson you shall be able to
- **classify the vehicles.**

Classification of vehicles

Based on central motor vehicle act

- Motor cycle
- Invalid carriage
- Three wheelers
- Light motor vehicle
- Medium passenger motor vehicle
- Medium goods vehicle
- Heavy passenger motor vehicle
- Heavy goods vehicle
- Any other motor vehicle of a specified description

Based on wheel

- Two wheeler
- Three wheelers
- Four wheelers
- Six wheelers
- Multi axles

Based on fuel used

- Petrol vehicle
- Diesel vehicle
- Gas vehicle (CNG & LPG)
- Electric vehicle

Based on body

- Saloon (BMW,AUDI)
- Sedan (Maruti ciaz, ambassador etc)
- Hatch back (Alto, i10, santro, Tata Tiago)
- Convertible (Jeep, maruti gypsy)
- Station wagon (Innova, Ertiga, etc)
- Van (Omni, Touristor)
- Special purpose (Ambulance, Milk van, etc)

Based on drive

- Front engine rear wheel drive (Sumo, Omni, Ambassador, etc) (Fig 1)
- Rear engine rear wheel drive (Tata Nano, Bajaj auto, Valvo bus etc) (Fig 2)
- Front engine front wheel drive (Alto, Ertiga, santro, Tiago etc) (Fig 4)
- Four wheel/ All wheel drive (jeep, Scorpio, Gypsy etc) (Fig 3)

Fig 1

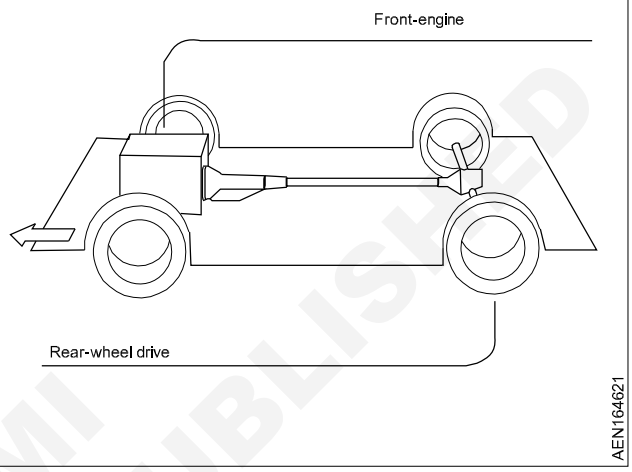


Fig 2

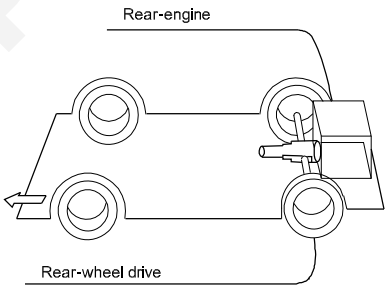


Fig 3

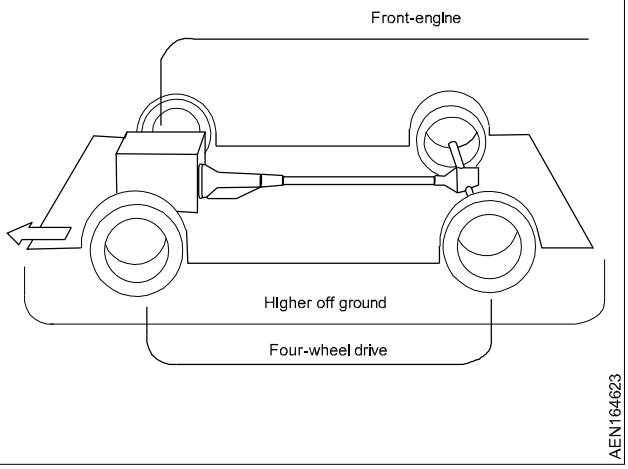
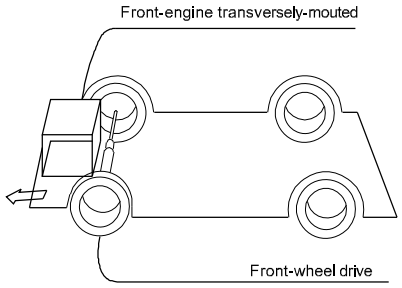


Fig 4



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Based on position of engine

- Front transverse engine (Example ; Maruti 800)
- Front longitudinal engine (Example ; Maruti Omni)
- Rear Transverse engine (Example ; Volvo bus)

Based on steering

- Conventional manual steering
- Power steering hydraulic
- Power steering electric

Based on transmission: Manual transmission.

Automatic transmission: This is transmission that uses a torque converter, planetary gears set and clutches or bands to shift a vehicle's forward gears automatically.

Automated manual transmission (AMT): This is an automated manual transmission it employs a mechanical clutch, but the action of the clutch is not controlled by the driver's clutch pedal. Gears shifts done by using automated electronic, pneumatic or hydraulic controls.

Continuously Variable Transmission (CVT): This transmission has a continuously variable drive ratio and uses belts, pulleys and sensors rather than gears to maintain a steady acceleration curve with no pauses for gear changes. Because of this, a CVT can keep the engine in its optimum power range, thereby increasing efficiency and gas mileage.

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 axle stand.**

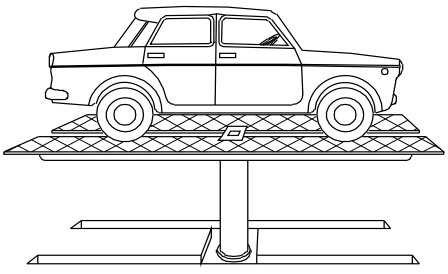
The modern automobile service stations are used the various types of equipments to lift the vehicles. They are as follows.

- Single post hydraulic car hoist
- Two post car hoist
- Four post car hoist
- Engine hoist
- Jacks
- Stands

Single post hydraulic car hoist (Fig1): It is facilitate the servicing and reaper works conveniently. It is constructed for dependable, trouble free performance and ensuring smooth and safe operation. The post is made of high grade steel. The car hoists are specially designed for resistant to wear and damage during water wash. Single post type is suitable for vehicle up to 6 tones.

Two post hoist (Fig 2): It is operated by electro -hydraulic system. it is easy to operate and maintain the double post hoist and safety provision also provided to hold the vehicle. Double post type suitable for vehicle upto 4 tones.

Fig 1



HYDRAULIC CAR HOIST

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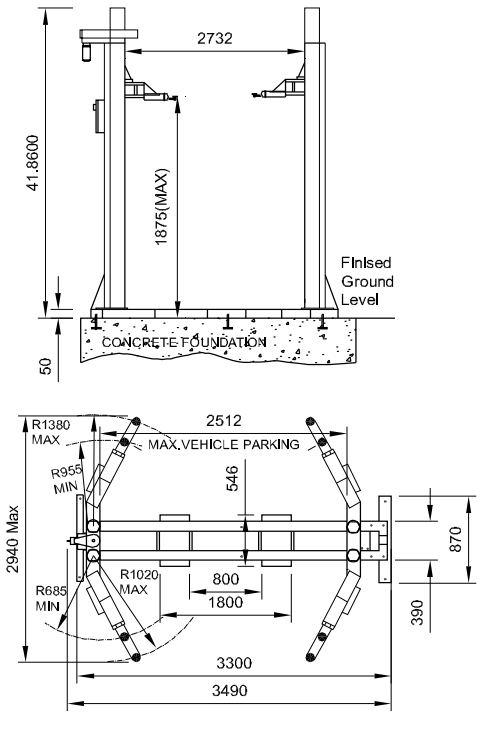
Four post car hoist (Fig 3): It is operate by electro hydraulically and balancing the lifting vehicle. It is easy to operate and maintain the moving parts. Four post hoists is work as single and double post hoist it is suitable for lift the vehicle light and heavy vehicle.

Fig 2



TWO POST HOIST

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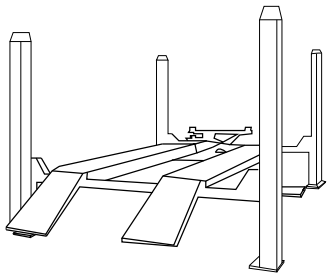
Fig 3



FOUR POST HOIST

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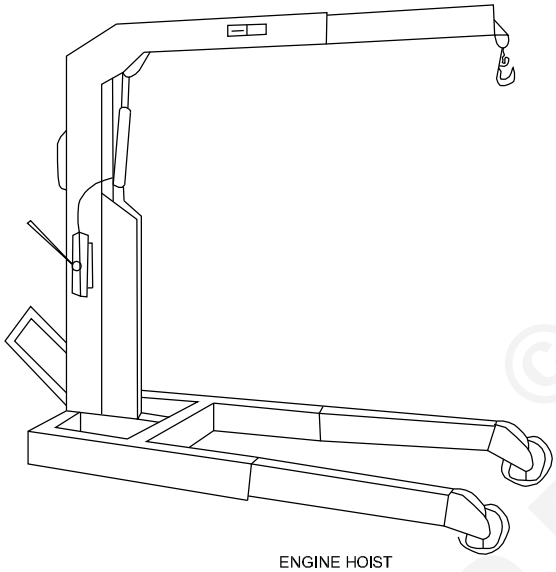
Engine hoist (Fig 4)

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.

Fig 4



ENGINE HOIST

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Jacks: Jacks 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.

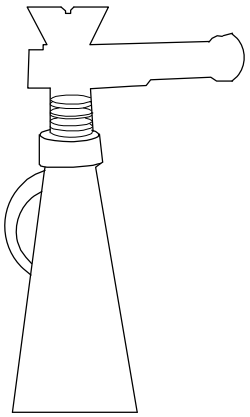
Never work under a car without safety stands or jack stands.

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 are operated by mechanically and hydraulically, Jack is designed to lift the vehicle and hold the vehicle load during the repair works. Jack is a standard accessory with many vehicles.

Types of jacks

- Light weight screw jack (Fig 5)
- Heavy duty bottle type hydraulic jack (Fig 6)
- Trolley types hydraulic jack (Fig 7)

Fig 5



MANUAL TYPE LIFITING JACK

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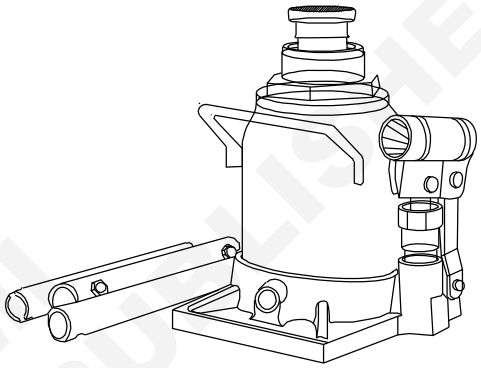
Fig 6



HEAVY DUTY BOTTEL TYPE LIFITING JACK

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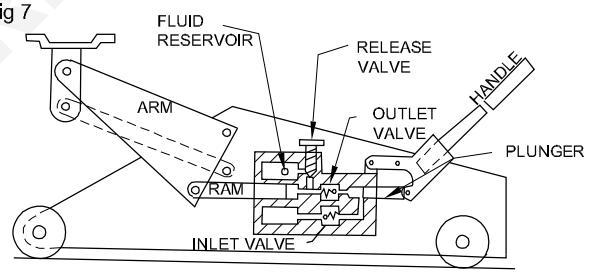
Fig 7



TROLLEY TYPE JACK

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

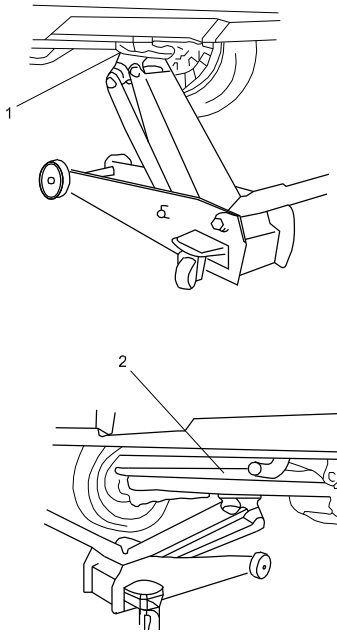
In raising rear vehicle end off the floor by jacking, be sure to apply jack against the center portion of rear axle (2)

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.

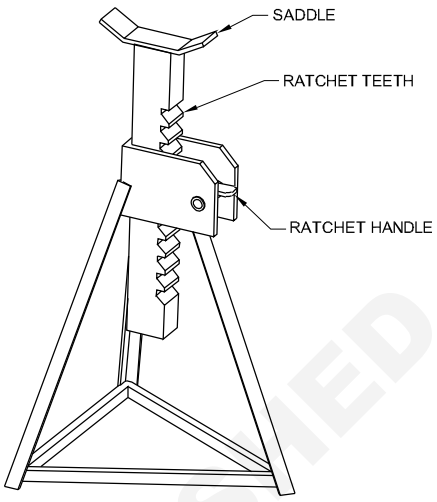
Fig 8



FLOOR JACK

To perform service with either front or rear vehicle end jacked up, be sure to place safety stands (1) under body so that body is securely supported. And the check to ensure that body does not slide on safety stands and the vehicle is held stable for safety's sake.

Fig 9



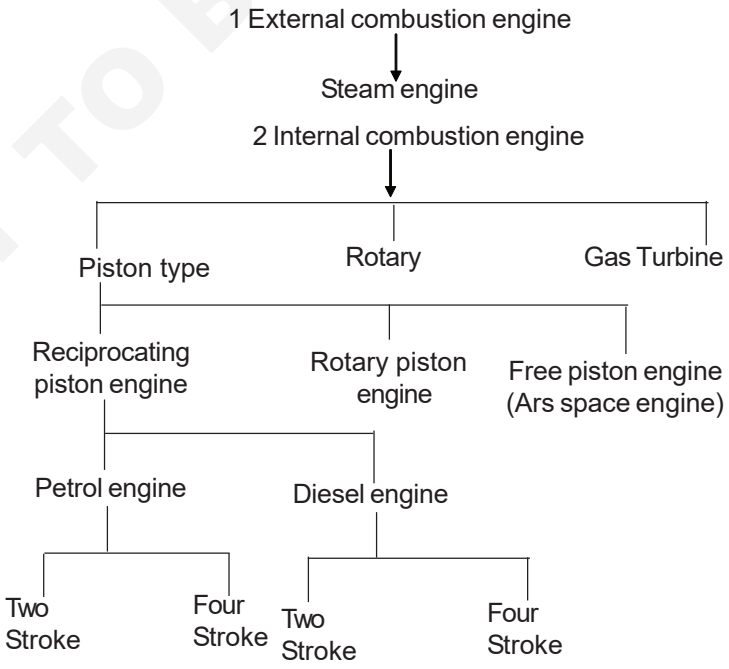
TYPICAL ADJUSTABLE JACK STAND

Axle stand (Fig 9): It is always ensure the safety before starting the work under the lifted vehicle, Jack report is not enough, it could be dangerous. Always use axle stands for safety work. Different size of stands are used depend upon the vehicle load.

Internal and external combustion engine

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

Types of heat engines



Internal combustion engine

Internal combustion engines are those heat engine, that burns their fuel and takes combustion inside the cylinder, this definition including the two stroke and four stroke engine, spark ignition and compression ignition engine, austine and jet engines are also internal combustion engine. Ex: Wankel.

External combustion engine

The external combustion engines are those heat engine that burn their fuel outside the engine cylinder. The energy developed during the combustion of fuel is transmitted to steam. This steam acts on the piston inside cylinder example - railway 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 palce outside the engine.
5	No 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.	No cooling of the cylinders required. Rather it is steam jacketed.
10	Single acting.	Mostly double acting.
11	Exhause 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.
13	No needs boiler, furnace or condenser.	Boiler, furnace and condenser are must.

Classification of I.C engines

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

Engines are classified according to the following factors.

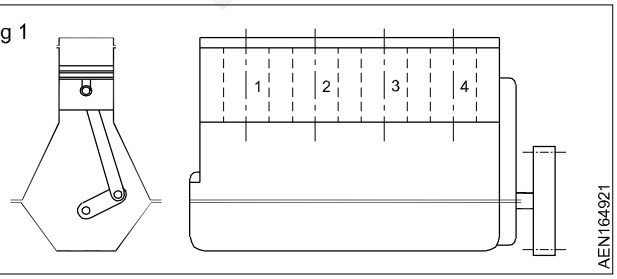
Number of cylinders

1 Single cylinder 2 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

Fig 1



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.

'V' shape 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.

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 2

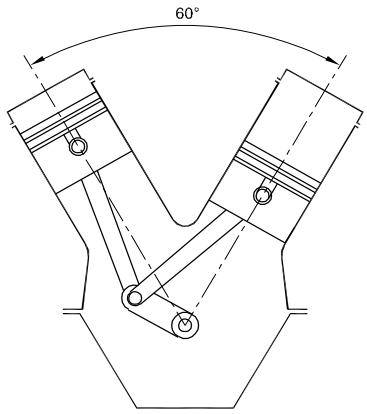


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Fig 3

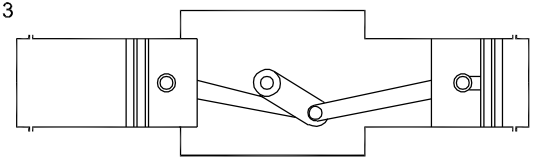

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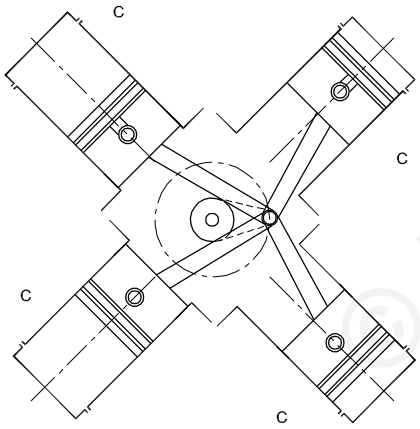
Fig 4



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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.

Types of engine as per number of cylinders

1 **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.

2 **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
- Gas

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

Engine Cooling system

- Air cooled engine
- Water cooled engine

Strokes of engine

- Four-stroke engine
- Two-stroke engine

Function 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.**

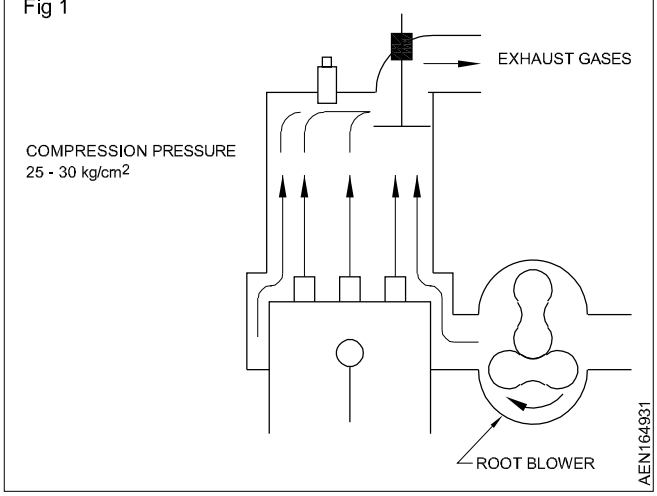
Two stroke diesel engine

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

First stroke: Piston at BDC to TDC, 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.

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.

Fig 1



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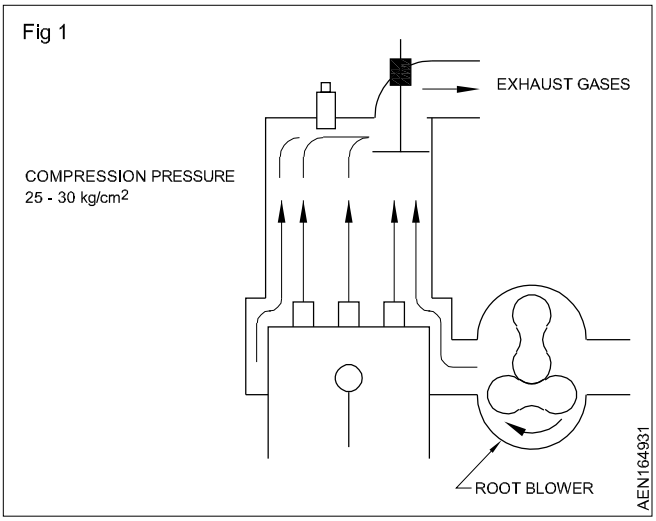
Second stroke: Piston at TDC (Fig 2) scavenging port and outlet valve closed. The fuel is directly injected into the cylinder with the help of a fuel injection pump and an injector fitted in the cylinder head. The fuel gets vaporised into an ignitable fuel air mixture by the hot air. After attaining 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.

Fig 1



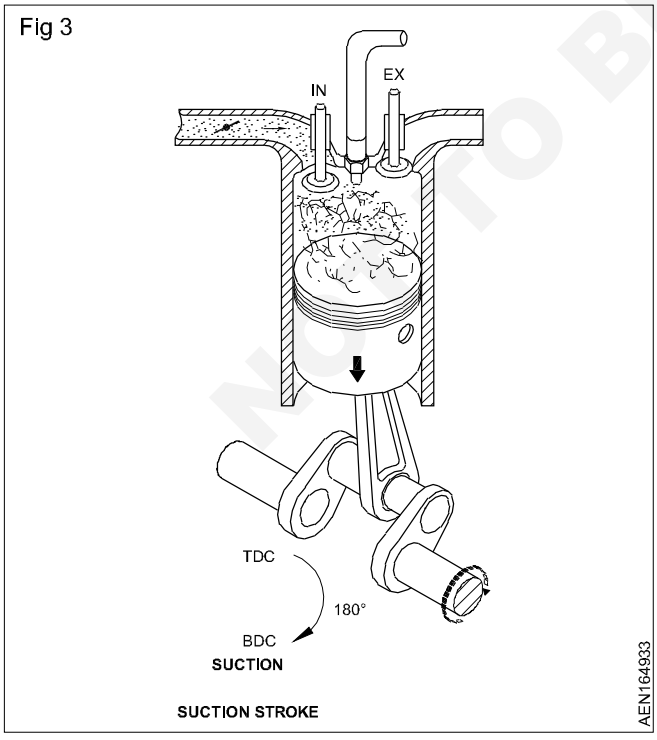
Four-stroke engine

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.

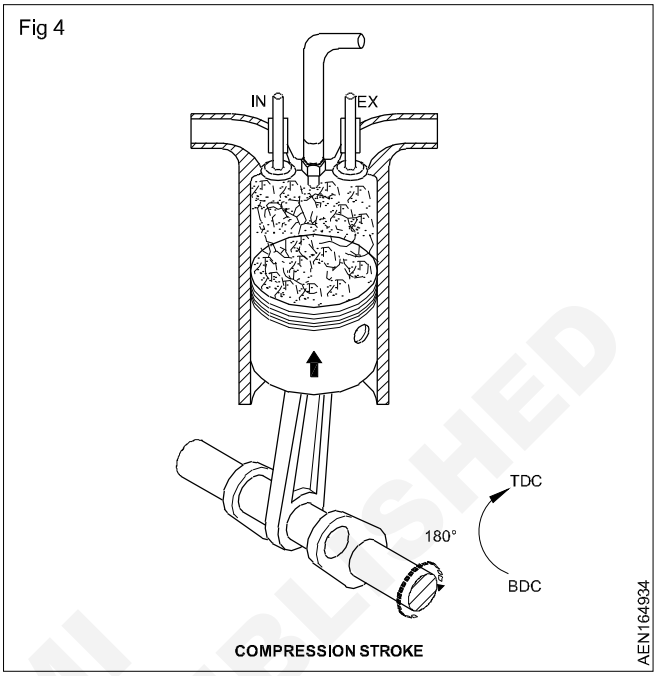
Fig 3



Compression stroke (Fig 4)

The inlet and exhaust valves are closed. The piston moves from BDC to TDC (Fig.4). The charged air is compressed in the cylinder. The compressed air pressure and temperature is increased upto 800°C.

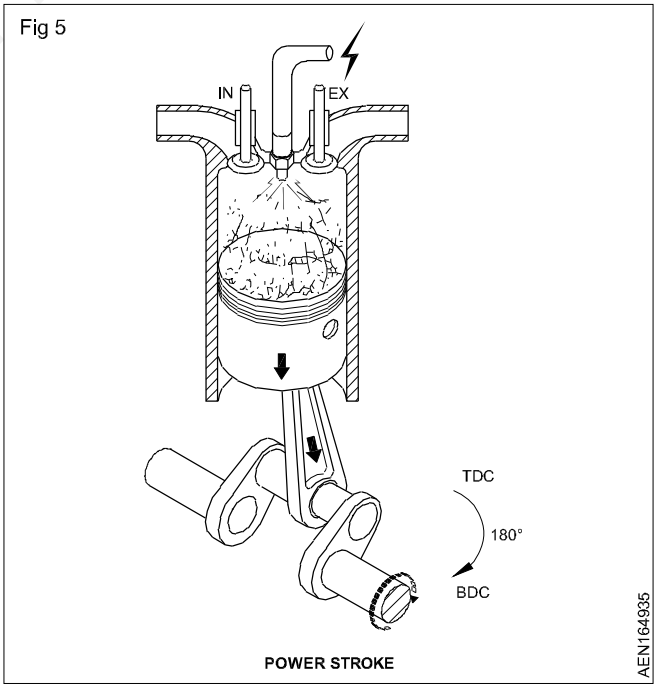
Fig 4



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

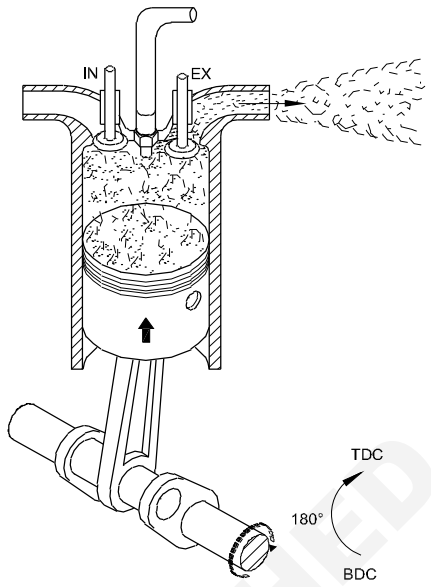


Exhaust stroke

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

Function of spark ignition engine

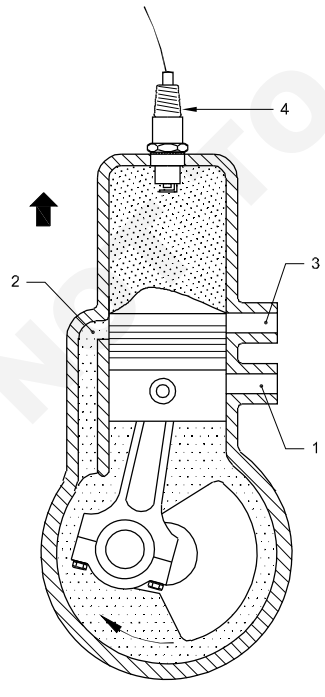
Objectives: At the end of this lesson you shall be able to
- **describe the function of a two-stroke engine**
- **describe the function of a four-stroke engine**
- **differentiate between a four-stroke and a two-stroke engine**
- **explain an OTTO cycle**
- **explain a diesel cycle.**

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) (Fig 1)

Fig 1



FIRST STROKE

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.

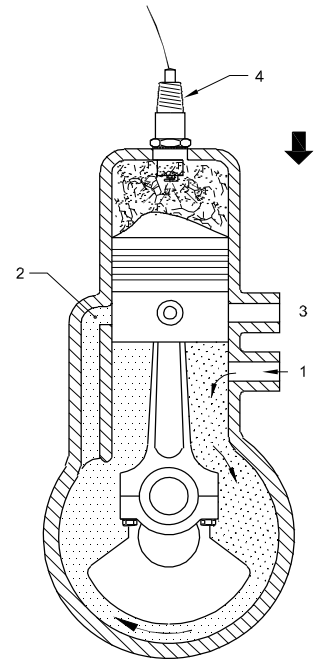
Second stroke (power and exhaust)

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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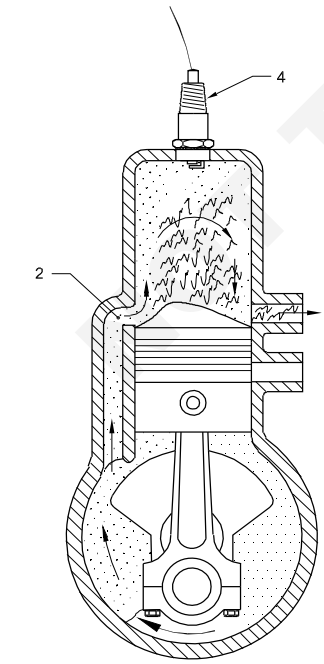
Spark ignition (Fig 3): In a spark ignition (SI) engine, petrol is used as fuel. During the suction stroke the air and fuel mixture is sucked into the cylinder. The quantity of the mixture is metered by the carburetor according to the load and speed. The ratio of air/fuel mixture is also metered by the carburetor.

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.

Fig 3



SECOND STROKE

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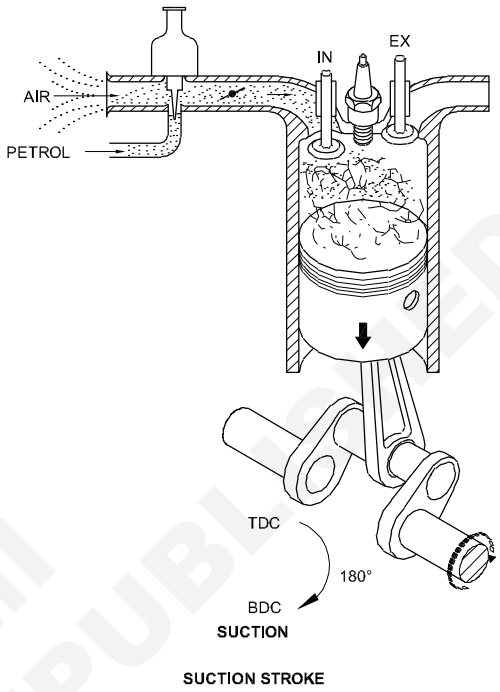
Four-stroke spark ignition engine: To produce power in a four-stroke engine the following operations take place in the sequence given below.

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



SUCTION STROKE

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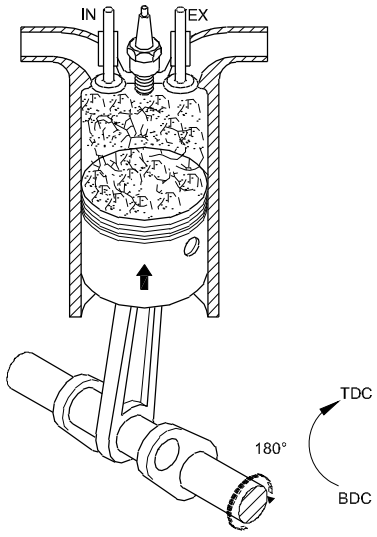
Compression stroke: The inlet valve closes. The exhaust valve remains closed. The piston moves from BDC to TDC (Fig 5). The charge (air/air-fuel mixture) is compressed. The pressure and temperature rise.

Fig 5



COMPRESSION STROKE

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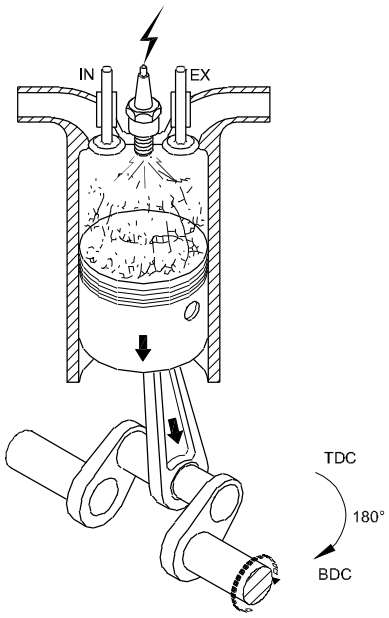
Power stroke

The compressed is ignited air fuel mixture 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.

Fig 6

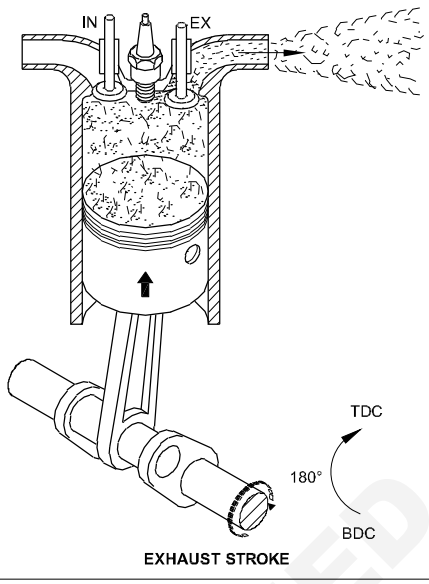


POWER STROKE

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.

Fig 7



EXHAUST STROKE

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.

Otto Cycle

1 - 2 - Suction
2 - 3 - Compression
3 - 4 - Heat addition
4 - 5 - Power
5 - 2 - 1 - Exhaust

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 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.
- Due to more idle strokes and non-uniform load on the crankshaft, a heavier flywheel is required.	- 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. Therefore, the engine is heavier.	- The engine has no valves and valve-operating mechanism therefore it is lighter in weight.
- The engine is costlier as it has more parts.	- The engine is less expensive as it has a lesser number of parts
- The engine efficiency is more as the charge gets completely burnt out. Consequently the fuel efficiency is more.	- The engine efficiency is less. A portion of the charge escapes through the exhaust port, and because of this, the fuel efficiency is less.

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)

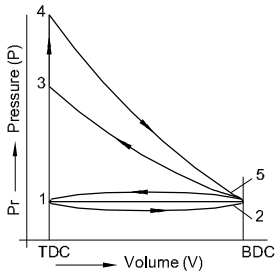
Compression takes place when piston moves from BDC to TDC. (2-3)

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)

Fig 8



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

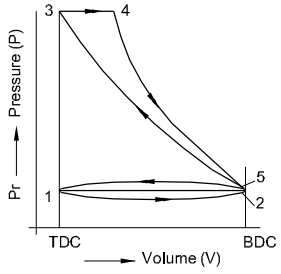
Suction takes place at (Fig 9) pressure below atmospheric pressure when piston moves from TDC to BDC. (1-2)

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

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)

Fig 9



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

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

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.

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 the engine cylinder	During the suction stroke air alone is sucked in to the cylinder
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 electric spark.	Fuel is ignited due to the heat of the highly compressed air. Combustion takes place at constant pressure.
Spark plug is used	Injector is used.
A carburetor 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 noisy.
Engine weight is less.	Engine weight is more.
It emits carbon monoxide. (CO)	It emits carbon dioxide. (CO_2)

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 types.

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

Technical specifications of vehicles

LPT - 1210 D

Specifications

Engine	
Model	6692 D.I.
Number of cylinders	6
Bore	92 mm
Stroke	120mm
Capacity	4788 cc
Gross H.P. (S.A.E.)	125 at 2800 R.P.M.
Taxable H.P.	31.5

Maximum Torque	30 mkg at 2000 R.P.M
Compression Ratio	17 : 1
Compression pressure at 150-200 R.P.M.	Minimum 20 kg/cm^2
Fuel injection begins	23° before T.D.C.
Firing order	1-5-3-6-2-4
Opening pressure of the Newnozzels	200 + 10kg/cm^2 injection nozzles Min. 180 kg/cm^2 Used nozzels
Maximum variation permissible in injection: nozzle pressure	5 kg/cm^2
Inlet valve clearance	0.20 mm
Exhaust valve clearance	0.30 mm
Air cleaner	oil bath
Total bearing area per bearing	55 sq.cm
No.of main bearings	7
Fuel injection pump	MICO BOSCH
Weight (Dry)	382 kg
Capacity of cooling system	20 litres
Crankcase oil capacity	Maximum - 14 litres Minimum - 10 litres
Cooling water temperature	75°C - 95°C

Depth max : 223 mm ($8\frac{3}{4}$")

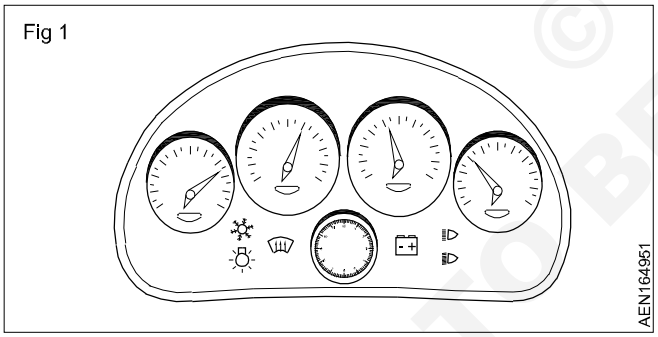
Dashboard gauges, meters and warnings lights

Objectives: At the end of this lesson you shall be able to
- **state different type of meters and their uses**
- **describe the purpose of each warning lights**
- **specify the purpose of each gauges.**

Odometer

An odometer (Fig.1) is an instrument that indicate distance travelled by a vehicle, such as motor cycle and motor vehicle automobile. The device may be electronic, mechanical, or a combination of both. It is also called as trip meter in case of short trips of every ride. The distance mentioned in the odometer generally in kms.

Fig 1



Speedometer

A speedometer or a speed meter is a gauge that measures and displays the instantaneous speed of a vehicle. The unit in which the display shown is in Km/hr. There are both analog and digital meters are available now a days.

Engine RPM meter

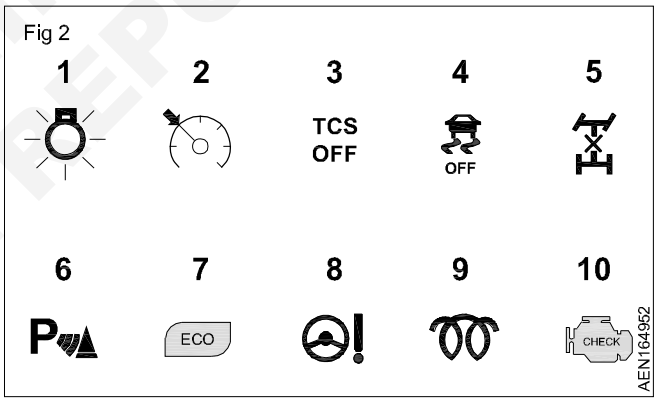
An engine rpm meter (Fig 2) is used to display the engine rotation in revolution per minute.

1 **Bulb indicator :** This shows you that you have a dead bulb. Not all cars have this, but it's a helpful warning.

2 **Cruise control indicator :** This indicator is used to display the accelerator opening level to maintain the set speed. This reminds you that cruise control is on.

3 **Traction control indicator:** This tells you the traction control is off. A blinking traction-control light indicates that the system is preventing wheel spin. In which case you should either; let off the gas a bit and drive a little slower; or let off the gas a bit and drive much slower.

Fig 2



4 **Stability control indicator:** This indicates that the stability control has been turned off. There's not much reason to turn it off on the road, and some cars can be dangerous in the wet without it. A blinking light indicates that the stability control system is actively preventing loss of control. If this happens, pay attention and stop trying to drive like an idiot.

5 **Centre differential lock (or 4Hi/Lo):** This indicates that the center differential on or car with part-time four-wheel drive has been engaged. We can't stress this enough; Part time all-wheel drive is not meant for on-road use, and running it on dry tarmac can cause "binding" and other problems. We've heard sob stories from dealerships where customers had to pay for costly repairs because the later didn't realize this.

6 **Proximity sensor indicator:** Some cars have proximity sensors all around instead of just the rear bumper. This helps you park your big, cumbersome

vehicle in tight parking spots. It also makes for incessant buzzing as motorcyclists and pedestrians filter around you in traffic. Recognizing whether it's on or off can help prevent a nasty scrape.

7 **Econ indicator:** This can mean different things on different cars. Some cars use it to tell you that economy mode is engaged, which means that the accelerator and the transmission are in their most relaxed mode. On some cars with cylinder deactivation, this tells you that the system is turned on (typically when you're cruising or coasting), and half your cylinders are not burning gas at the moment. On other cars, this lights up when you are driving in an "economical" manner, and it can be used as a training tool for good, efficient driving. Other cars use color-changing dash lights for the same purpose. They're educational, helpful and rather cool.

8 **Electric power steering indicator:** This indicates a fault in the EPS system. It could mean temporary overheating of the assist motor or a major fault in the system. Electric steering motors are usually compact, and violent sawing at the wheel can sometimes overtax them. This can happen when you're doing a 30-point turn in a tight garage, or when you're banging comes on a tight autocross. Best let things cool down and see if the problem goes away; otherwise, it's time for a checkup.

9 **Glow plug indicator:** Lacking spark plugs, diesels rely on pressure and heat to burn their fuel. As there's little heat in the combustion champer when you first start it in the morning, glow plugs heat up the fuel coming out of the injectors to give the engine a better chance of starting. The light should turn on briefly after you switch the ignition to the 'on' position. Once it's off, the plugs are hot enough to start the car. A flashing light may indicate busted plugs, but some cars use the glow plug light as a catch-all indicator for problems ranging from bad injectors to exhaust gas recirculation valve issues. Get it checked as soon as possible.

10 **Check engine light:** It can signal any number of issues or faults with the sensors and electronic equipment on the engine, some of which are serious, some of which are not. The most common cause is a busted exhaust oxygen sensor, which is bad for emissions but won't prevent your car from running. Other common causes include ignition coil and spark plug problems on gasoline cars, or an issue with any of the dozen-odd sensors that keep your engine happy. Even if you think it's nothing serious, don't ignore it. Have your car subjected to a diagnostic scan as soon as possible.

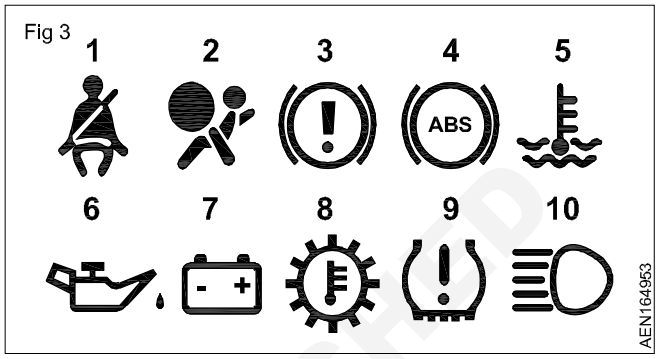
Panel board indicator lights

1 **Seatbelt indicator:** This indicates that the driver is not wearing the seatbelt. On newer vehicles, weight sensors in the seat tell the car if someone is sitting there, and warnings will appear for passengers, too. If the driver or passengers remain unbelted, a warning chime will sound. Don't ignore it. Studies show that seatbelt use reduces the chance of injury in a crash by 50%. Worse yet, being hit by an air bag with out your seat belt on can be fatal.

2 **Airbag indictor:** This signals a malfunction with the airbags or air bag sensor. This means that they may not go off in a crash.

3 **Brake indicator:** This signals light indicate such as several things. (Fig 3)

Fig 3



a Vehicle parking brake is engaged, so disengage it;

b The parking brake sensor is out of alignment, so have align and fixed it properly.

c The brake fluid level is low

d The hydraulic pressure between the two braking circuits are mismatched. The last two are potentially dangerous, and could mean a possible fluid leak, as well as reduced or even completely absent braking performance.

Don't wait for the light to go off; check your fluid every morning before you go out, because sometimes the warning light comes on too late. Some newer cars also have a brake pad warning light that goes off if the pads need to be replaced.

4 **ABS indicator:** Some cars have a separate ABS light that signals a problem with the ABS system. If this goes off, that means that the Antilock Braking System has malfunctioned and the brakes may lock up under hard braking. Bring the car in for servicing immediately.

5 **Temperature warning:** Some older cars with temperature gauges merely have a red light, but many modern cars have this symbol. This indicates that your engine is overheating or is about to overheat. Best to pull over immediately to cool down, to avoid potentially expensive engine repair bills.

6 **Oil level/Pressure warning:** There's no genie in this lamp. Just the magic slippery stuff that keeps your engine lubricated. This typically signals your oil level is low by about two liters. No lasting damage should occur if you top off the oil the moment you see this warning. But if you ignore it, your engine could end up looking like a frying pen that's been left on the burner for a few hours. Not a pretty sight and a new engine is much more expensive than a new frying pan.

7 **Electrical system warning:** This one looks like a battery, which means battery problems. It could also

mean alternator problems, so simply buying a new battery may not be enough. Thankfully, many shops can test the alternator's charging capacity when you go in for a battery replacement.

8 **Transmission warning light:** This comes in many different forms, and can indicate a malfunction with the transmission itself, the gearshift or transmission fluid overheating. You most often see this on trucks when you're hauling heavy loads, or in high performance cars with automatic transmission if you drive them a little too hard. Needless to say, pulling over to let the transmission cool down is a good idea.

9 **Tire pressure monitoring system:** This indicates either an issue with the TPMS itself or low pressure in one of your tires. Check immediately, Low pressure carry increased risk of blowout on the highway due to tire over heating. Not to mention the danger of hydroplaning in the rain, as wider tires slide over the water more easily than narrower one.

10 **High beam indicator:** While not a warning light perse, this bright-icon represents a big danger to other motorists, and it is one of the most ignored indicators in the Philippines. Leaving your high beams on will blind other motorists and can lead to nasty accidents. Remember to turn them off when there's oncoming traffic or when driving behind another car.

You don't need to see the road 2km ahead when you can simply follow the other guy ahead of you.

You don't need to be a "car whisperer" to know something's wrong when your dashboard lights up like a Christmas tree. But knowing what these lights denote can mean the difference between a quick fix and a long walk home.

Gauges used in automobiles

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**
- **explain the purpose of a temperature gauge**
- **explain the working of a temperature gauge**
- **explain the purpose of an oil pressure gauge**
- **explain the working of an oil pressure 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 gauges are the following.

- Fuel gauge (Balancing coil type)
- Temperature gauge (Balancing coil type)
- Oil pressure gauge (Balancing coil type)

Fuel gauge

Purpose

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

Tank unit

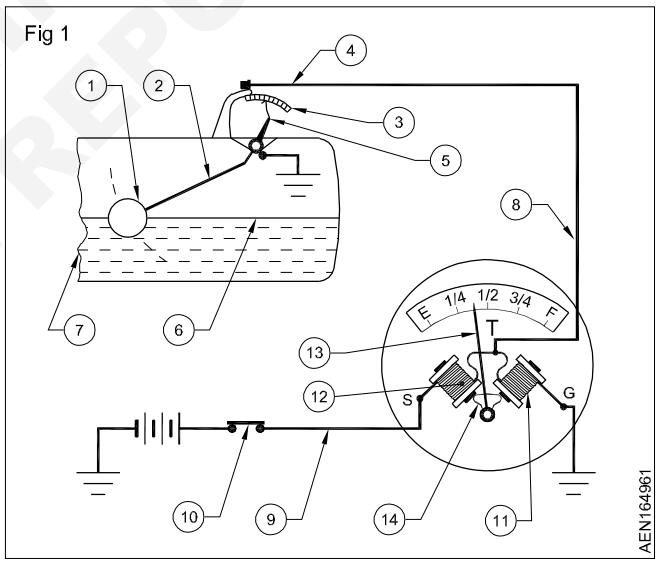
It consists of a tank unit and the indicator unit (Fig 1). The two units are connected in series by a single wire to the battery through the Ignition switch. When the ignition switch is turned on, current passes through both the units.

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)

It is fitted on the panel board.

Fig 1



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

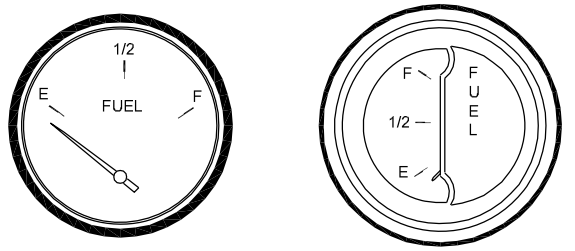
It consists of two coils (11) & (12) and a pointer (13) with the magnet (14) attached to it.

Working

When the ignition switch (10) (Fig 2) 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.

Fig 2



FUEL GAUGES

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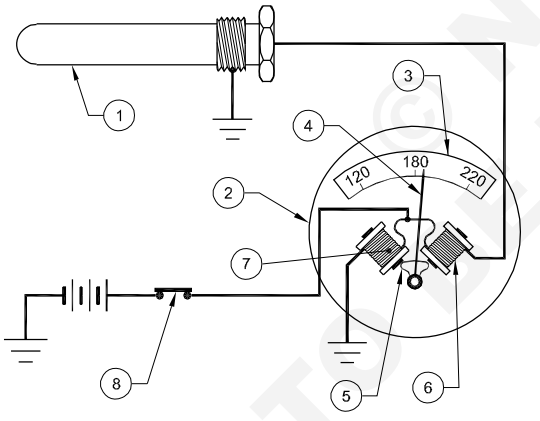
Temperature gauge

Purpose

It is used to know the temperature of water in the cooling system of engine at all times. It cautions the driver against overheating of the engine.

- It consists of an engine unit (1) immersed in the engine coolant in the cylinder head or cylinder block in the form of a pellet. (Fig 3)

Fig 3



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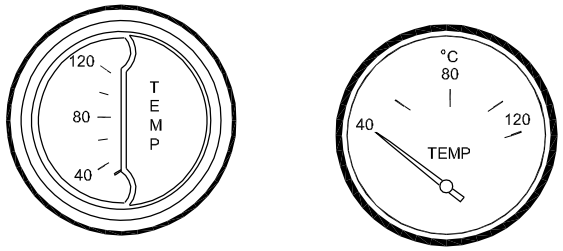
- It is made of special material whose electrical resistance increases when temperature is lowered and it reduces when the temperature is increased.
- The resistance unit is provided with the dash unit (2) and it is fitted on the panel board.
- The dash unit consists of a dial (3) pointer (4), a magnet (5) and coil (6) and (7). (Fig 4)
- The two terminals of gauge are connected to the ignition switch (8) and the engine unit (1). The operating current is supplied from the battery through the ignition switch.

Working

When the coolant temperature rises, the engine unit becomes hot. When the engine unit temperature is high the resistance is less and more current passes to the right coil of the indicating units.

Fig 4



TEMPERATURE GAUGES

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The difference in the strength of the magnetic field between the two coils increases and the armature and pointer move towards the right to indicate a high temperature.

When the engine coolant temperature falls down, the resistance becomes high. This results in less current flowing through the left coil, and the magnetic field becomes less and causes the armature and pointer to move towards the left to indicate lower temperature.

Oil pressure gauge

Purpose

This device is used to know the pressure of lubricating oil during the working of the engine and serves as a warning signal to the driver against any sudden failure of the lubrication system.

Types

- Bourdon tube type gauge (non-electric)
- Balancing coil type (electric)

The Bourdon tube gauge is not widely used nowadays, as it has certain drawbacks i.e. the connecting tube leaks at joints.

In modern vehicles balancing coil type (electric) oil pressure gauges are used.

Working

It consists of two units (i.e) engine unit and the dash unit. (Figs 5 & 6)

The engine unit consists of a diaphragm, sliding contact, variable resistance.

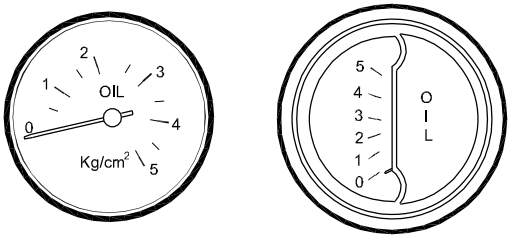
The dash unit consists of two coils (11) & (12) and a pointer (13) with a magnet (14) attached to it. Both coils are connected in series with battery through ignition switch.

The increase in oil pressure pushes the diaphragm outward. This action results in increase in the resistance at the engine unit.

The right hand coil of the dash unit becomes magnetically stronger than the left hand coil.

Consequently the armature and the pointer swing towards the right side in indicate higher oil pressure.

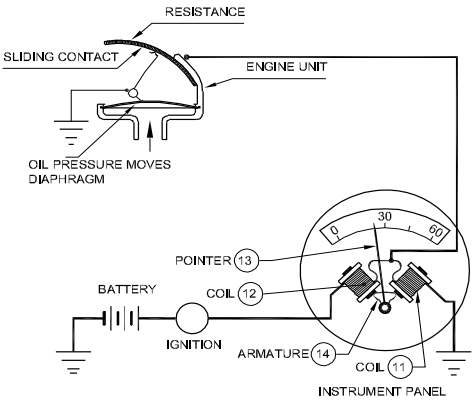
Fig 5



OIL PRESSURE GAUGES

AEN164965

Fig 6



SCHEMATIC WIRING CIRCUIT OF A BALANCING -COIL OIL-PRESSURE INDICATING SYSTEM.

AEN164966

Starting and stopping methods of engine

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

- **list out different types of engine cranking methods**
- **explain the different types of starting methods of diesel engine**
- **explain method of stopping the diesel engines.**

For starting the engine the following different methods are used.

1 Hand cranking
2 Electric Motor cranking
3 Hydraulic cranking motors
4 Compressed air cranking
5 Gasoline engine starting

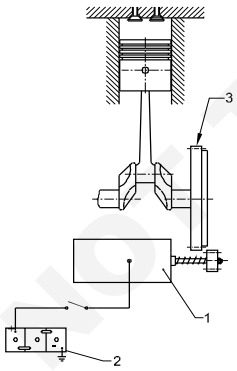
Hand cranking

Usually small diesel engines are being started using crank handle or rope.

Electric motor cranking

In this system a starter motor (1) is used to rotate flywheel (3) of the engine. A battery (2) is used to supply power to the starter motor. (Fig 1)

Fig 1



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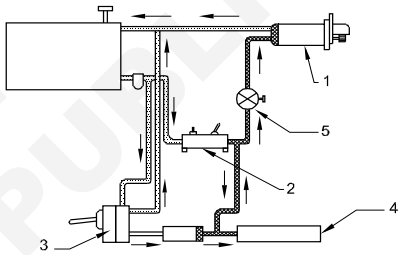
Hydraulic cranking motors

In this system hydraulic fluid under pressures passes through hydraulic starter motor (1) to rotate the engine flywheel. A hand pump (2) or an engine driven pump (3) is provided to create and develop pressure of fluid. This fluid under pressure accumulates in the accumulator (4). After pressing the starting lever, control valve (5) allows the hydraulic fluid under pressure to pass through the hydraulic starter motor. (Fig 2)

Fig 2



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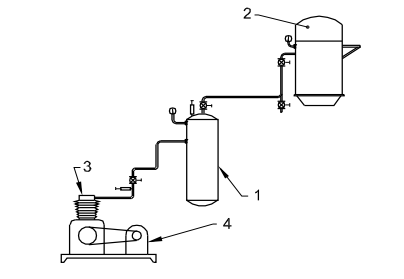
Compressed air cranking

In this method compressed air from the reservoir (1) is admitted through an automatic starting valve in the engine cylinder head when the piston is at the top dead centre at the beginning of the power stroke, at a pressure capable of cranking the engine (2). When the engine is turning fast enough, the injected fuel ignites and the engine runs on its own power, whereupon the air supply is cut off. An air compressor (3) is used to create air pressure. Air compressor (3) is driven by the engine or electric motor (4). (Fig 3)

Gasoline engine starting

This is used to start the heavy duty earth moving engines. Starting of the gasoline engine is done either by hand cranking or by an electric motor. The gasoline engine then cranks the heavy engine. Generally diesel engines are stopped by cutting the fuel supply after reducing the engine speed to the minimum level.

Fig 3



AEN164973

Switches

Objectives: At the end of this lesson you shall be able to
- **state the function of SPST switch**
- **state the function of relays, solenoids and buzzers.**

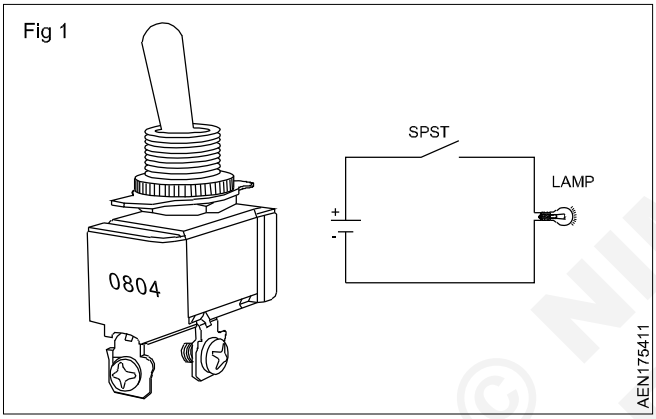
Switch

Switch is an dectrical component that can disconnect or connect the conducting path in an electrical circuit.

Single pole single throw switch (Fig 1)

A single pole single throw switch is a switch that only has a single input and can connect only to one output. This mean it only has one input terminal. The SPST switch serves in circuits as ON-OFF switches.

Fig 1



When the SPST is closed the circuit is closed and light from the lamp switch ON when the SPST is then opened, the light from the lamp goes out and the circuit is OFF.

The above circuit shows the basic nature and function of a SPST switch.

Mercury switch

A Mercury switch is an electrical switch that opens and closes a current when a small amount of the liquid metal mercury connects metal electrodes to close the circuit. There are several different basic designs but they all share the common design strength of non eroding switch contacts. This type of switch performs much better than the ball tilt switch the liquid metal connection is unaffected by dirt, debris oxidation it wets the contacts ensuring a very low resistance bounce free connection and movement and vibration do not produce a poor contact.

Ganged switches

Gang - operated switches are used in circuit up to the highest voltages

Relays

Relays are switches that open and close circuits electromechanically relays control one electrical circuit by opening and closing contacts in another circuit.

ISO Relay: Many of the electromechanical relays used in automotive applications are termed ISO relays an ISO relays is one which adheres to a standard pattern for its electrical terminals, that has been spelled out by the international standards organisation. ISO relay terminal patterns include super ISO, ISO 280, Mini 280 ISO and micro 280 ISO. They are widly used in both Erope and the US.

Devices in the super ISO format generally handle about 70 -A loads. Those with the 280 ISO foot print have general purpose application within automotive power control most new developments in relate to fielding smaller devices able to fit into more compact spaces. These relays are used in switching applications such as motors, lamps, resistive loads cooling fans HVAC and window defrost system.

Solenoids

Solenoid is a device composed of a coil the housing and a movable plunger (armature) when an electrical current is introduced a magnetic field forms around the coil, which draws the plugged in more simply, a solenoid converts electrical energy into mechanical work.

The coil is made of many turns of tightly wound copper wire, when on electrical current flows through this wire, a strong magnetic field/ flux is created.

The housing usually made of iron or steel, surrounds the coil concentrating the magnetic field generated by the coil.

The plunger is attached to the stop through the concentration of the magnetic field providing the mechanical force to do work.

Buzzers

A buzzer is an audio signaling device which may be mechanical, electro mechanical or electric typical uses of buzzer and beepers include alaram devices tuners and conformation of user input such as a mouse click or keystroke.

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.

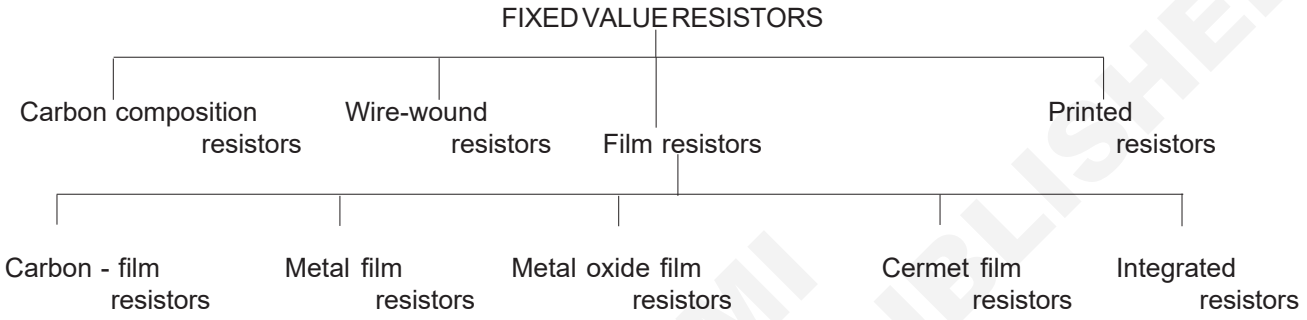
Fixed resistors are manufactured using different materials and by different methods. Based on the material used and their manufacturing method/process, resistors carry different names.

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

Carbon composition resistors

Construction

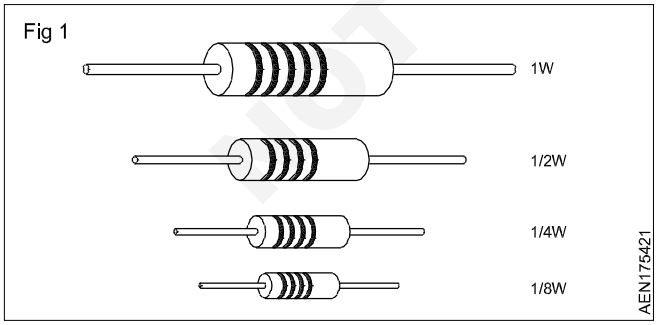
These are the simplest and most economical of all other types. Brief constructional detail of the simplest type of carbon composition resistors commonly called carbon resistor.



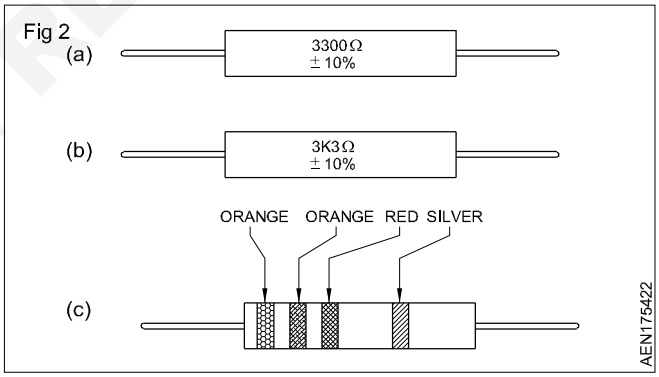
A mixture of finely powdered carbon or graphite(A), filler and binder is made into rods or extruded into desired shapes. Leads(B) made of tinned copper are then attached to the body either by soldering or embedding(C) in the body. A protective layer/tube(D) of phenolic or Bakelite is moulded around the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

Resistor values - coding schemes (Fig 1)

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 2a or using a typographic code as shown in Fig 2b or using a colour code as shown in Fig 2c.



Colour band coding of resistors

Colour band coding as shown in Fig 2c is most commonly used for carbon composition resistors. This is because the physical size of carbon composition resistor is generally small, and hence, printing resistance values directly on the resistor body is difficult. Refer Table 1.

Tolerance

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

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

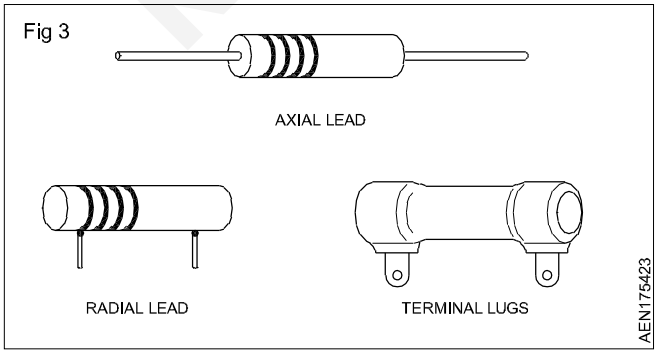
Applications

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 3. 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 3



Stepped resistor

Stepped resistance stepped or trapped resistors have two or more fixed values. The different resistance (Carbon or wire) are connected to different terminals in a switch. As the switch is moved, different resistance values are placed in the circuit.

Variable resistors

A variable resistor is a resistor of which the electric resistance value can be adjusted. A variable resistor is in essence an electro - mechanical transducer and normally work by sliding a contact (wiper) over a resistve element. when a variable resistor is used as a potential divider by using 3 terminals it is called a potentiometer. when only two terminals are used it functions as a variable resistance and called a rheostal electronically controlled variable resistors exist. which can be controlled electrically instead of by mechanical action. These ressistors are called digital potentiometers.

Potentiometer

The potentiometer is the most common variable resistor. It functions as a potential divider and is used to generate a voltage signal depending on the position of the potentiometer. This signal can be used for very wide variety of applications including. Amplifier gain control (audio volume), measurement of distance, angles, tuning of circuits and much more when variable resisters are used to tune or calibrate a circuit or application, timer potentiometers or trim posted are used these are mostly small potentiometers mounted on the circuit board, which can be adjusted using a screw driver.

Rheostat resistor

Rheostats are very similar in construction to potentiometers but are not used as a potential divider, bus as a variable resistance. They use only terminals instead of the 3 terminals potentiometer use one connection is made at one end of the resistive element. the other at the wiper of the variable resistor paste variable resistor wired as rheostats are used in circuits to perform tuning or calibration.

Diode

A diode is a two - terminal electronic component that conducts current primarily in one direction it a plate in which electrons can flow in only on direction in the other. A diode vacuum tube or thermionic diode is a vacuum tube with two electrods, heated cathode and has low resistance in one direction and high resistance from cathode to plate.

Diode identification and rating

There are a number of common, standard and manufactures driven numbering and coding schemes for diode. The rating of diodes important to circuit design and component selection. Diode manufactures provide detailed specifications on their products. diode's identification and ratings are found in reference book and websites up to date.

Clamping diodes: It is consist of a diode, which conducts electric current in only one direction and prevents the

signal exceeding the reference value and a capacitor, which provide a DC offset from the stored charge. The capacitor forms a time constant with the resistor load. Which determines the range of frequences over which the clamper will be effective.

Zener diodes

Zener diode is basically like an ordinary PN junction diode but normally operated in reverse based condition. But ordinary PN junction diode connected reverse based condition is not used as zener diode practically. A zener diode is a specially designed, highly doped PN junction diode.

Avalanche diode

An avalanche diode is a type of semiconductor diode, which is designed to experience avalanche breakdown at a specified reverse bias voltage. The PN junction of an avalanche diode is designed to prevent current concentration and resulting hot spot. So that the diode is undamaged by avalanche breakdown.

The construction of the avalanche diode is similar to the zenzer diode and indeed both zenzer breakdown and avalanche breakdown for present in these diode. Avalanche diodes are optimized for avalanche breakdown conditions. So they exhibit small but significant voltage drop under breakdown condition, unlike zenzer diodes always maintain a voltage higher than breakdown.

The normal diode allows an electric current in one direction, where as avalanche diode allows the current in both direction ie forward and reverse direction but it is specially designed to work in reverse beas condition. Avalanche diode is used for the protection of the circuit against unwanted voltage and surge voltage.

Photo diode

The photo diode is a knid of PN junction semi conductor diode, which works with intensity of light falling on it at the reverse biased condition

The photo diodes are available in a metallic package. The diode is PN junction mounted in an insulated plastic substrate. Then use seal the plastic substrate in the metal case - ON the top of metal case, there is transparent wnidow, which allows light to entire up to the PN junction. Two leads, anode and cathode of the diode come out from the bottom of the metal case. A tab extending from the side of the bottom portion of the metal case identifies the cathode lead, photo diode is used in alarm and counter circuit.

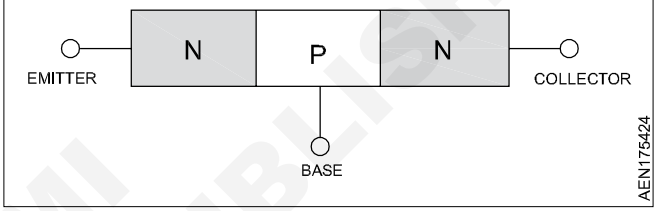
Light Emitting diode (LED)

A light emitting diode is a special type of PN junction diode. The light emitting diode is doped and made of a special type semi conductor. This diode can emit light when it is the forward biased state. Aluminium indium, gallium phosplide and indium gallium nitride are two of the most commonly used semi conductors for LED technologies. The color of the LED device is expressed in terms of the dominant wave length emitted. The colour and forward voltage of LEDs depend upon the temperature of the LED PN junction.

NPN Transistor (Fig 4)

The transistor in which one P - type material is placed between two n - type materials is NPN transistor, in NPN transistor, the direction of movement of an electron is from the emitter to collector region due to which the current constitutes in the transistors. The NPN transistor amplifies the weak signals enter into the base and produces strong amplify signals at the collector end. In NPN transistor the direction of movement of an electron is from the emitter to collector region due to which the current constitutes in the transistor such type of transistor is mostly used in the circuit because their majority charge carrers are electrons which have high mobility as compared to holes.

Fig 4



PNP Transistor

The transistor in which one n - type material is dropped with two p -type matterials such type of transistor is known as PNP transistor. It is a current controlled device. The small amount of base current controlled both the emitter and collector current. The PNP transistor has two crystal diodes connected back to back. The left side of the diode is known as the emitter - base diode and the right side of the diode is known as the collector - base diode. The PNP transistor turns on when a small current flows through the base. The direction of current in PNO transistor is from te amitter to collector.

The letter PNP transistor indicates the voltage requires by the emitter, collector and the base of the transistor. The base of the PNP transistor has always been negative with respect to the emitter and collector. The current which enters into the base is amplified into the collector ends.

Photo transistor

A photo transistor a device that has the ability to detect the level of the incident radiation and accordingly change the flow of electric current between emitter and collector terminal. It is a 3 - layer semiconductor device that consists of a light sensitive base region. It is basically a transistor whose action depends on the application of light. Hence named photo transistor. The photo transistor is basically an enhancement of photo diode. Both photo diode and light transistor are light sensing device but the sensitivity of photo transistor is some what more as compared to the photo diode. As photo transistor has the ability to give larger gain than that of the photo diode. Photo transistor operates on the principle of photo electric effect.

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.

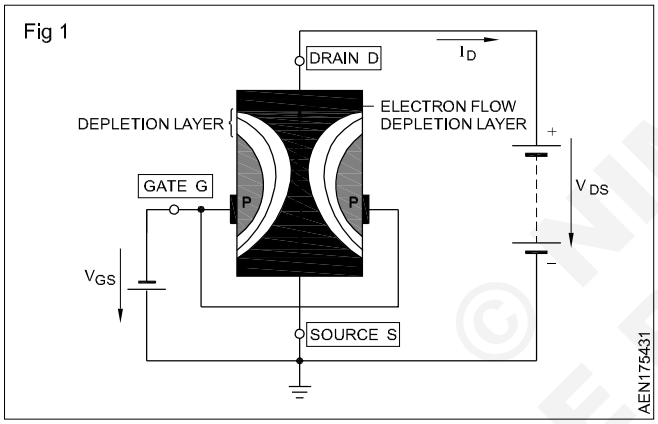
In simple terms it means that the main current in a bi-polar transistor is controlled by the base current.

FET is a voltage controlled device.

This means that the voltage at the gate controls the main current.

In addition to the above, in a bi-polar transistor, the main current always flows through N-doped and P-doped semiconductor materials. Where as in a FET the main current flows either only through the N-doped semiconductor or only through the P-doped semiconductor as shown in Fig 1.

Fig 1

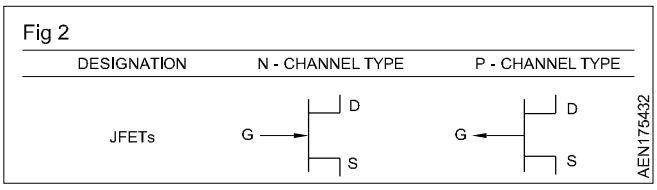


If the main current flow is only through the N-doped material,then such a FET is referred as a P-channel or P type FET.The current through the P-doped material in the P-type FET is only by Holes.

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.

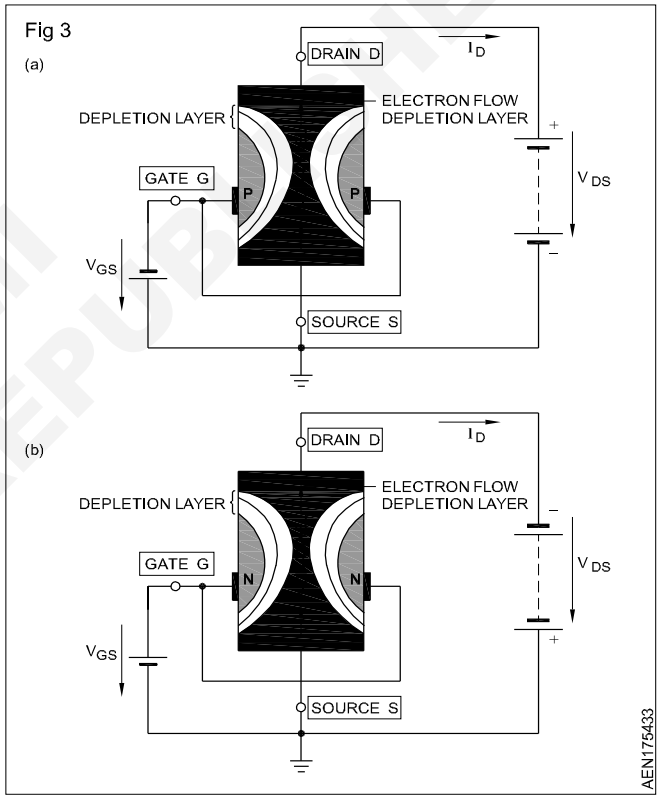
Fig 2



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.

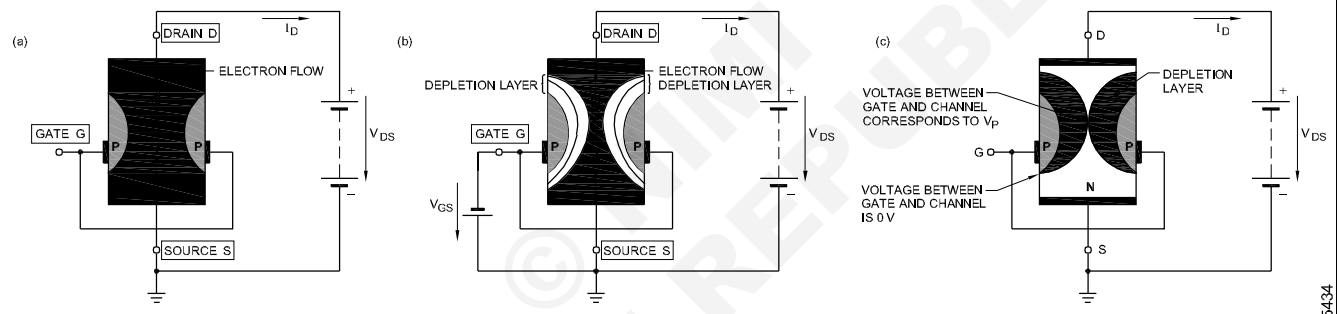
This depletion region decreases the width of the channel causing the drain current to decrease.

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



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.

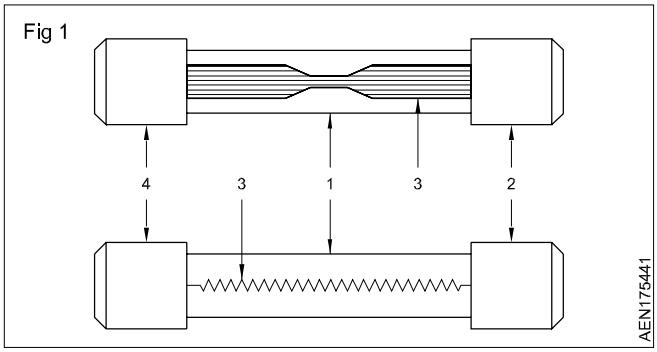
An electric current heats the wire when the current passes through it. The amount of heat depends upon the current and resistance in the wire.

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)

Fig 1



A fuse opens the circuit by blowing out when current (overload) flows in the circuit to prevent severe damage to the accessories.

The flow of excess current in a circuit may be caused by a short circuit.

Construction

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

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
- Reversel amp

Circuits without fuse

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

Fuse rating and colour

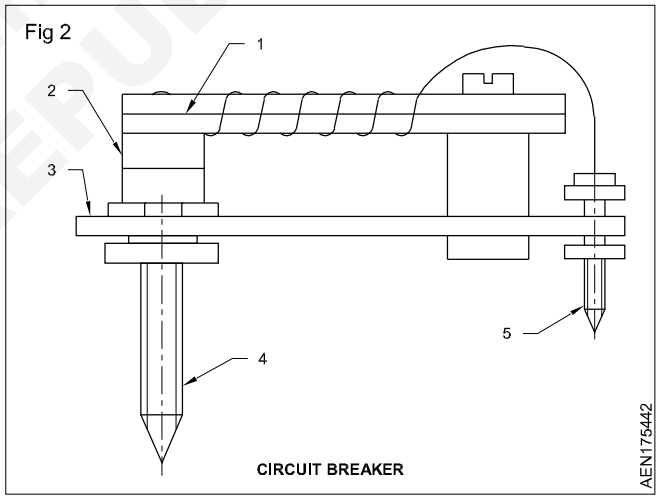
Rating	Colour
3 Amp	Violet
5 Amp	Tan
10 Amp	Red
20 Amp	Yellow
25 Amp	White
30 Amp	Light green

Circuit Breaker

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 willl 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.

Fig 2



Electrical circuit protection

Electrical circuit protection is the purposeful use of a failsafe device, that automatically causes a disruption in an electrical circuit when it recognizes an excess and unsafe load of power in a circuit common circuit protection devices and components include circuit breaker, fuses, surge protection and protective relays.

Circuit Breaker

Circuit breaker is a device for interrupting an electric circuit to prevent excessive current, as that caused by a short circuit from damaging the automotive parts in the electrical circuit or from the fire.

Fuse

A fuse is an electric/electronic or mechanical device which is used to protect circuits from over current, over load and make sure to protection of the circuit. Electric fuse as

invented by thomas alva edison in 1890. These are many types of fuses, but function of all these fuses is same. working principle of a fuse is based on the heating effect of current. Fuse ratting = (Power/voltage) x 1.25

For example (100 w/230v) x 1.25 = 5.4A

Cartridge fuses

Cartridge fuses are used to protect electrical appliances such as motors air conditions, refrigerators, pumps. There are two types of fuses.

1. General purpose fuse with no time delay and 2. Heavy duty cartridge fuses. with time delay cartridge fuses are enclosed in a base and can be divided in further in link type cartridge fuses and D type cartridge fuses. When the circuit is completed the tip of the cartridge make contacts through the fuse link conductor.

Blade type and bolted type fuses - These type fuses comes in plastic body and two metal caps to fit in the socket mostly, they used in automobiles for wiring and short circuit protection. Expect this fuse limiters, glass tube are widely used in automotive industry. The rating of vehicle fuses 12v to 42v._In bolted types of fuses, the base of the fuse contacted directly to the base of the fuse same like HRC fuses.

Maxi fuse

Maxi - fuse is a fast - acting blade fuse standard for vehicle circuit protestation designed to provide predictable time delay and low heat dissipation. Colour coded for easy identification of fuse ratings. Rated at 32v. maxi fuse circuit protection. maxi type fuses - Blade type, Glass tube type.

Positive temperature coefficient of resistance

A positive coefficient for a material means that its resistance increases with an increase in temperature. Pure metals typically (gold, silver, copper) have positive temperature coefficients of resistance, semi conductor materials (carbon, silicon, germamam) typically have negative temperature coefficients of resistance.

Fusible link

Fusible lniks includes mechanical and electrical devices. A mechanical fusible link is a device consisting of two strips of metal soldered together with a fusible alloy that is designed to melt at a specific temperature these allowing the two pieces to separate mechanical fusible linkes are utilized as the triggering device in fire sprinkler systems and mechanical automatic door relases mechanism that close fire doors in ware houses mechanical fusible links come in a variety of designs and different temperature ratings.

An electrical fusible is a type of electrical fuse that is constructed simply with a short pieces of wire typically four American wire gauge sizes. Smaller than the wire that is being protected for example an AWG - 16 fusible link might be used to protect AWG 12 wiring. Electrical fusible links are common in high - current automotive application. The wire in an electrical fusible link is encased in high - current automotive application. The wire in an electrical fusible link is encased in high - temperature fire - resistant insulation to reduce hazards, when the wire melts.

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 wiring circuit diagram**
- **state the American and metric wiring gauge**
- **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

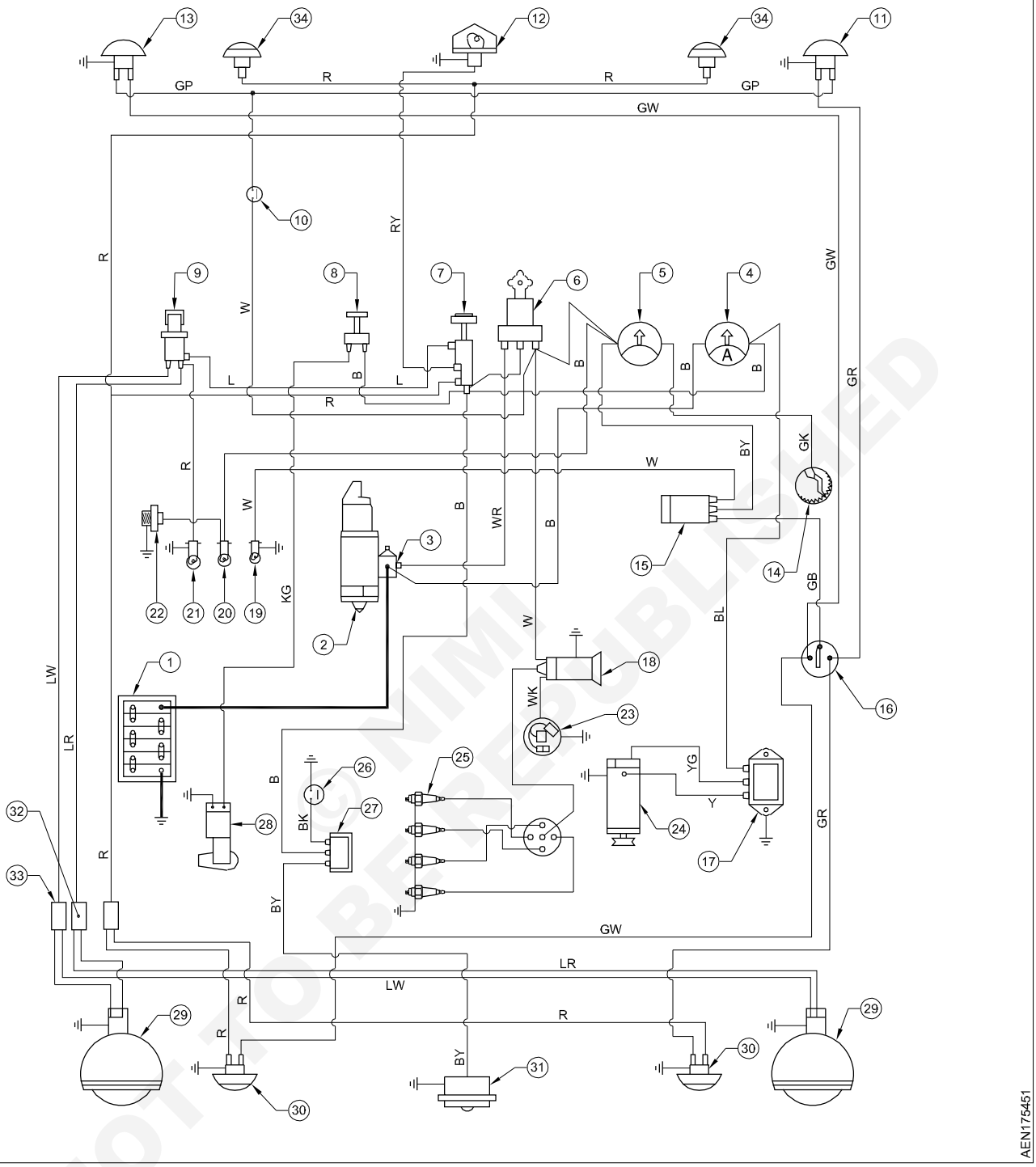
The specification of the cable refers to the number of stands and diameter of each strand. Eg. 25/012 indicates, the cable consists of 25 strands of 0.012" gauge diameter of each strand.

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.

Wiring and circuit diagram

Connection are used in automotive wiring. So many wires are complicated to inspect and tracing fault in automotive wiring circuit. Automotive wiring diagrams are help to speed up the whole process the wiring diagrams have many number codes and symbols in order for diagrams. To read the wiring diagram you should know the electrical symbols and wire colour code and numbers to read car wiring diagrams to trouble shoot and fix simple electrical system problems in no time. For the same reason wire colour codes and number are very easy to identify the wiring circuit to go to quickly find where the connector is located on the vehicle.

Fig 1



The wiring diagram need to find an open loop or a short to ground condition in specific wire, instead of having to remove all the carpeting and trims to follow the wires all the way to where the problem is, you can simply identify all the connector first, and then find their location. Then remove only the trims necessary to gain access to them.

Difference between the primary and secondary wiring

Primary wiring system carries low power systems 16 volts or less and secondary wiring carries the higher amperages to be found under hood. For example ignition coil.

Comparison between solid and stranded primary wire

Solid wire conductors are conducted of one single piece of metal. It is tougher than stranded conductor but rigid and less flexible than a stranded conductor stranded conductors are made of multiple small strands, which group together to make up a single conductor. It is more flexible than a solid conductor, but less durable.

Types of stranded constructions

- Bunch stranding
- Concentric stranding
- Unilay stranding
- Rope lay stranding

AWG

In the American wire gauge (AWG) system. Wire size diameter can be calculator by applying the formula D(AWG) = 005.92 (C36 - AWG/39) inch for the 00,000,0000 etc gauges you use -1 -2 -3, which makes more sense mathematically than double naught. This means that in American wire gauge every 6 gauge decrease gives a doubling of the wire diameter and every 3 gauge decrease doubles the wire cross sectional area - similar to dB in signal and power levels. An approximate but accurate enough D = 460* (57/64) $^{(awg+3)}$ or D = 460* (0.890625) $^{(awg+3)}$

Metric wire gauges

Metric wire gauge scale, the gauge is 10 times the diameter in millimeters. So a 50 gauge metric wire would be 5mm in diameter. Note that in AWG the diameter goes up as the gauge goes down but for metric gauge. It is the opposite. Probably because of this confusion most of the time metric sized wire is specified in millimeters rather than meteric gauges.

Ground strap function

The ground strap or ground wire is the cable that connects the engine block to the chassis or sometimes directly to the negative battery terminal. This strap completes the circuit for electrical for electrical accessories grounded to the engine block instead of directly to the chassis. The accessories may include the ignition system, alternator or any number of sensors of these, the alternator requires the most power flow because it produces upward of 200 amps to recharge the battery through its positive out put wire.

The ground strap and grounding system that helps keep your system simple may also prove it is undoing causing vehicle wide malfunctions resulting from few little frazed wires.

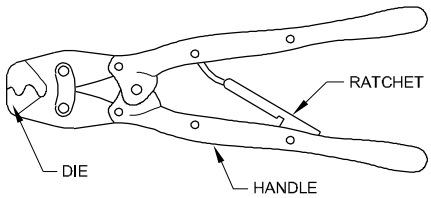
Types of wire terminals

Terminals are defined as a device designed to terminal a conductor that is to be affixed to a post, stud. Wire terminals come in many different shapes and sizes. Depending on sizes of the wire, terminals include ring, spade, hook, quick disconner bullet butt terminals and flagged wire terminals are available in insulated and non insulated, determining the best fit depends on usage. Wire insulation provides a protective cover serving as a non-conductor. The insulation spares the wire from water and moisture as well as protects against extreme heat or cold. wire insulation is typically available in vinyl, nylon and heat shrink non - insulated terminals provide much more economic value with its low cost also commonly used when extra protection is unnecessary.

Different types of wire termination

Crimp connection: In this type of connection the conductor is inserted into a crimp terminal and is then crimped with a crimping tool (Fig 1).

Fig 1



CRIMPING TOOL

Electrical connectors

While electronic circuit can process signals and produce output they almost always need to be connected to external components power source inputs or outputs. These connectors are done with the use of connectors and they come in many different types, shaps, sizes and ratings. Choosing the wrong connector for your design can cause a range of issues from bulky product szes to components catching fire so understanding the different types of connectors is imperative. While there are many connector types available (headers, sockets, DIN and DB)

Wire size and ampere ratings: Ampacity is the maximum current that a conductor can carry continuously under conditions of use without excading its temperature rating current is measured in amperes. `

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 of Fig 1).

The distinction between wires in a group is done by the use of a coloured bracer on the main colours of the insulator of each wire.

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 con

ductors 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.

Wire size		60°C (140°F)		75°C (167°F)	
AWG	(mm^2)	Copper	Aluminum	Copper	Aluminum
14	(2.1)	15	_	15	_
12	(3.3)	20	15	20	15
10	(5.3)	30	25	30	25
8	(8.4)	40	30	50	40
6	(13.3)	55	40	65	50
4	(21.2)	70	55	85	65
3	(26.7)	85	65	100	75
2	(33.6)	95	75	115	80
1	(42.4)	110	85	130	120
1/0	(53.5)	_	_	150	120
2/0	(67.4)	_	_	175	135
3/0	(85.0)	_	_	200	155
4/0	(107.2)	_	_	230	180
250 KCMIL	(127)	_	_	255	205
350	(177)	_	_	310	250
500	(253)	_	_	380	310
600	(304)	_	_	420	340

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. But adopting these methods, considerable length of cable is saved and more compact wiring is done.

Joining of wires by crimping and soldering

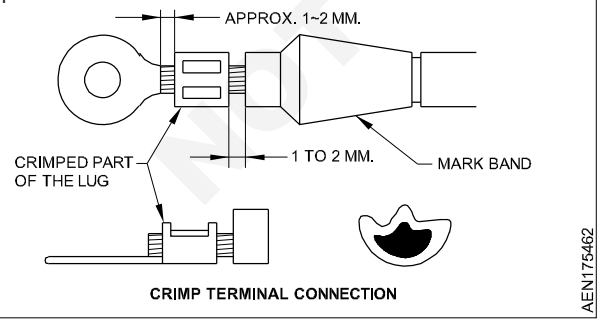
Objectives: At the end of this lesson you shall be able to
- **state the necessity of proper termination**
- **list the different types of terminations**
- **state the care needed for connections and terminals**
- **state the method of soldering the cable ends using an electric soldering iron.**

Necessity for proper termination: Cables are terminated at electrical appliances, accessories and equipment etc. for providing electrical connections. All terminations must be made to provide good electrical continuity, and made in such a manner as to prevent contact with other metallic parts and other cables.

Loose terminations will lead to overheating of cables, plugs and other connecting points due to higher resistance at those terminations. Fires may also be started due to the excess heat. Wrong termination like excess or extended conductor touching metallic part of the equipment may lead to giving shock to the person who comes in contact with the equipment. Touching of strands projecting from one terminal with other terminal leads to short circuit. To conclude, we can state that wrong termination will lead to overheating of terminating points and cables, short circuits and earth leakage.

It is important to choose a crimp terminal that matches the conductor diameter and the dimensions of the connecting screw terminal. (Fig 1&2)

Fig 1

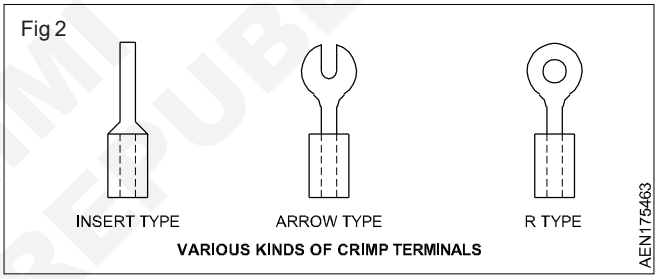


CRIMP TERMINAL CONNECTION

Insert screw setting: The conductor is inserted between the terminal block and the special form of washer (Fig 3), and then the screw is tightened.

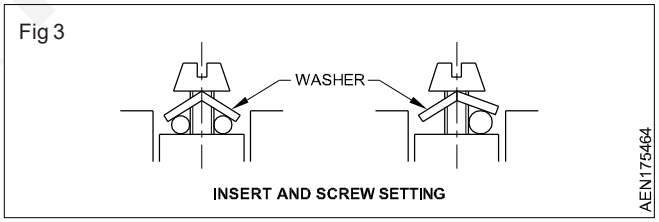
Screw on terminals with loop/ring conductor: A loop is formed clockwise in the bare portion of the conductor to match the size of the screw diameter. Then the loop is inserted to the screw and tightened. (Fig 4) In the case of a stranded conductor, soldering of the loop is essential to prevent strands getting fray.

Fig 2



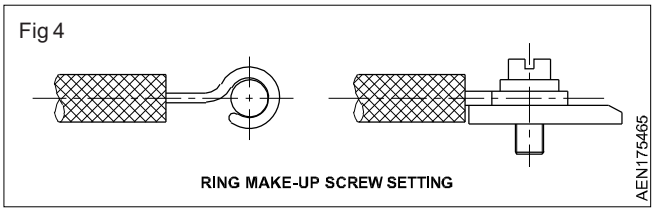
VARIOUS KINDS OF CRIMP TERMINALS

Fig 3



INSERT AND SCREW SETTING

Fig 4



RING MAKE-UP SCREW SETTING

Soldering

One method of termination is to solder the cable ends to the terminals. Soft solder is an alloy of tin and lead. It is used to join metals together by being melted on to a joint to provide a film that unites the surfaces.

For soldering of wires to a terminal, a solder, which will solidify rapidly, is needed. This shortens the time taken to perform the operation and lessens the risk of the components becoming displaced before the solder cools.

Cored solder: The solder used for electrical /electronic work is usually in a cored form having a core or cores of

resin flux. Cored solder 60:40 (60% tin 40% lead) is mostly used for electrical work.

Types of wire terminals and connectors

Molded connectors : Vehicular molded connectors in 6. pole, 3 pole, 2 pole configuration molded weather resistant PVC bodies car, trueks, trailors, boats.

Features

– Color coded for easy installation

– Polarized for proper mating of a circuits

– Terminals are precision aligned for maximum current carrying and disconnecting

– Flat type body.

Multiple - wire hard shell connectors : This connector is used for connect CPU, EDC and other electrical circuit boards. Multiple wire is connected with this hard shell connector.

Bulk head electrical connector: Bulk head connector is a term used to defies mounting style of connectors. These devices are designed to be inserted into a panel. The bulk head connectors are accurately molded of nylon or plypropylene material. These devices are regarded as a kind of coupler.

Weather pack connectors: Many different styles of connector are available including PVC heavy duty and weather proof. This type of connector is suitable type for all weather.

Metripack connectors: Metri pack system are designed to compactable with processing techniques such as automated push to seal and pull-to-seal assembly, dual stage crimping, load cell crimp inspection and automated parts identification and orientation.

The metripack connectors are idal for sealed and unsealed applications in motors, switches, sensors, junction boxes and other devices.

Heat shrink butt connectors: Heat shrink butt connector soap by water proof wire connector, electrical connectors wire terminals are insulated automotive copper connectors.

This type of wire connector increased the current flow and ensure less voltage drop, preventing wiring failures and reducing equipment down time wire never slipout of the connector, dual - walled tubing ensures water proof seal and prevents wire corrosion.

Importance of printed circuit board: The printed circuit board is very important in all electronic gadgets, which are used either for domestic use or for industrial purpose PCB design services are used to design the electronic circuit. A part from electrically connecting it also gives mechanical support to the electrical component.

Printed circuit board is used to connect electronic components using conductive pathways tracks or signal traces etched from copper sheets laminated on to a non-conductive substrate.

Wiring harness: The wire harness is a assembly of electrical cable or wires, which transmit signals or electrical power. The cable are bound together by a durable material such as rubber, vinyl, electrical tape, conduit a weave of extruded string or a combunation.

Wire harness provide several advantages over loose wires and cables by binding the many wire and cables into a cable harness the wire and cables can be better secured against the adverse effects of vibrations, abrasions and moisture.

By constricting the wires into a non- flexing bundle usage of space is optimized and risk of a short circuit is decreased and wire installation time also decreased and the process can be easily standardized. Binding the wires into a flame retardant sleeve also lowers the risk of electrical fires.

Ignition circuit

Objectives: At the end of this lesson you shall be able to
- **explain the different electrical circuits in automobiles**
- **explain the ignition circuit**
- **explain the need of ignition coils**
- **explain the need of condensers**
- **explain the need of spark plugs.**

Description of automobile electrical circuits

The present day automobile almost contains an electric power plant under its hood and stores electrical energy. This energy is delivered either at low voltage or in the form of high voltage surge.

The automotive electric system is classified under five main headings (Fig 1)

i Generation, storage and distribution system (charging system)

ii Starting system

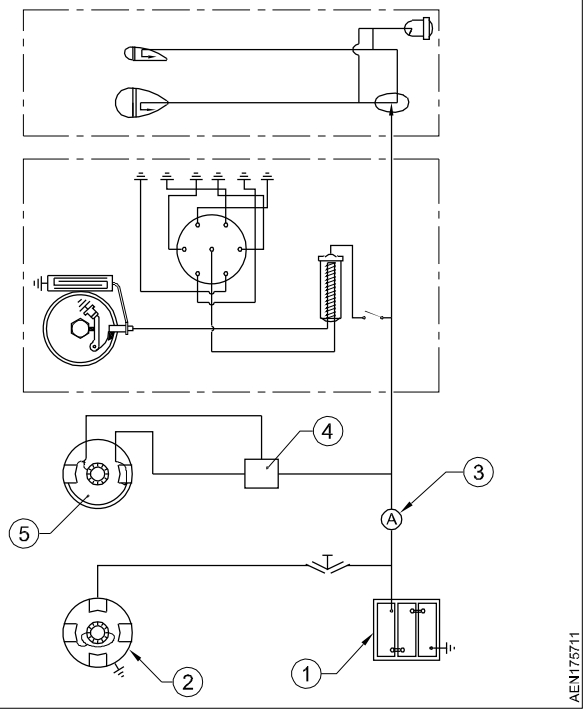
iii Ignition system

iv Lighting system

v Auxiliary system

All the circuits are connected together and linked to the car battery (1). The starting or cranking system is connected directly to the battery (1) through cables and switch to provide a low resistance path for the large current required by the starter motor (2).

Fig 1



The generating circuit is connected to the battery via the ammeter (3) which register in the charge when current is supplied to the battery (1). A control box (4) is provided in the circuit to control voltage and current. The control box (4) connects and disconnects the battery (1) and the generator (5).

The ignition primary circuits, the lighting circuit and the auxiliary circuits are connected to the same side of the ammeter (3) as in the generator so that when the generator is in operation they receive current directly from the generator (5). When the generator is not running, these circuits draw current from the battery. (1) All the circuits are controlled by the individual switches in between the battery and the load.

Ignition system

All spark ignition engines require an ignition system to ignite a fuel mixture in the cylinder. A very high voltage is required to generate sparks to ignite the cylinder charge at the set time. Two types of ignition systems are used.

i Battery ignition system

ii Magneto ignition system

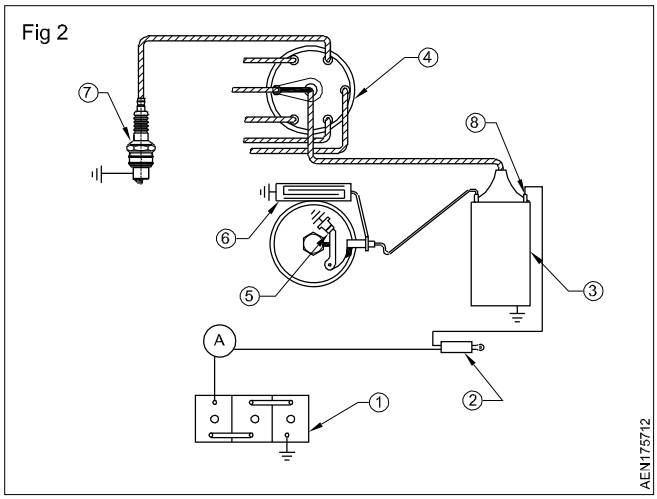
Battery ignition system (Fig 2): The battery ignition is used in passenger cars, light trucks and a few two wheelers. This system consists of the following parts.

i Battery	ii Ignition switch
iii Ignition coil	iv Distributor
v Contact breaker	vi Spark plug

Ignition switch

It is fitted on to the panel board in between the battery and the ignition coil. It connects or disconnects the primary circuit from the battery (1).

Fig 2

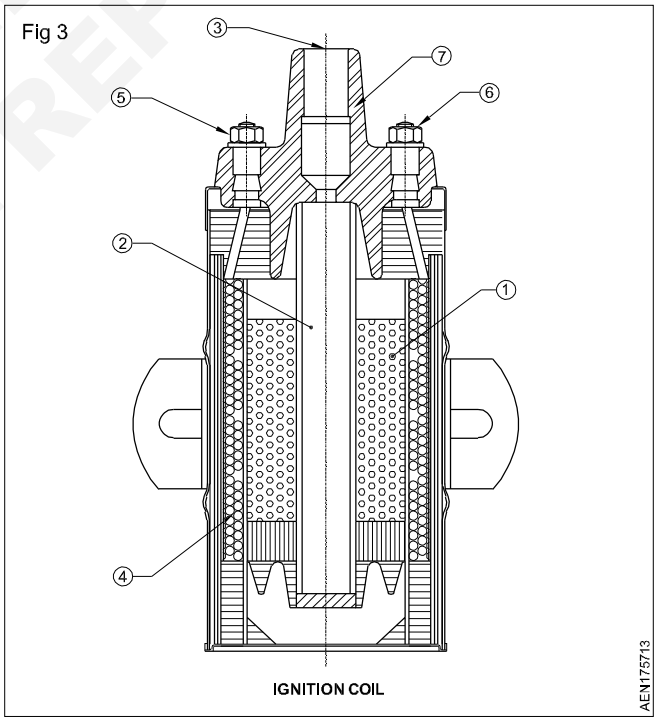


Ignition coil (Fig 3)

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 windings (1) is grounded over the core (2). It consists of about 21,000 turns. One end of the windings is connected to the secondary terminal (3) and the other end of 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). the bakelite cap (7) insulates the secondary terminal from the container and primary terminals.

Fig 3



Distributor: A distributor is fitted on the engine. It is driven by the engine camshaft. The distributor opens and closes the primary circuit of the ignition coil. It distributes the resulting high tension surges from the secondary winding of the ignition coil to the various spark plugs of the engine at a set time.

Contact breaker: It connects and disconnects the primary circuit at regular intervals to produce high voltage

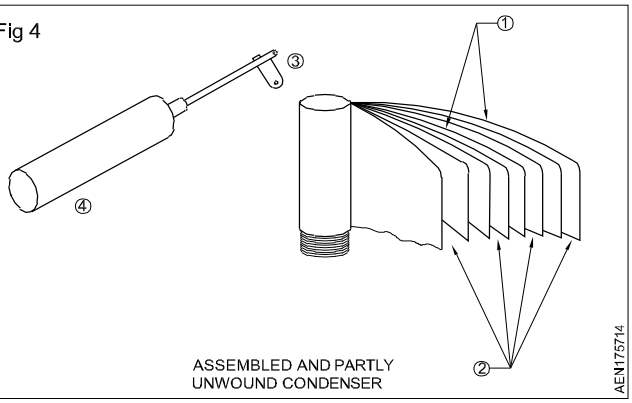
in the secondary winding of the coil. The points are two in number, one is directly fitted to the base plate and the other is insulated and operated by the rotating cam.

Condenser (Fig 4): 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 of the condenser case (4).

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.

Fig 4

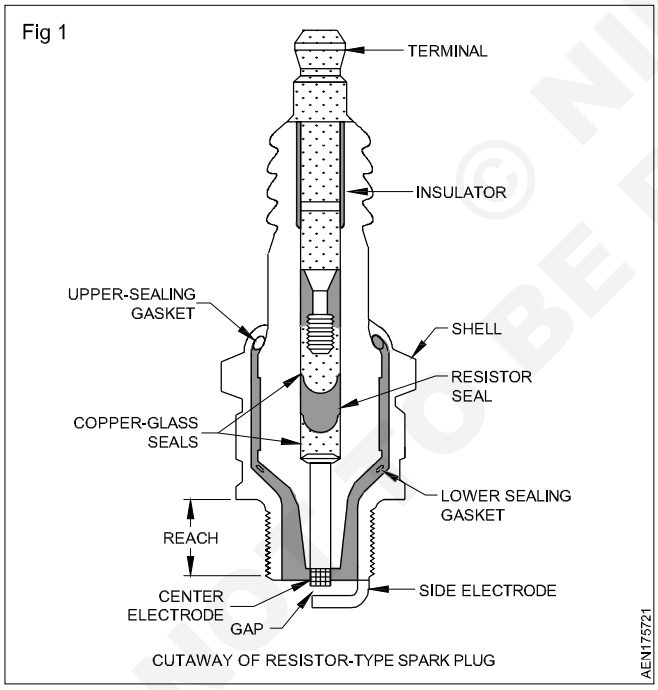


Spark plug

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.

Fig 1



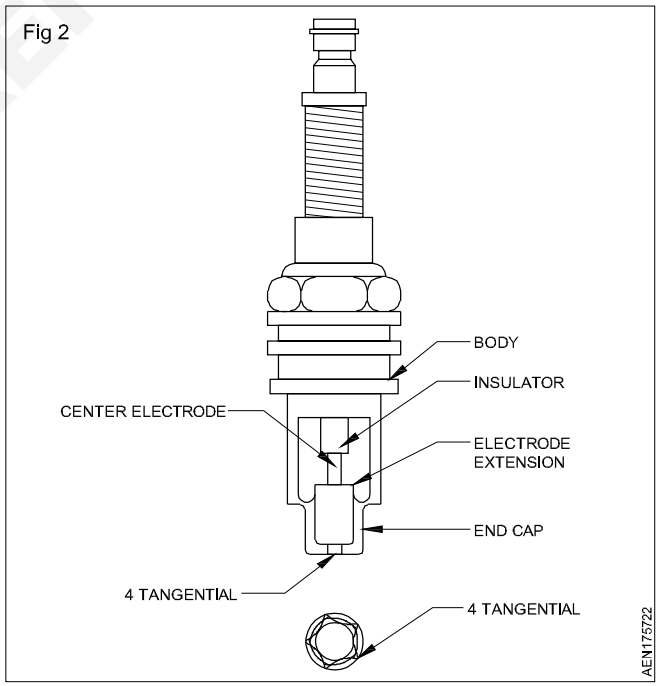
Explain the working of spark plug: The primary job of the ignition system is to produce the high - voltage surges that cause the sparks at the spark plug gaps. Fig 2 shows in simplified form, how this is done. The ignition coil has two windings: a primary winding of a few hundred turns of relatively 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.

Spark plug with end cap designed to improve combustion swirl. (Fig 2)

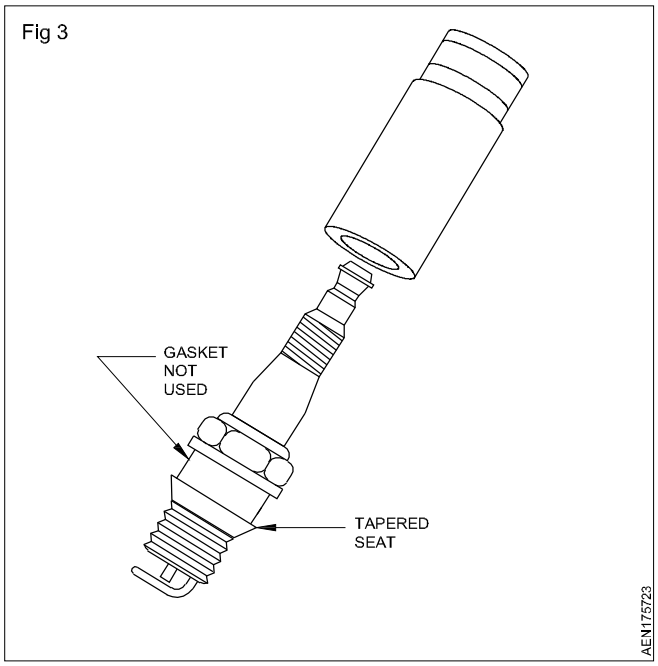
Fig 2



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.

Fig 3



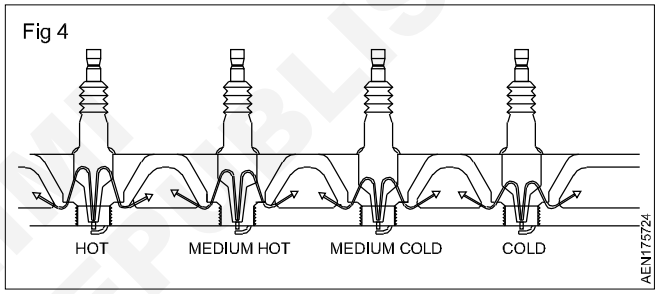
Precautions

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.

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



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.

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).

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.

Fig 1

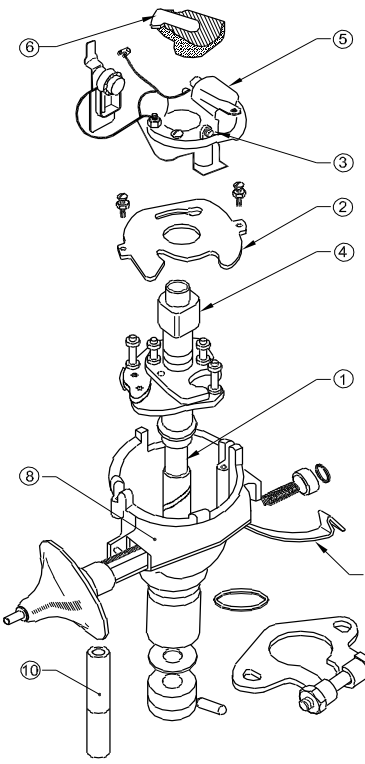
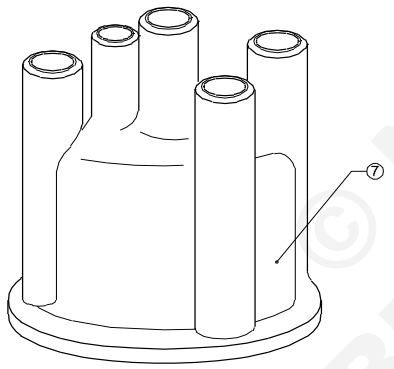
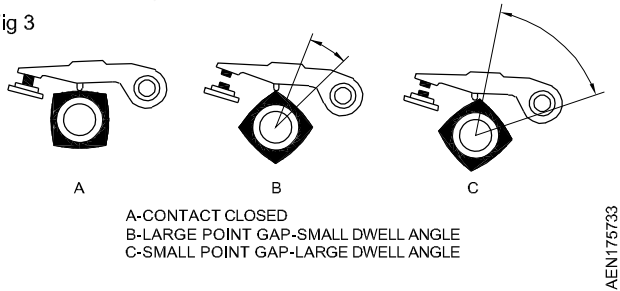


Fig 2



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



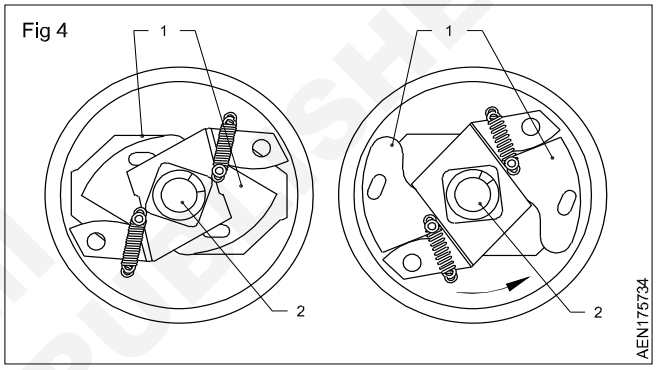
An advance mechanism is provided in the distribution to ensure that under every condition of engine operation, ignition take place at the set time. The advance angle is set in such a way that ignition occurs before the T.D.C of the piston to have better fuel economy. There are two types of advance mechanism.

i Centrifugal advance mechanism

ii Vacuum advance mechanism

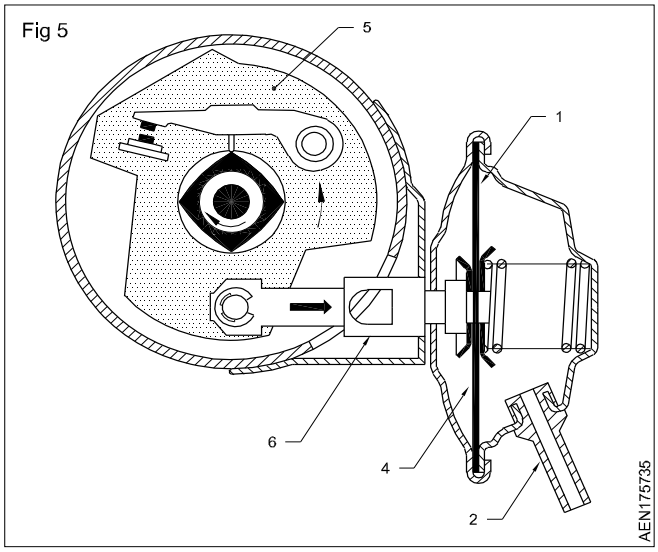
Centrifugal advance mechanism (Fig 4): The centrifugal advance mechanism consists of a pair of weighs (1) attached with the distributor shaft (2). As the speed of the shaft increases, the flyweights (1) swing outward and shift the cam in the rotation of the shaft. As a result the cam lobe contact the 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.

Fig 4



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.

Fig 5

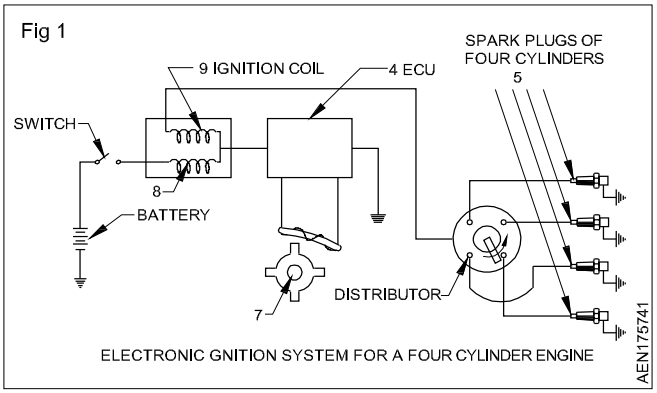


Electronic ignition system

Objectives: At the end of this lesson you shall be able to
- **describe the principle of electronic ignition system**
- **describe the pulse generator**
- **describe the hall effect sensor**
- **state the factors of electronic spark advance**
- **describe the distributor less ignition system.**

Principle of electronic ignition system (Fig 1): A timer (7) is used in the distributor(6) of electronic ignition system. It sends electrical pulses to an electronic control unit (4)(ECU) which switches off the flow of current to the primary winding (8). As a result, a high voltage is induced in the secondary winding(9) which is then distributed to the spark plugs (5) as in the case of the breaker point ignition system.

Fig 1



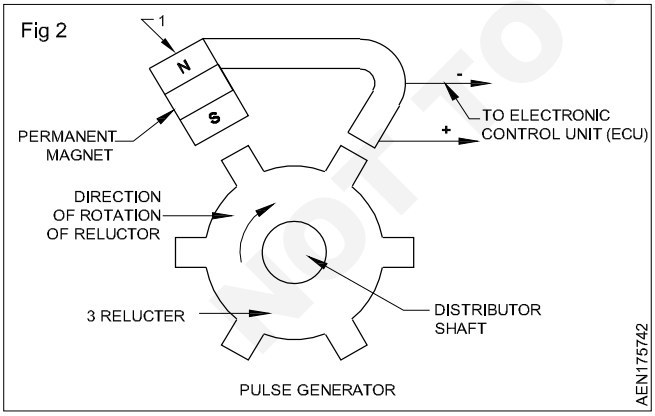
ELECTRONIC GNITION SYSTEM FOR A FOUR CYLINDER ENGINE

The electronic control unit later switches on the flow of current to the primary circuit so that the primary circuit current can be built up for the next cycle.

The timer may be a pulse generator or a hall effect sensor.

Pulse generator (Fig 2): A pulse generator consists of a permanent magnet (1), a timer (2) coil and reluctor (3). The permanent magnet and the time coil remain stationary. The reluctor is fitted to the distributor shaft and is in the shape of a wheel with teeth.

Fig 2



PULSE GENERATOR

When the distributor shaft revolves, the reluctor wheel rotates, its teeth moving very near to the pole plates of the permanent magnet.

The reluctance of the air gap between the other inductor tooth and the timer coil is reduced. At the same time, the reluctance of the air gap between the reluctor tooth and the magnet is also reduced.

This results in a strong magnetic field around the timer coil.

Current is permitted to flow through the timer coil to the electronic control unit, where the primary current flows. As a result, the ignition coil builds up a strong magnetic field.

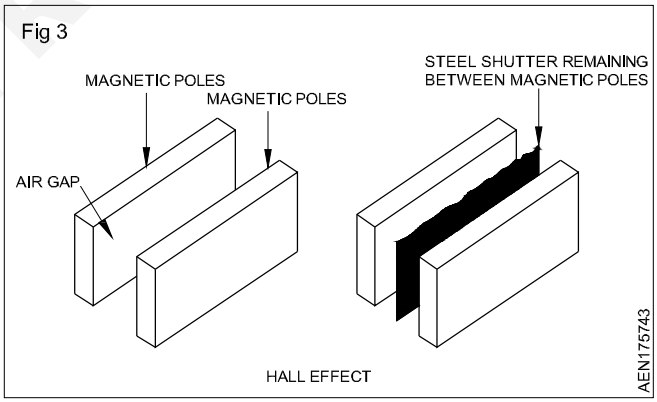
As the reluctor wheel rotates slightly further, the reluctor tooth moves away from the timer coil. The air gap becomes wider offering a high reluctance. This results in a weaker magnetic field for the timer coil and the induced voltage reverses. The flow of current to the primary circuit is stopped.

The magnetic field in the ignition coil collapses and enough high voltage is produced for producing spark at the spark plug.

The reluctor wheel in the figure has six teeth. This wheel is used for a six - cylinder engine. The reluctor wheel has the same number of teeth as there are cylinders in the engine.

Hall effect sensor (Fig 3): The hall effect was named after the scientist who discovered the effect. Magnetic sensors used in electronic distribution utilize the principle of hall effect.

Fig 3



HALL EFFECT

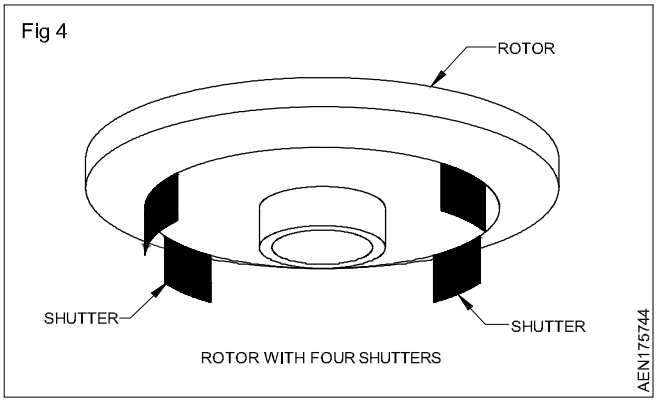
As shown there is magnetism in the air gap between the two poles of a magnet. When a steel shutter is placed or moved between these poles, the magnetism in the air gap is cut off. This principle is called hall effect.

A rotor with curved plates is used in the Hall effect distributor of an electronic ignition system. These curved plates are called shutters (Fig 4). The shutters are curved in such a way that they can move between the two poles of the magnetic sensor with the movement of the rotor.

The number of shutters is the same as the number of cylinder in the engine.

Whenever a shutter passes between the two poles of the magnetic sensor, it cuts off the magnetism in the air gap

between the poles. This sends a signal to the electronic control unit.



When a shutter moves away from the air gap, the magnetic sensor develops a voltage. ECU then receives a single from the magnetic sensor, to permit the current to pass through the primary winding of the ignition coil. However, when a shutter passes between the poles, the magnetic field is cut off and the signal voltage comes to zero.

When the ECU suddenly cuts off the flow of current to the ignition coil primary winding, the magnetic field collapses. This results in the production of high voltage in the secondary winding which gives rise to a spark in the spark plugs.

The Hall effect magnetic sensor is more accurate than the magnetic pulse generator explained earlier.

Electronic spark advance: The mechanical centrifugal advance mechanism and the vacuum advance mechanism are not used in some electronic ignition systems. However, the electronic spark advance systems are adopted in the electronic ignition system. To control the spark advance, several engine sensors feed information to a computer. The following information is fed to a computer:

i Movement of the throttle

ii Pressure of air

iii Temperature of air coming to the air cleaner

iv Temperature of engine coolant

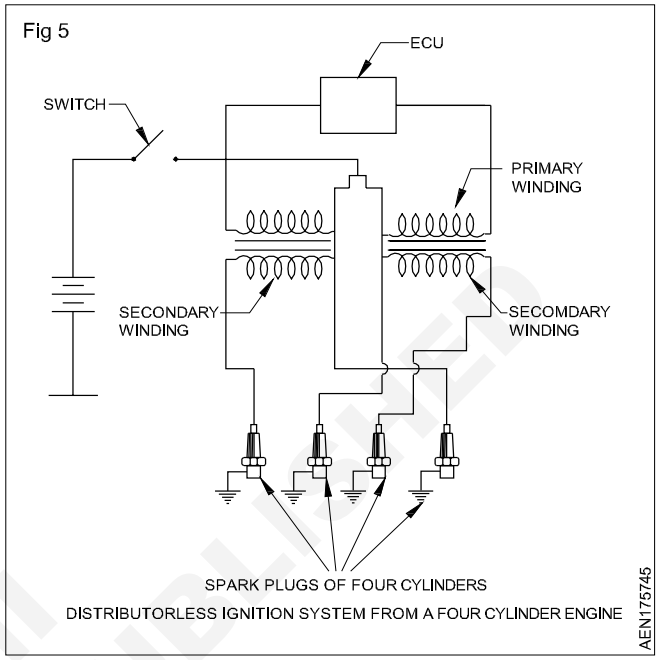
v Vacuum in the intake manifold.

vi Speed of the engine.

vii Position of the piston.

The sensors send the appropriate signals to the computer which then correlates the signals. After processing the information, the computer provides the best spark advance for the operating conditions.

Distributor less ignition system (Fig 5): This engine has no distributor. In this system, two spark plugs are ignited at the same time. Out of these two spark plugs, one provides ignition in one cylinder during its exhaust stroke. However, the ignition has no effect, as only burnt gases are present inside the cylinder during the exhaust stroke.



The other spark plug ignites the mixture in another cylinder when the piston is at the end of the compression stroke. Here normal combustion takes place.

In the ignition coil, there are two primary and two secondary windings. The rotary hall effect sensor on the crankshaft controls the flow of current through the primary winding and consequently, the production of high voltage in the secondary winding.

The trigger has two triggering points, one for each primary winding. Each triggering point sends a signal to the electronic control unit (ECU) so that the flow of current through one of the two primary windings is stopped. When the flow of current is stopped, the magnetic field in the primary winding collapses suddenly and a high voltage is produced in the secondary winding.

A four cylinder engine with the firing order 1,3,4,2 has a special arrangement in which cylinders 1 and 4 and cylinders 3 and 2 are paired.

In a six cylinder engine, which has no distributor, there are three pairs - cylinders 1 and 4, cylinders 5 and 2, and cylinders 6 and 3. Each ignition coil is a true transformer.

Starting system

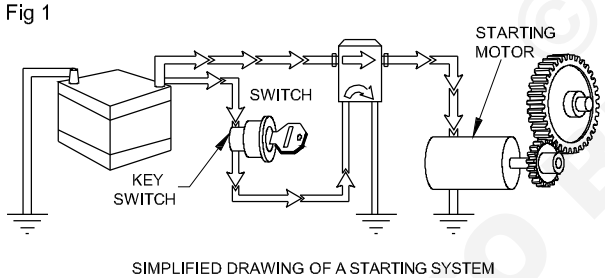
Objectives : At the end of this lesson you shall be able to
- **state purpose of the starting system**
- **describe the starting circuit**
- **state the principle of starting motor**
- **explain construction of starting motor**
- **explain operation of starting motor.**

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



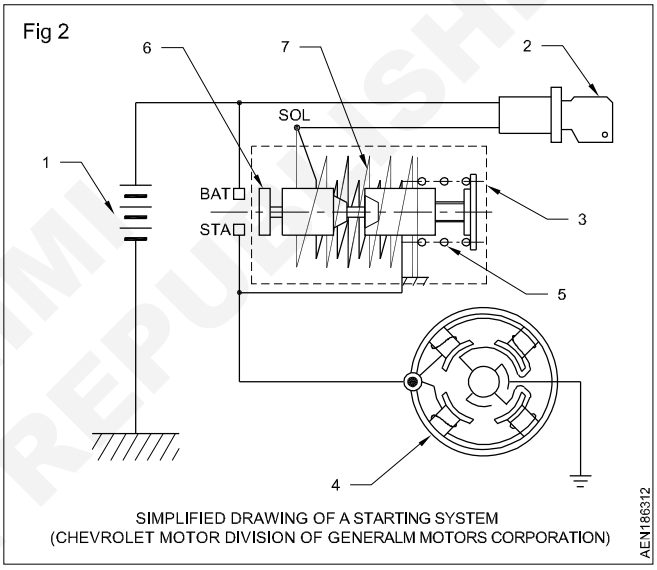
SIMPLIFIED DRAWING OF A STARTING SYSTEM
(CHEVROLET MOTOR DIVISION OF GENERALM MOTORS CORPORATION)

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.

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.

Fig 2



SIMPLIFIED DRAWING OF A STARTING SYSTEM
(CHEVROLET MOTOR DIVISION OF GENERALM MOTORS CORPORATION)

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

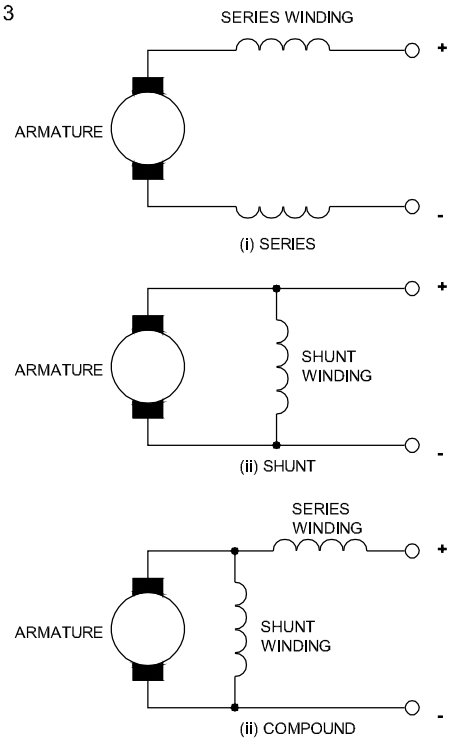
When a current is passed through an armature coil which is placed between two stationary magnets an e.m.f. is induced and the armature coil starts rotating.

Construction

Three kinds of DC starter motors are used. (Fig 3)

- Series
- Shunt
- Compound

Fig 3



SIMPLIFIED DRAWING OF A STARTING SYSTEM
(CHEVROLET MOTOR DIVISION OF GENERALM MOTORS CORPORATION)

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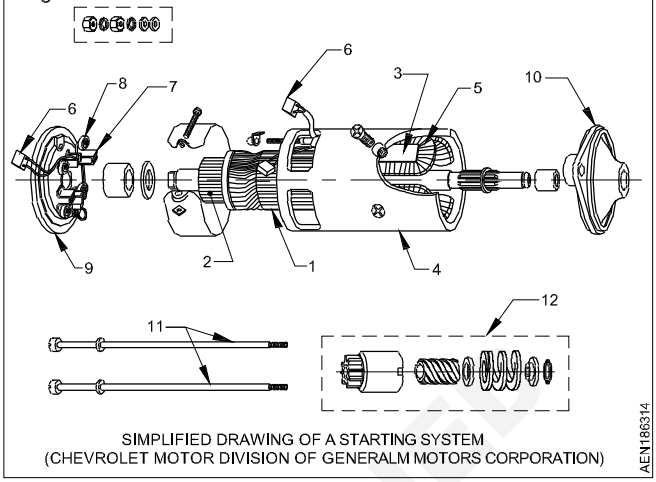
In automobiles the series wound type is generally used. In this the field and armature coils are connected in series. This enables the motor to produce a high starting torque. The armature windings (1), (Fig 4) are fixed in slots and their ends are soldered to the commutator segments (2). The pole shoes (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 4



SIMPLIFIED DRAWING OF A STARTING SYSTEM
(CHEVROLET MOTOR DIVISION OF GENERALM MOTORS CORPORATION)

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Operation of starter motor

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.

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 are three types

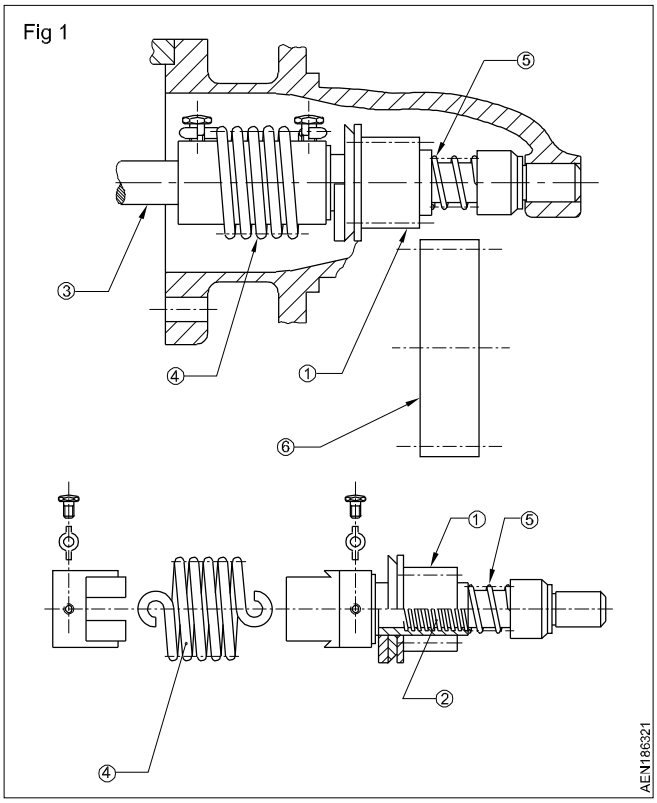
- Bendix drive
- Over-running clutch drive
- Axial or sliding armature type and non coaxial type

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



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 (Figs 2 & 3)

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. 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 2

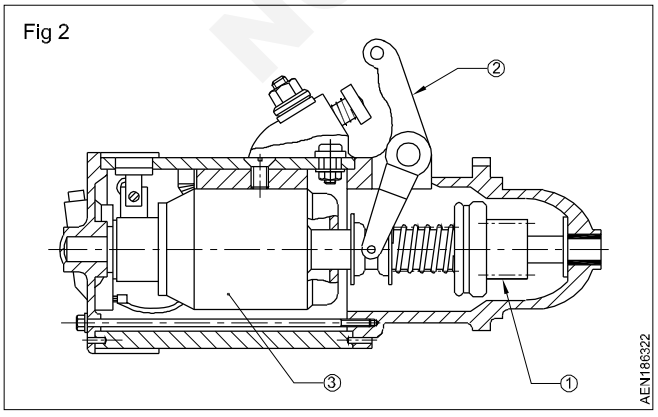
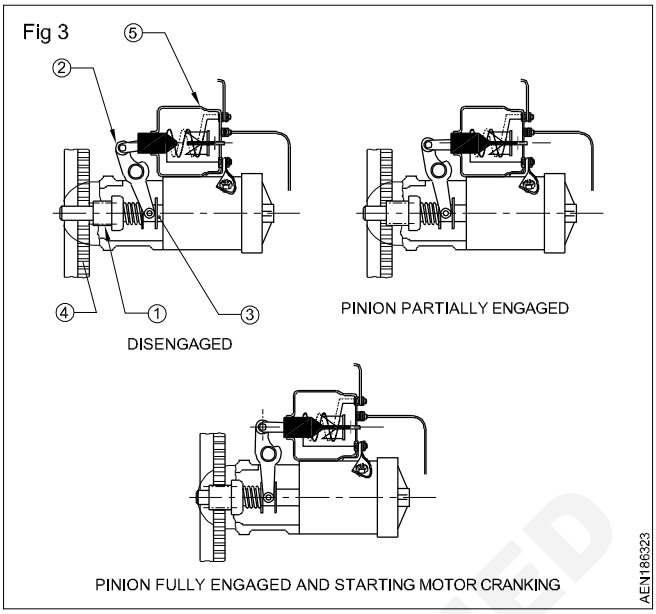


Fig 3

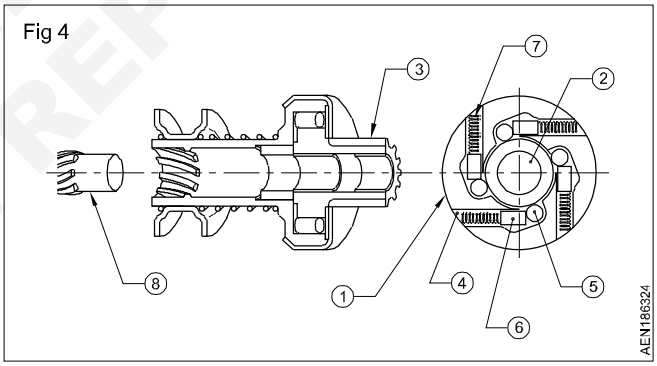


The over-running clutch (Fig 4)

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 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.

Fig 4

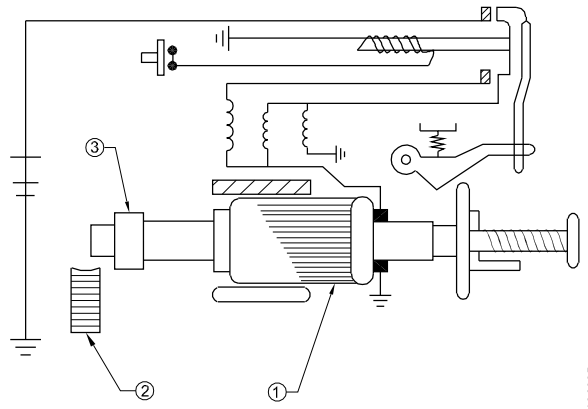


The pinion (3) is forced to rotate with the armature shaft and cranks the engine. When the engine starts its attempts to drive the armature shaft (8) cause the rollers (5) to rotate out of the small ends of the notches. This will release the collar (3) from the shaft. This allows the pinion (3) to rotate at high speed without driving the armature.

Axial or sliding armature drive (Fig 5)

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 auxiliary 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 5



AXIAL OR SLIDING ARMATURE DRIVE

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

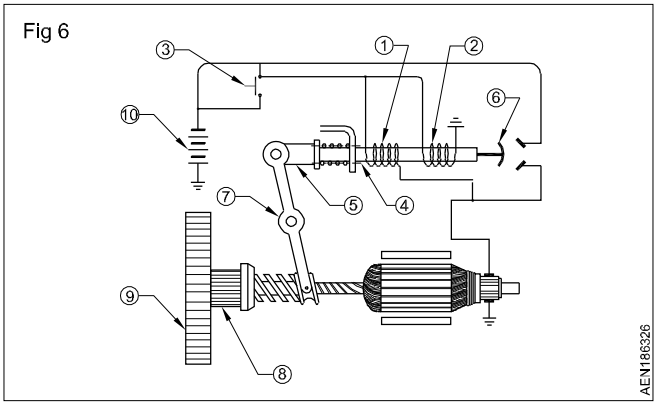
The solenoid switch is a strong electromagnetic switch. It is used to operate the over-running clutch drive pinion to engage with the flywheel ring gear. It also acts as a relay to close the contacts between the battery and the starting motor.

Construction of solenoid switch (Fig 6)

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.

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).

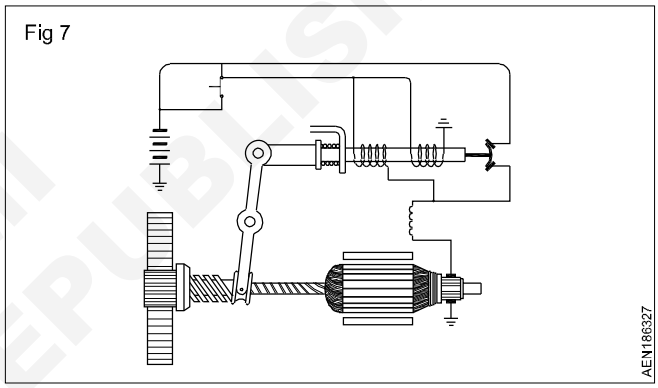
Fig 6



Function of solenoid switch (Fig 7)

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.

Fig 7



Trouble shooting in starting system

The condition, possible cause and the correction in trouble shooting a starting system as follows;

Condition	Possible cause	Correction / Reference item
Motor not running (No operating sound of magnetic switch)	Battery discharged.	Recharge battery
	Battery voltage too low due to battery deterioration	Replace battery.
	Poor contact in battery terminal connection.	Retighten or replace
	Loose grounding cable connection	Retighten.
	Fuse blown off	Replace fuse.
	Poor contacting action of ignition switch and magnetic switch	Replace ignition switch and/or magnetic switch.
	Lead wire coupler loose in place	Retighten
	Open circuit between ignition switch and magnetic switch.	Repair.
	Open circuit in pull in coil	Replace magnetic switch.
	Brushes are seating poorly or worn down	Repair or replace brush assembly
	Poor sliding of plunger and/or pinion	Repair
	Faulty starting motor control relay	Replace starting motor control relay.
	Faulty ECM and its circuit	Check ECM
Motor not running (operating sound of magnetic switch heard)	Battery discharged.	Recharge battery
	Battery voltage too low due to battery deterioration	Replace battery.
	Loose battery cable connections	Retighten.
	Brushes are seating poorly or worn down	Repair or replace brush assembly
	Weakened brush spring	Repair or replace brush assembly.
	Burnt commutator	Replace armature.
	Layer short-circuit of armature	Replace armature.
	Crankshaft rotation obstructed	Repair.
Starting motor running but too slow (small torque) (If battery and wiring are satisfactory inspect starting motor)	Insufficient contact of magnetic switch main contacts	Replace magnetic switch
	Layer short circuit of armature	Replace armature.
	Disconnected, burnt or worn commutator.	Repair or replace armature.
	Worn brushes	Replace brush assembly.
	Weakened brush spring	Repair or replace brush assembly.
	Burnt or abnormally worn end bush	Replace bush.
Starting motor running, but not cranking	Worn pinion tip	Replace over-running clutch.
	Poor sliding of over-running clutch	Repair.
	Over-running clutch slipping	Replace over-running clutch.
	Worn teeth of ring gear	Replace flywheel.
Noise	Abnormally worn bush	Replace bush.
	Worn pinion or worn teeth of ring gear	Replace over-running clutch, flywheel.

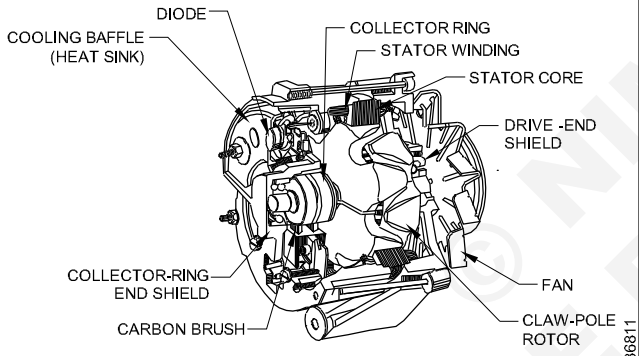
Alternator

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 begining, 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.

The vehicles in large cities have to,offten,move at very slow speeds due to heavy traffic. 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.

Fig 1



SECTIONAL VIEW OF BOSCH CLAW-POLE ALTERNATOR

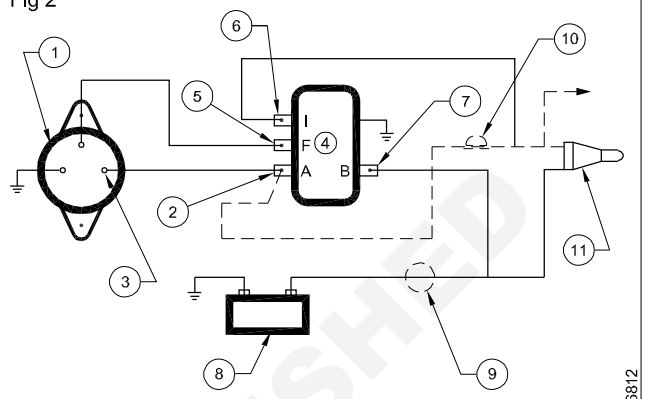
Alternator wiring circuit in a vehicle (Fig 2): The alternator's (1) output terminal (3) is connected to the 'A' terminal (2) of the voltage regulator. The alternators (1) field terminal (5) is connected to the 'F' terminal of the voltage regulator (4). The 'B' terminal of the regulator is connected 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.

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 shft is mounted and encased between drive end frame and slip ring end frame.

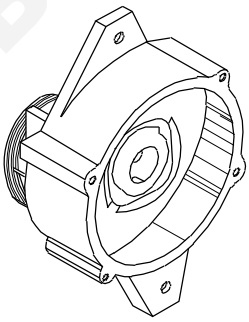
The rotor assembly (Fig 4): This consists of a steel shaft which carries the driving pulley and cooling fan, a cylindrical iron core, and two insulated slip rings. A large number of turns of insulated wire are wound over the core to from the field winding.

Fig 2



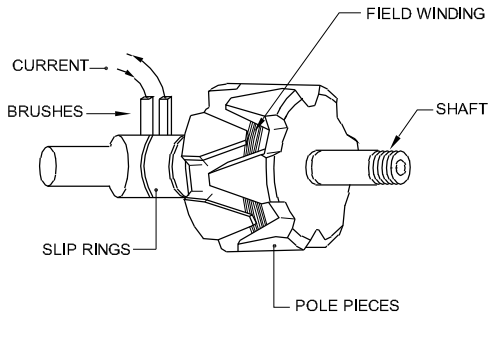
ALTERNATOR WIRING CIRCUIT IN A VEHICLE

Fig 3



DRIVE END FRAME

Fig 4



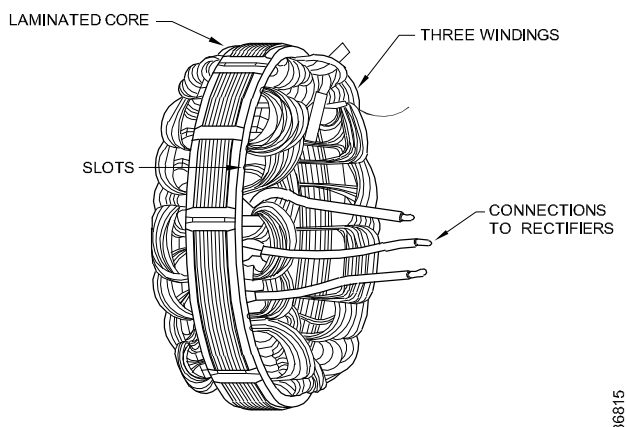
Each end of the winding is connected to its own slip ring and spring-loaded brush. The winding is enclosed by two iron pole pieces with eight interlocking fingers which be come alternate north and south poles when direct current is passed through the winding via the brushes.

Stator assembly (Fig 5): It is a stationary part which is help between two end covers. (Fig 1 & 5)

This consists of laminated, cylindrical, iron core which is slotted to permit the fitting of three sets of insulated windings. In the lighter units these windings are star connected and in the heavier units delta connected. The number of coils depends on the number of poles.

The 'N' pole and 'S' pole of the magnet pass each stator winding and due to interruption of the magnetic flux the current is generated in the stator windings.

Fig 5



STATOR ASSEMBLY

Diodes: The diodes are made of silicon and these allow current to flow in one direction only. They are so connected as to allow the current to flow the alternator to the battery but not in the opposite direction.

Three diodes on the negative side are connected to the rear end housing and three diodes on the positive side are mounted on an insulated heat sink.

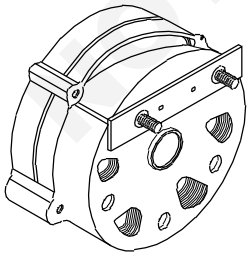
The diodes convert the AC produced by the alternator to DC since the automobile accessories are designed to utilise DC current.

Slip ring end frame (Fig 6)

The slip ring end frame supports the rectifier mounting plates and a pre-lubricated bearing for rotor/shaft rotation.

The rectifiers are pressed into the slip ring end head or heat sink and are connected to the stator leads.

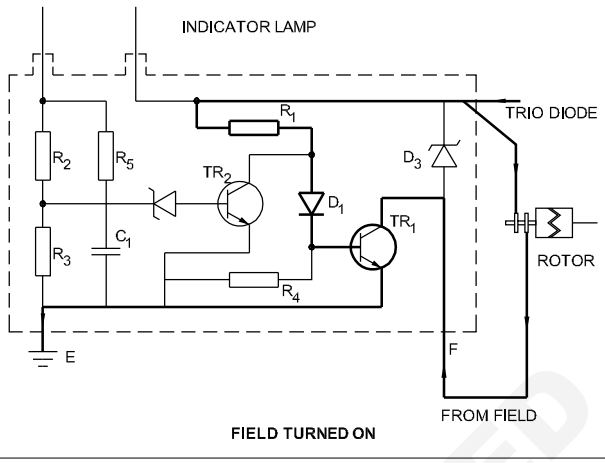
Fig 6



SPRING END FRAME

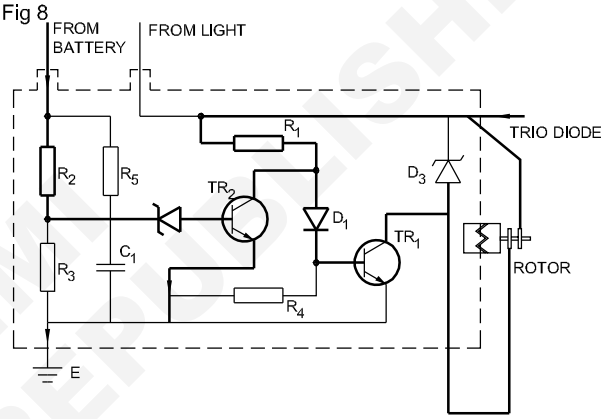
Electronic regulator (Fig 7 & 8): To protect the battery and the accessories against high voltage, the alternator voltage must be controlled. This is done by using a voltage regulator which varies the current flow to the rotating field (rotor). The regulator work is done by electronically.

Fig 7



FIELD TURNED ON

Fig 8



FIELD TURNED OFF

A transistor regulator consists primarily of resistors, capacitors (condensers), diodes and transistors. It is a complete static unit which controls the alternator voltage. It is durable and efficient. It safely allows a high field-current flow, and it has a longer service life than the vibrating contact regulator. An equally important feature is the ease with which it can be tested, adjusted and serviced.

When the permanently magnetized rotor rotates, an alternating voltage is induced in the stator winding which is rectified by the three negative and three positive diodes and DC current flows into the battery. The rectified current of each phase winding also flows over diodes D1,D2, D3, into the regulator to resistor R1, to the collector of resistor TR3 and to the resistor R3, to the ground. The transistor TR3 is not switched on because the low voltage allows zener diode D6 and diode D5 to block the base circuit. However, transistors TR2 and TR1 are switched on because current can now flow over both emitter bases to ground.

With both transistor switched on, current from the output terminal of the alternator supplies current to the regulator over resistor R5 to the field coil and transistor TR1 (collector elements) to ground. Output current also flows from resistor R5 to resistor R2 and R4 to ground. As charging voltage increases, the voltage impressed across

resistor R4 is also impressed across diode D5 and zener diode D6.

When the breakdown voltage is reached, transistor TR3 switches on because the emitter-base circuit ground is completed. This causes TR2 and TR1 to shut off since current now flows over the lower resistance circuit from resistor R1, transistor TR3 (collector-emitter) to ground, robbing the current flow from transistor TR2. The field current flow stops. As system voltage decreases, diodes D5 and D6 stop conducting current and transistor TR3 shuts off. This cycle repeats many times per second to maintain present alternator voltage. The capacitors C1, C2 and C3 and diode D4 perform the same function.

Operation of alternator (Fig 9)

When the engine is started, the belt drives the rotor (3) assembly.

During rotation the 'S' poles and 'N' poles of the rotor magnet pass through each stator coil (4).

Due to this rotation of the rotor assembly the current is generated in the stator coil (4), alternatively positive and negative.

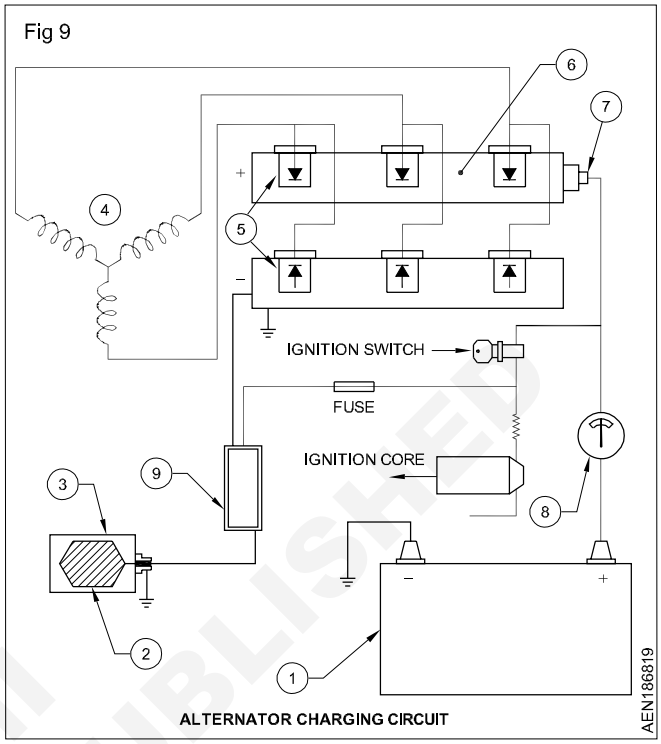
If more roto magnets pass through each stator coil (4) in a given time, the generation of current will be more, since they from the ends of metal fingers each finger acting like a magnet. These fingers interlock but do not touch each other.

The current produced is allowed to pass through silicon diodes (5)mounted on the heat sink (6). The diodes convert the AC to DC.

The heat produced in the diodes is dissipated by the heat sink.

The current passes through the battery terminal (7), the ammeter (8) and to the battery (1) for charging.

Fig 9



ALTERNATOR CHARGING CIRCUIT

Electronic diesel control (EDC) system

Objective : At the end of this lesson you shall be able to
- **state the function of electronic diesel control system.**

EDC system

Electronic diesel control system (Fig 1 & 2) is provide in diesel fuel system for diesel control and precise metering and delivery of of fuel into the combustion chamber of CRDI diesel engine.

Fig 1

ELECTRONIC DIESEL CONTROL DEVICE

AEN197311

The electronic control system provides greater ability for precise measuring data processing environment flexibility and analysis to ensure efficient diesel engine operation.

– It receives to ensure efficient diesel engine anelyze/ calculate it and sends the instruction to the actuators.

– It converts information from analog to digital.

– It consists of microprocessors to process the information from sensors to ECM and ECM to actuators.

– Number of microprocessors depends upon the number of sensors and actuators.
  - It also consists of memory to store the data.
  - Speed is in the form of 8 Bit, 16 Bit, 32 Bit, 64 Bit etc., to pass the information from sensor to ECM, ECM to actuator and also in networking system.
  - Individual programmes have to be made for each sensor and actuator.

Main control systems in diesel engine

- It controls the fuel for idling.
- It controls the fuel for high speed.
- It controls the fuel according to the speed and load conditions.
- It controls the exhaust gas recirculation (EGR) valve.

Working

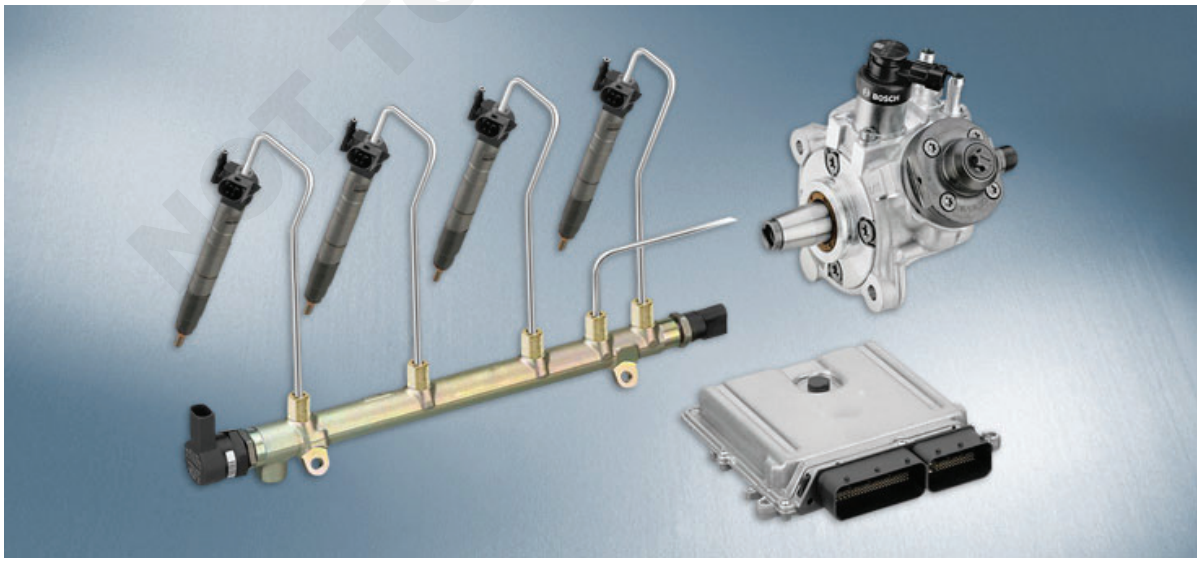
It gets the input from the different sensors named are as follows.

1 Throttle position **TP** (intake air quantity)

2 Cam position **CMP** (for valve timing)

3 Crank position **CKP** (for RPM and firing order)

Fig 2



COMMON RAIL WITH FUEL INJECTORS

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4 Engine coolant temperature **ECT** (Cylinder temperature)

5 Inlet air temperature **IAT** (temperature of inlet air)

6 Manifold absolute pressure **MAP** (inlet air pressure)

7 Oxygen $\mathbf{O_2}$ (percentage of oxygen in exhaust gas)

After receiving the above inputs, it analyzes/calculates the amount of fuel is required for the cylinder, accordingly it supplies the voltage to the injector solenoid. The solenoid will open the injector to supply the fuel into the combustion chamber. The minimum injector opening period is $1/10^{th}$ second.

Minimum 3 important sensors (TP, CKP & CMP) inputs are required at the time of starting, if any one of the sensor fails, engine does not start.

Rest of the sensors (IAT, ECT, MAP, and O2) fails; engine will start but the performance of the engine will affect.

- **In a vehicle minimum one EDC/ECM is required**
- **More than one EDC/ECM are used depends on number of controls.**

Example of control units EDC/ECM in a vehicle

1 Engine management

2 Automatic transmission

3 Power steering

4 SRS (Air Bag) supplemental restraint system

5 ABS (Antilock braking system)

Exhaust gas recirculation (EGR) EGR valve allows the exhaust gases into the inlet manifold, to burn the unburn gases to reduce the emission.

The opening angle of the valve is controlled by the EDC, depending upon the amount - (%) of oxygen passing through exhaust gases.

EDC gets the percentage of oxygen from the oxygen sensor.

Sensor

It senses the information in the form of physical or chemical variables and sends that information to the ECM in the form of voltage i.e. between 0-6 volts or 0-12 volts.

Ex: Throttle valve opening position (angle) information sends to the ECM in the form of voltage.

ECM

It analyzes or calculates the information which have come from the sensors and gives the instruction to the actuators.

Ex: It supplies the current to the solenoid to open the injector opening duration depends on Inputs

Actuators

Based on instructions from the ECM, it does the mechanical work.

Ex: Injector open duration depends on ECM instruction.

Schematic layout system components

Input from senders & switches
Engine speed sender CKP
Hall sender CMP
Accelerator pedal position APP
Air mass meter HFM
Intake air temperature IAT
Coolant temperature ECT
Radiator outlet coolant temperature
Charge pressure sender G31
Fuel temperature sender
Fuel pressure sender
Exhaust gas recirculation potentiometer
Lambda probe
Exhaust pressure sender
Cutch position
Throttle valve potentiometer
Brake light switch

→ **ECU** →

Output from ECU
Fuel pump relay
Fuel pump for pre-supply
Injection valves
Valve for fuel dosage
Fuel pressure regulating valve
Solenoid valve for charge pressure control
Intake manifold flap motor
Throttle valve module
Exhaust gas recirculation valve
Radiator Fan
Automatic glow period control unit
Lambda probe heater

Electronic Control Module (or) system (ECM)

Objectives: At the end of this lesson you shall be able to
- **describe E.C.M Electronic control module (or) system**
- **state the various control system**
- **explain the fuel injection control system**
- **explain the fuel pump control system**
- **explain the injection control system**
- **explain the radiator fan control system.**

Electronic control system: The electronic control system consist of various sensors which detect the state of engine and driving conditions, ECM which controls various devices according to the signals from the sensors and Various controlled devices. The control systems are as follows

- Fuel injection control system
- Idle speed control system
- Fuel pump control system
- Radiator fan control system

Idle speed control system: This system controls the bypass airflow by means of ECM & IAC valve for the following purposes. To keep the engine idle speed as specified at all times. The engine idle speed can vary due to load applied to engine, to improve starting performance of the engine to compensate air fuel mixture ratio when - decelerating, to improve drivability while engine is warmed up. IAC valve operates according to duty signal sent from ECM. ECM detects the engine condition by using the signals from various signals and switches and controls the bypass airflow by changing IAC valve opening. When the vehicle is at a stop, the throttle valve is at the idle position and the engine is running, the engine speed is kept at a specified idle speed.

Fuel pump control system

ECM controls ON/OFF operation of the fuel pump by turn

E.C.M and sensors used in engine

Objectives: At the end of this lesson you shall be able to
- **state the location and uses ECM and various sensor**
- **describe the working of ECM**
- **state the functions and working principle of sensors.**

Electronic Control unit (ECU): Electronic Control unit receives the variety of information from different sensors and controls a series of actuators on an internal combustion engine to ensure the optimum running. ECU may be named as Engine control unit (ECU), Engine control module (ECM), Powertrain control module (PCM) etc. For explanation purpose ECU is divided into two portion inside and outside.

Inside the ECU we have a micro computer. Micro computer consists of RAM - Data supplied by the sensor is stored. Here the information are stored temporarily. It also records strategy results in RAM including adaptive strategy values such as fuel trim. Diagnostic trouble codes are also recorded in RAM when the computer determines that a fault exists. There are two types of RAM, Volatile and non-volatile. A volatile RAM must have constant source of voltage from battery, memory gets erased when disconnected from power source. A non-volatile RAM does not lose its stored information if its power source is disconnected.

ROM: Software (reference value) stored permanently.

It contains permanently stored information that instructs the micro processor on what to do in a very basic and in response to input data.

PROM: It is same as that of ROM but programmed with regard to specific vehicle. Information stored in the PROM is stored in the form of electronic charts or tables. These tables are referred as Maps. These charts enable microprocessor to respond to a specific combination of input conditions when making a decision concerning an actuator. In modern vehicle PROM IC may be reprogrammed on order to update the computer strategies as needed. The term ROM, PROM and RAM are standard through the computer industry but vehicle industries may not use the same term.

Microprocessor: It is a heart of a computer and has the task of making all decisions. It records input information, then compares with internal program. It then sends the proper commands.

Outside the ECU we have socket or connectors

Inputs for ECU: Circuits which feed information to ECU. Sensor circuits - Sensor either generates a voltage or changes resistance and then modified voltage sent to ECU.

Diagnostic Monitor circuit: Feed back circuit which monitors the output values. Feed back circuit informs the ECU whether the relay has actually energized or not. The use of such feedback circuits enhances the computer ability to aid the technician in diagnosis of these systems.

Informational input circuits: Information from other ECUs shares with each other for belter co-ordination. Output of one ECU is input to other ECU. Signals from

the driver or passenger such as switching on A/C etc. Signals from the technician so as to identify the various causes for malpractice of sensors and others.

Output for ECU: Actuator Circuit. Theses circuit allow the computer to control the required actuators viz. warning lights, relay of motor, solenoid etc.

Informational output circuits: Messages to other ECUs Signals to driver or passenger, viz coolant temperature more, rear de-froster turned on etc. Signals to technician, when the technician makes a request to ECU for diagnostic trouble code, the ECU will respond by talking back to the technician in some way. On modern vehicle the computer communicates the same information via scan tool through binary code.

Data buses: When ECU communicates with other ECU they communicate through circuits called serial data bus.

Manifold air pressure: It is located at Inlet manifold, it is used to measures the absolute pressure in the intake manifold and compares it with a reference vacuum. This information is required to knows how much load the engine is under. This data is the basis for fuel delivery and timing control.

How it works : It is comprised of a silicon chip in which a thin diaphragm has been etched micromechanically. Four deformation resistors are diffused on the diaphragm. their electrical resistance changes when mechanical force is applied the measuring element is surrounded on the component side by a cap which, at the same time encloses the reference vacuum.

Throttle position: It is located on the throttle body, it is used to register the angle of rotation of the throttle valve and the speed of its movement. This information is required to measure engine load, adjust timing, fuel delivery, EGR, converter clutch operation. It is an emergency signal in case of a failure of the primary load sensor (MAF).

How it works: Resistive type sensor based on potentiometric sensor. The sensor's rotor is attached to the throttle valve shaft, and when the throttle valve moves, the sensor's special wipers move over their resistance tracks so that the throttle's angular position is transformed into a voltage ratio.

Intake air temperature: It is located at the air intake track, it is used to detect temperature of the incoming stream. It is the part of MAF sensor. This information is required, to heat the incoming air by engine if intake air temperature is below the requirement.

How it works: Resistive sensor, based on thermistor principle. There is a heated wire is maintained at a predetermined temperature above the intake air's temperature at sensor body. When there is change in temperature of air, it tends change in resistance and accordingly intake temperature is measured.

Coolant temperature: It is located at coolant passage before the thermostat. It is used to measure the engine coolant temperature. This information is required to switch on the electronic cooling fan as well as to adjust fuel injection and ignition timing, variable valve timing.

How it works : Resistive type based on thermistor. As temperature is subject to the sensor the internal resistance change.

Exhaust gas oxygen sensor (lambda sensor): It is located at the exhaust gas manifold. It is used to measure the free oxygen is the exhaust gas. This information is used to control the fuel injection. Because this information is a direct result of the air/fuel ratio, rich mixture yields little free oxygen while lean mixture yields more free oxygen as not all oxygen consumed during combustion and accordingly the injection is controlled.

How it work : The important component of oxygen sensor is a hollow ceramic body that contains zirconium dioxide, a white crystalline compound. The inner and outer surface of body is attached with platinum plate. The inner area is exposed to atmosphere and the outside is exposed to the exhaust. When the sensor is heated approximately 300 to 850 deg C, zirconium di oxide becomes oxygen ion conductive, electrically charged oxygen ions form on the platinum plates.

The amount of oxygen to which each plate (inner and outer) is exposed determines how many ions on the plates. When there is a difference in the number of ions on the plates, a difference in potential of voltage occurs between the two plates. If less oxygen in exhaust, greater voltage produced and more oxygen less voltage.

Crankshaft and camshaft position sensor - Engine Speed sensor: It is located at main crank pulley, the flywheel, the camshaft or on the crankshaft itself. It is used to determine which cylinder is firing an do find engine speed. This information is required to establish injector synchronization & coil firing sequence in Direct ignition system.

How it works : Inductive type sensor based on magnetic inductance. This type of sensor consists of permanent magnet, yoke and coil. This sensor is mounted close to a toothed gear. As each tooth moves by the sensor, an AC voltage pulse is induced in the coil. Each tooth produce a pulse. As the gear rotes faster there more pulses are produced. The ECU determines the speed the component is revolving based on the number of pulses. The number of pulses in one second is the signal frequency.

When it fails, there is a chance the engine will not start, or cut out while running. Crank or camshaft position sensors and engine speed sensors are similar devices that operate based on pulse detection and counting.

Vehicle speed sensor: Vehicle Speed Sensors are much the same as a camshaft or crankshaft sensor. The sensors can be mounted either in the transmission case or rear differential assembly. Those in the transmission are typically gear driven.

Vehicle information is required to regulate power steering pressures for higher assist at slow speeds, making parking lot manoeuvres easier to perform. And also used at ABS to determine when the wheel is locked up and accordingly releases pressure to that wheel to maintain directional stability.

Common Rail Diesel Injection (CRDI)

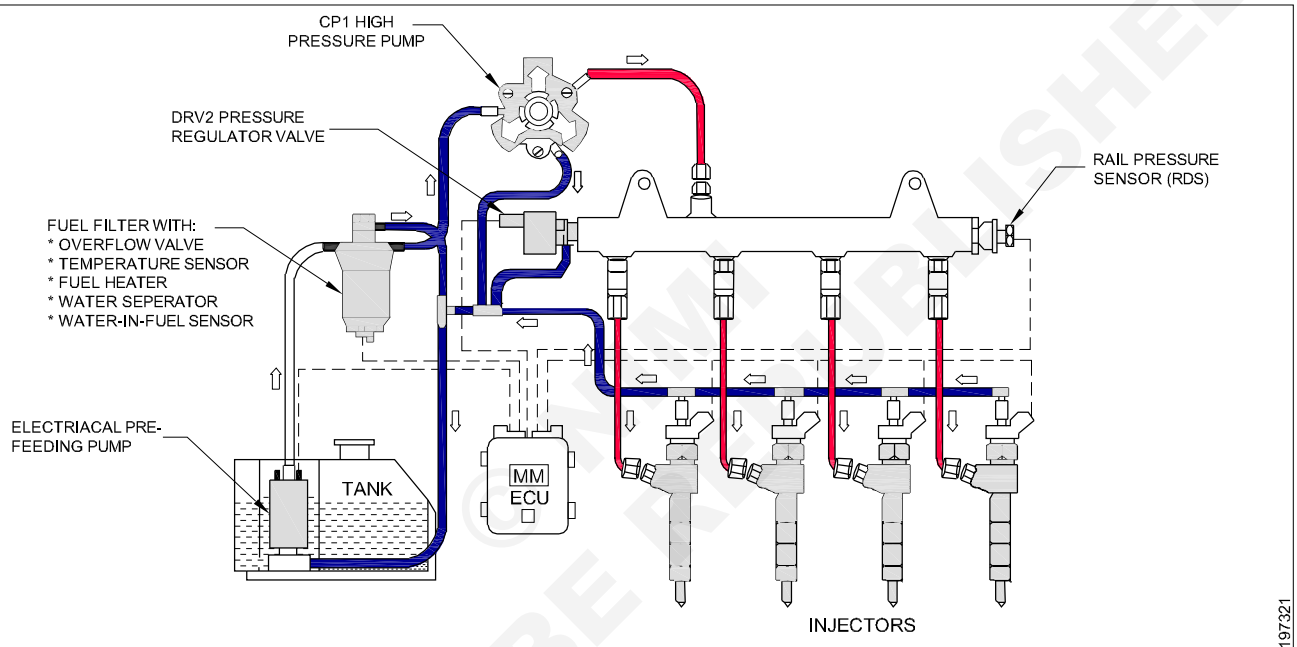
Objectives: At the end of this lesson you shall be able to

- **describe the construction of CRDI**
- **explain the working of the CRDI**
- **list out the merits and demerits of the CRDI.**

Construction and working of CRDI system (Figs 1&2)

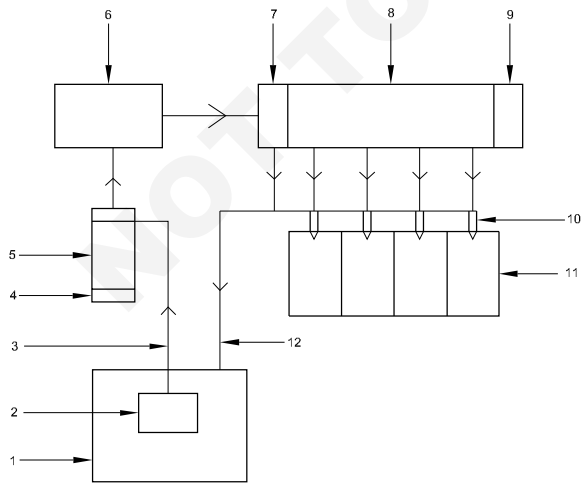
The common rail fuel system consists of fuel tanks fuel pump, common rail, pressure regulator, injectors and sensors. The electrical fuel pump (low pressure) in placed inside the fuel tank, It develops pressure upto 6 bar and supplies to the high pressure fuel pump (CRDI) through fuel filter and water separator. The high pressure fuel pump develops pressure 200 to 2000 bar and supplies to the common rail and common rail to fuel injectors inject fuel into the combustion chamber. Fuel injector are operator by ECM through solenoid valve. Common rail consists of fuel pressure regulator rail pressure sensor and fuel pressure regulator supplies the excess amount of fuel to the fuel tank (≤ 1 bar pressure). The common rail pressure sensor send information to ECM/EDC, the existing pressure in the common rail will control the RPM of the fuel pump. Common rail will distribute the fuel to all the cylinder with equal pressure, then all cylinders will develop uniform power, which will reduce vibration and noise of the engine.

Fig 1



DIESEL DIRECT INJECTION SUSTEM (DDIS) -- FUEL SYSTEM LAYOUT

Fig 2



1. FUEL TANK
2. ELECTRICAL FUEL PUMP
3. FUEL SUPPLY LINE
4. WATER SEPARATOR
5. FUEL FILTER
6. HIGH PRESSURE FUEL PUMP (CRDI PUMP)
7. FUEL PRESSURE REGULATOR
8. COMMON RAIL
9. FUEL RAIL PRESSURE SENSOR
10. FUEL INJECTOR
11. ENGINE
12. FUEL RETURN LINE

COMMON RAIL DIRECT INJECTION SYSTEM (CRDI) FUEL SUPPLY SYSTEM

Hydraulically actuated electronically controlled unit injector (HEUI)

Objectives: At the end of this lesson you shall be able to
- **describe the HEUI (Hydraulically Actuated Electronically Controlled Unit Injector)**
- **explain basic components**
- **explain the working principle of HEUI**
- **advantages of HEUI.**

Hydraulically Actuated Electronically Controlled Unit Injector (HEUI) (Fig 1)

HEUI Fuel System represents one of the most significant innovations in diesel engine technology in the diesel technology. HEUI made easy of many limitations of mechanical and conventional electronic injectors, and sets new standards for fuel efficiency, reliability and emission control. The highly sophisticated HUEI system uses hydraulic energy instead of mechanical energy to operate fuel injectors. Working along with the engine's ECM (Electronic Control Module), the HEUI system provides extremely accurate control of fuel metering and timing, so that it ensures unmatched engine performance and economy.

Unmatched engine performance and economy.

In the traditional common rail fuel system, the entire fuel line is under high pressure. With the HEUI system, fuel remains at low pressure until it is injected into the cylinder. Fuel pressure is created hydraulically in response to a signal from the Electronic Control Module (ECM).

The HEUI fuel system consists of four basic components

HEUI (Fig 1) Injector Uses hydraulic energy (as opposed to mechanical energy from the engine camshaft) from pressurized engine lube oil for injection. The pressure of the incoming oil (800 to 3300 psi) controls the rate of injection, while the amount of fuel injected is determined by the ECM.

Electronic Control Module (ECM): This sophisticated on-board computer precisely manages fuel injection and other engine systems. The HEUI injector solenoid is energized by an electronic signal generated in the ECM. Using input from multiple sensors, the ECM's dual microprocessors use proprietary software and customer supplied performance parameters to produce maximum engine performance under any conditions.

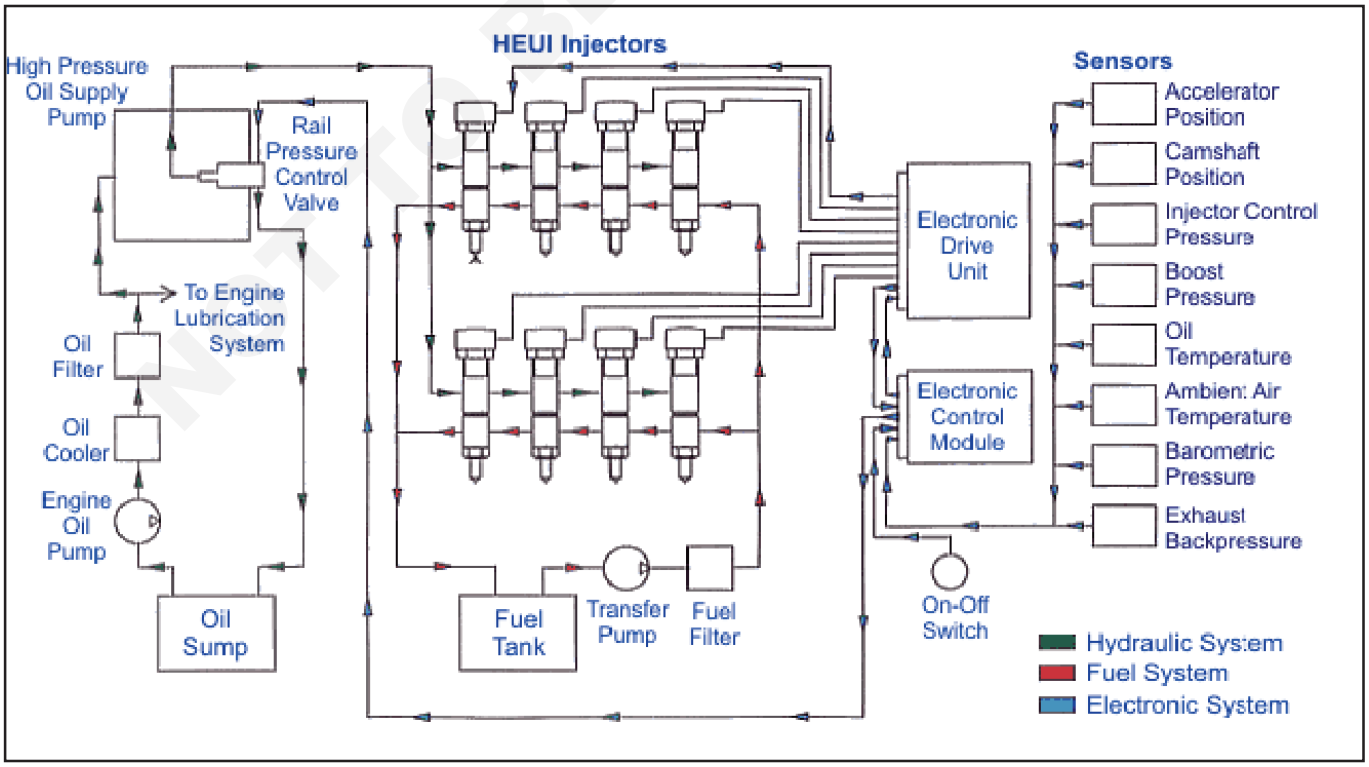
High pressure oil pump: The variable displacement axial pump features a built-in reservoir to immediately supply oil at cold starts.

Injector actuation pressure control valve: This electronically operated valve controls oil pump output and injection pressure.

Working principle

HEUI is divided in two sections. One is low pressure fuel chamber. Another one is high pressure oil chamber, fuel is supplied at low pressure and oil is supplied at high pressure to the respective chamber.

At the time of injections allows the high pressure oil in to the injection body and actuates the intensifier. The intensifier in turn pressurizes the diesel on the other side of it. So that the intensifier pressurizes seven times of the oil pressure and increases the pressure of the diesel.



After then the injector lifts the spindle and injects the diesel through the holes of an injector.

Improved fuel economy: The ability to inject fuel at any crank angle results in up to 2.7 percent better fuel economy compared to scroll mechanical injectors. Optimum fuel economy also means reduced gaseous emissions and less white smoke during cold engine starts.

Optimum performance: The control of fuel delivered during ignition delay and main injection, known as rate shaping, is made possible by the HEUI's ability to operate independent of engine speed. Rate shaping modifies engine heat release characteristics, which also helps reduce emission and noise levels. Rate shaping optimizes engine performance by varying the idle and light load rate characteristics independent of rated and high load conditions.

Reduced smoke and particulate emissions

Since the HEUI injector's performance does not depend on engine speed, it can maintain high injection pressures through a wide operating range. Electronic control of these pressures helps improve emissions and low-speed engine response.

Reduced engine noise A split injection feature leads to a more controlled fuel burn and lower noise levels. Additional benefits include reduced shock loads as well as less wear and tear on drive train components.

Sensors

Types of sensors

1 Engine coolant temperature (ECT)

2 Manifold absolute pressure (MAP)

3 Inlet air temperature (IAT)

4 Oxygen (O_2)

5 Throttle position sensor (TP)

6 Cam position (CMP)

7 Crank position (CKP)

8 Anti-lock braking system (ABS)

The above sensors are being used for the engine management system.

Recently one more sensor is added i.e ABS

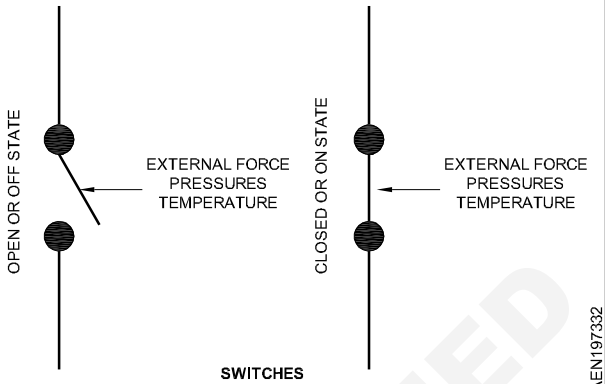
Apart from the above so many other sensors are using in the vehicle. In modern vehicles 10 to 100 plus sensors are using.

Classification & working principle of sensors

- Switches
- Resistive sensor
- Current generating sensor
- Hall effect sensor
- Hot film air mass meter
- Lambda sensor

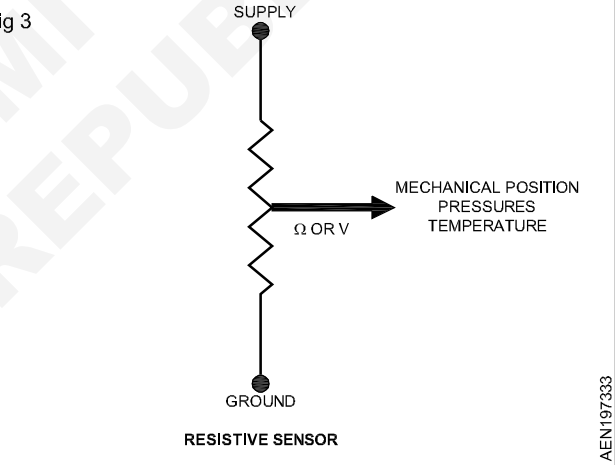
Switches (Fig 2): Switches are basically on-off sensors & the input given to ECU is normally in two states i.e either "ON" or "OFF" physical position of the switch can be change by operating condition like temperature, pressure, external force etc.

Fig 2



Resistive sensor (Fig 3): In resistive sensor the variation is resistance happens due to change in input data like position, temperature pressure etc. Input to the control unit is not necessarily the resistance but can be the voltage also.

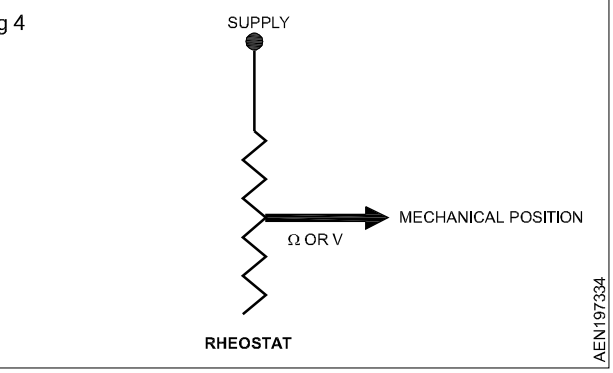
Fig 3



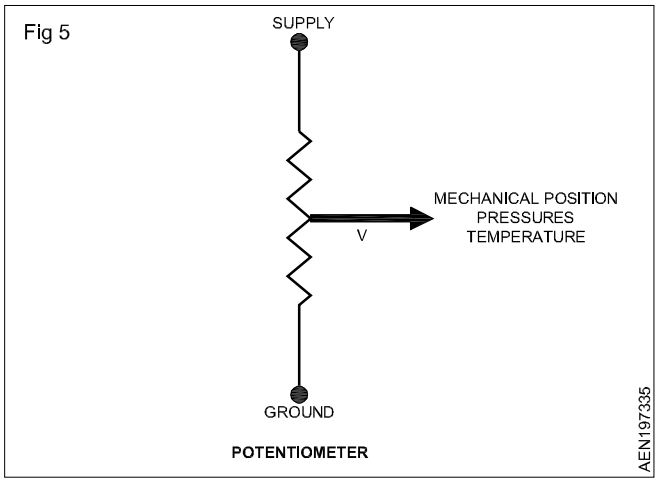
Types of resistive sensor

1 **Rheostat (Fig 4):** Generally 2 wire sensor. Change is resistance happen due to change in mechanical position. Value of resistance or voltage is interpreted by ECU for calculation. Measurement of value happen inside the control unit.

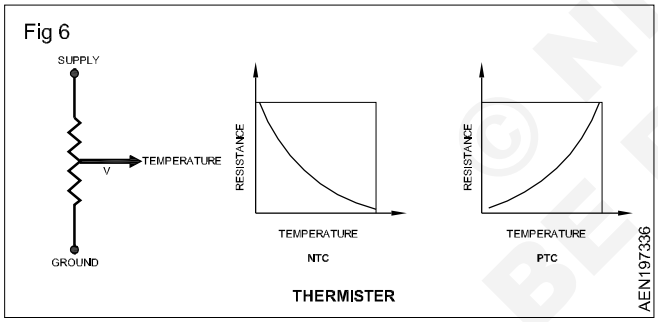
Fig 4



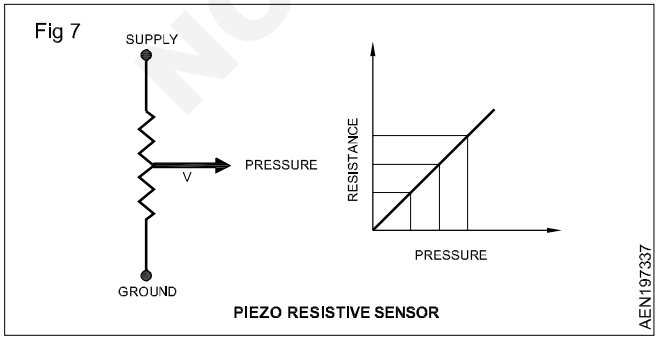
2 **Potentiometer (Fig 5):** Generally 3 wire sensor. Change is resistance happen due to change in mechanical position. Value of voltage is interpreted by ECU for calculation. Measurement of value happen outside the control unit.



3 **Thermistor (Fig 6):** Thermistor are those sensors whose resistance value changes due to change in temperature. Thermistor are supplied with constant voltage. Out put voltage changes due to change in resistance which is continuously monitor by control unit to decide the temperature value. Thermistor can have either negative temperature co efficient [NTC] or positive temperature co efficient [PTC].



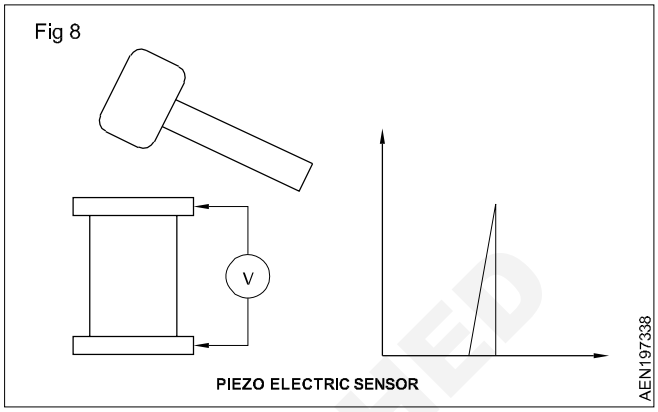
4 **Piezo resistive sensor (Fig 7):** Piezo resistive sensors are those whose resistance changes die to change in pressure. They are subjected to external pressure which causes change in resistance. Constant voltage is supplied & out put voltage changes due to change in pressure which is interpreted by control unit to decide the pressure value.



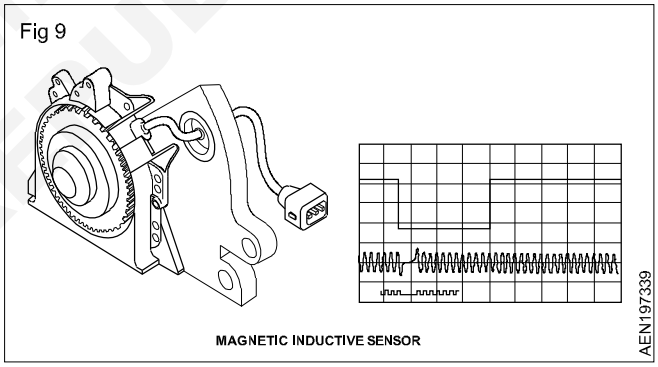
5 **Current generating sensor:** Certain sensors generate the voltage when subjected to change is physical phenomenon such as pressure, position etc. They are mainly classified as follows.

- Piezo electric sensor
- Magnetic induction sensor

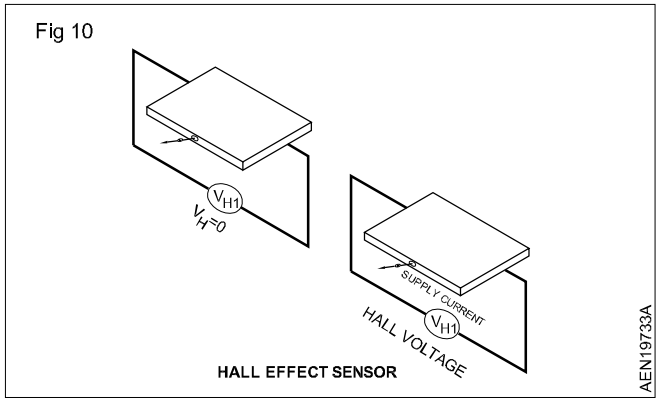
6 **Piezo electric sensor (Fig 8):** Certain crystal such as quartz when subjected to a pressure generate potential difference on its surface. The phenomenon is reversible.



7 **Magnetic inductive sensor (Fig 9):** This kind of sensor are consist of coil wound around the permanent magnet. When the magnetic filed is disturb by external means current is generated inside the coil terminals. The pattern of current obtained is depends on the kind of disturbance produce.

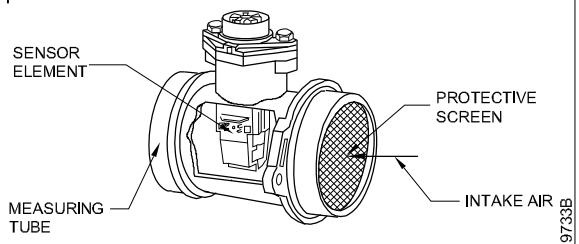


8 **Hall effect sensor (Fig 10):** When a current passes through the semiconductor plate there is no current develop at right angles to the direction of current. However when this plate is subjected to a magnetic filed, voltage is developed at right angles to the direction of current. The magnitude of this voltage is proportionate to the magnetic field through the semiconductor.



9 Hot film air mass meter (Fig 11): This sensor is used to measure the air flow in engine management system. It consist of measuring tube & sensor electronic with sensor element. The sensor element consist of heating resistors, two thermistor R1 & R2, & intake air temperature sensor.

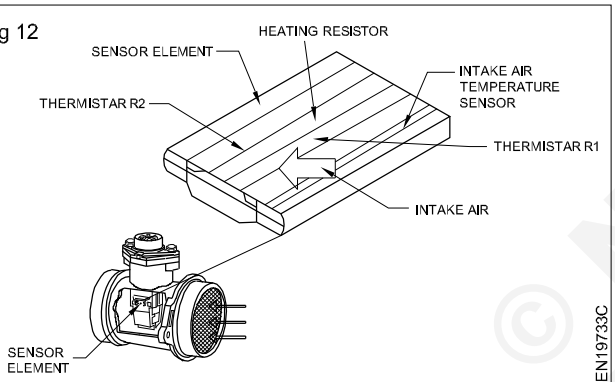
Fig 11



HOT FILM AIR MASS METER

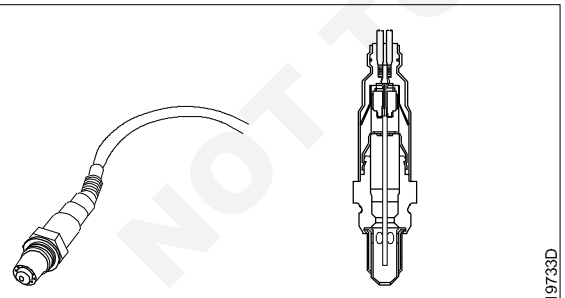
10 Sensors & actuators (Fig 12): Sensors element is heated at constant temperature appr. 120°C above intake air temperature. Due to air flow there is a temperature difference at R1 & R2. This difference is recognized by electronic module & the intake air mass is calculated. This also decide the direction of air flow.

Fig 12



11 Lambda (oxygen) sensor (Fig 13): This sensor is normally used in petrol engine to decide the oxygen content in exhaust gas. Based on the input from this sensor the ECU do minor correction to the amount of fuel being metered.

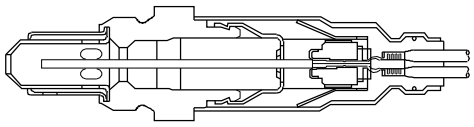
Fig 13



LAMBDA (OXYGEN) SENSOR

12 Lambda (oxygen) sensor (Fig 14): The difference in oxygen content between the exhaust gas & ambient air causes a change in the electrical voltage within the probe. A change in the composition of the air fuel mixture produces a sudden voltage change by which l = 1 can be identified.

Fig 14



LAMBDA (OXYGEN) SENSOR

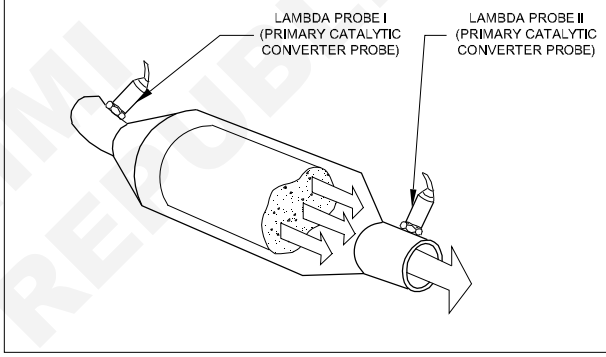
13 Sensors & actuators (Fig 15): In connection with OBD II, second lambda sensor is connected after catalytic converter. It test correct functioning of the catalytic converter.

Actuators

1 Injectors
2 Power windows
3 Wiper motors
4 Relays etc

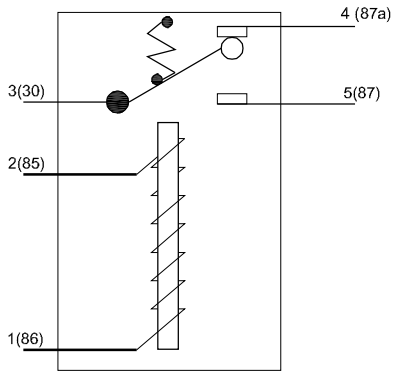
Number of actuators depends upon the devices to be operated.

Fig 15



14 Relay (Fig 16): A relay is an electrically operated switch. many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with compete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

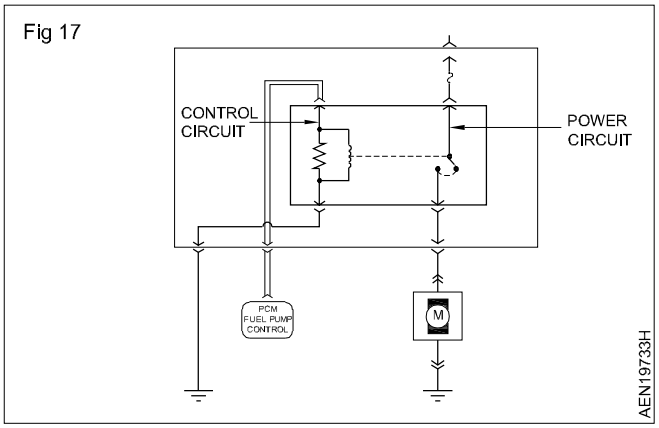
Fig 16



RELAY

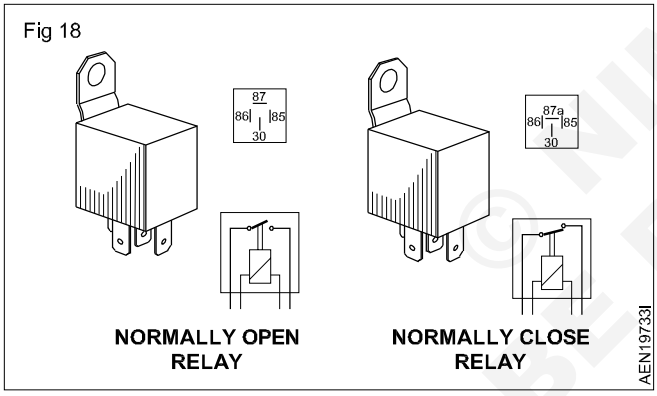
- **Control circuit:** Control the operation which are activated by control unit or switch. It required very less power to activate. (Fig 17)
- **Power circuit:** Connected to the load. Main current flows through this circuit. (Fig 17)

Fig 17



- **Normally open relay [NO]: (Fig 18)** Power circuit is in open position. Circuit closes when control circuit is activated.
- **Normally close relay [NC]: (Fig 18)** Power circuit is in close position. Circuit opens when control circuit is activated.

Fig 18



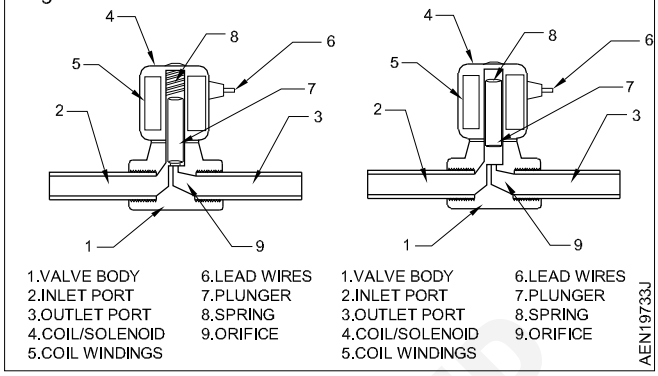
Working principles of actuators

DC Motors

Solenoid (Fig 19): A solenoid is an electromechanical switch/ valve that is controlled by an electric current. The electric current runs through a solenoid, which is a wire coil wrapped around a metallic core.

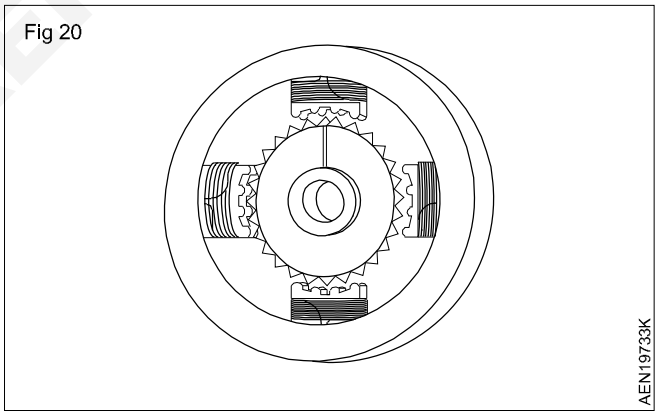
A solenoid creates a controlled magnetic field when an electrical current is passed through it. This magnetic field affects the state of the solenoid valve, causing the valve to open or close.

Fig 19



Stepper motor (Fig 20): Stepper motors provide a means for precise positioning and speed control without the use of feedback sensors. The basic operation of a stepper motor allows the shaft to move a precise number of degrees each time a pulse of electricity is sent to the motor. Since the shaft of the motor moves only the number of degrees that it was designed for when each pulse is delivered, you can control the pulses that are sent and control the positioning and speed. The rotor of the motor produces torque from the interaction between the magnetic field in the stator and rotor. The strength of the magnetic fields is proportional to the amount of current send to the stator and the number of turns in the windings.

Fig 20



Multi point fuel injection/Electronic fuel injection system

Objectives: At the end of this lesson you shall be able to
- **state introduction of MPFI**
- **state the main components of MPFI**
- **explain the working principle.**

Petrol vehicles uses device called carburetor for supplying the air fuel mixture in correct ratio to cylinders in all rpm ranges. Due to construction of the carburetor is relatively simple, it has been used almost exclusively on gasoline engines in the past. However in response to recent demands for cleaner exhaust emission, more economical fuel consumption, improved drivability, etc., the carburetor now must be equipped with various compensating devices, making it more complex system. So in place of the carburetor, therefore, the MPFI (Multi point fuel injection) system is used, assuring proper air fuel ratio to the engine by electrically injecting fuel in accordance with various driving conditions.

MPFI system injects fuel into individual cylinders, based on commands from the 'on board engine management system computer' - popularly known as the engine control unit/ECU. These techniques result not only in better 'power balance' amongst the cylinders but also in higher output from each one of them, along with faster throttle response.

The electronic fuel injection system supplies the combustion chambers with air/fuel mixture of optimized ratio under widely varying driving conditions.

Main components of MPFI system (Fig 1): This system has four major components they are:

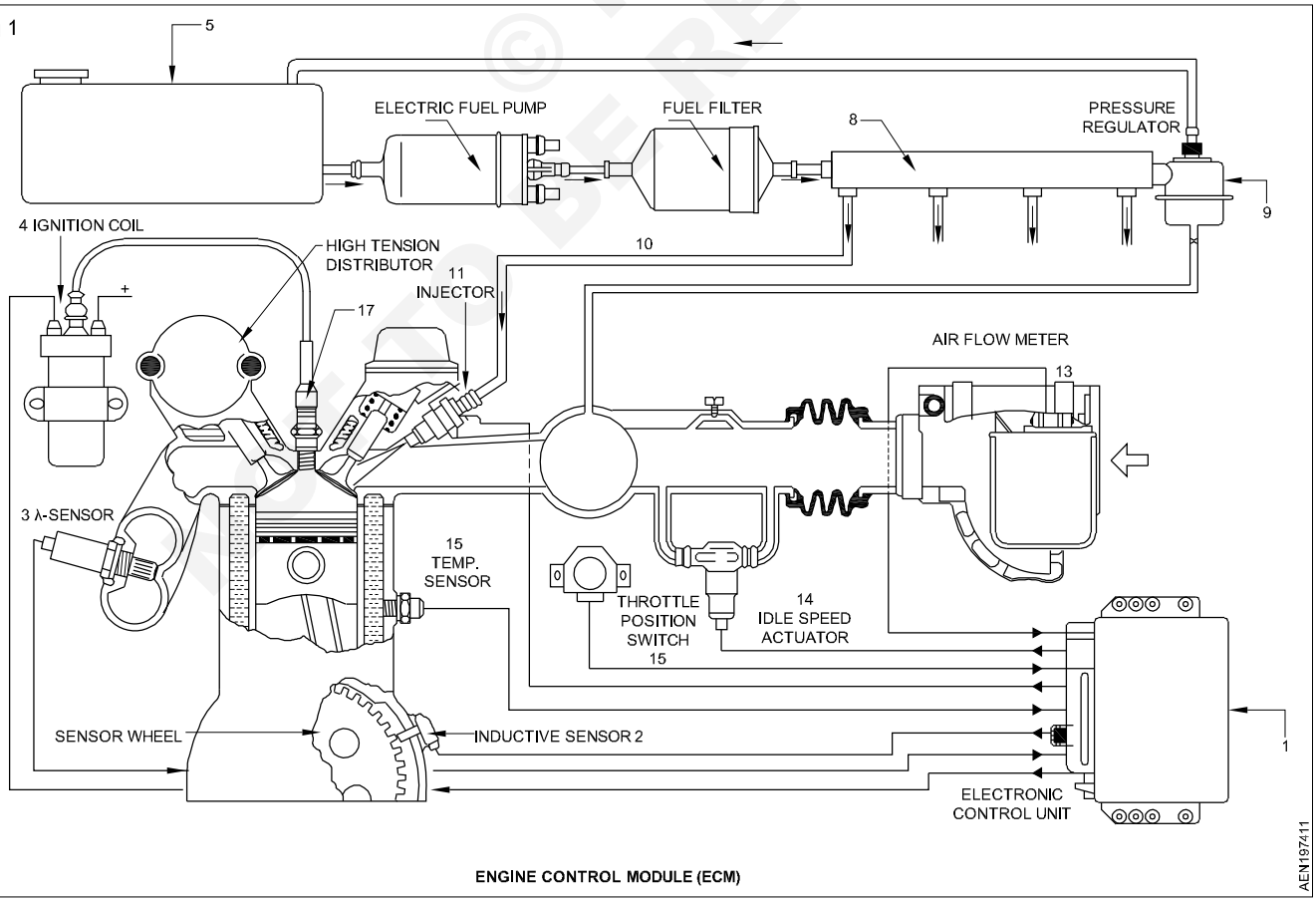
1 Air intake system (Fig 2)

2 Fuel delivery system (Fig 3)

3 Electronic control system

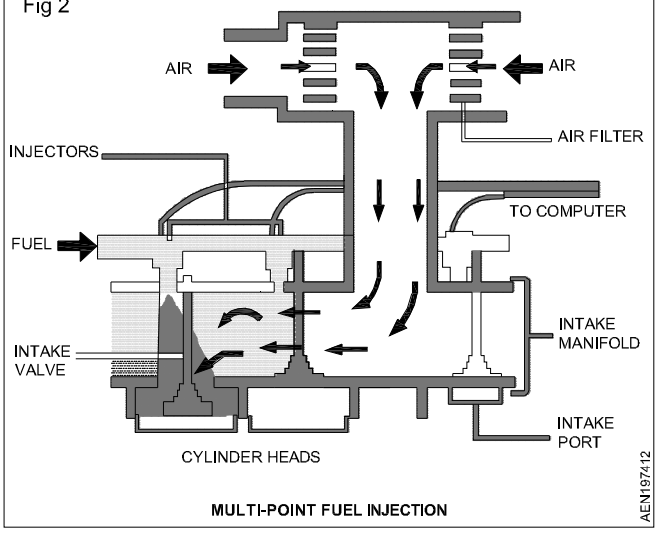
Air intake system (Fig 2): The air (corresponding to the throttle valve opening) is filtered by the air cleaner, passes through the throttle body, and is distributed by the intake manifold and finally drawn into each combustion chamber. When the IAC (intake air control) valve is opened according to the signal from ECM, the air bypasses the throttle valve through bypass passage and is finally drawn into the intake manifold.

Fig 1



ENGINE CONTROL MODULE (ECM)

Fig 2



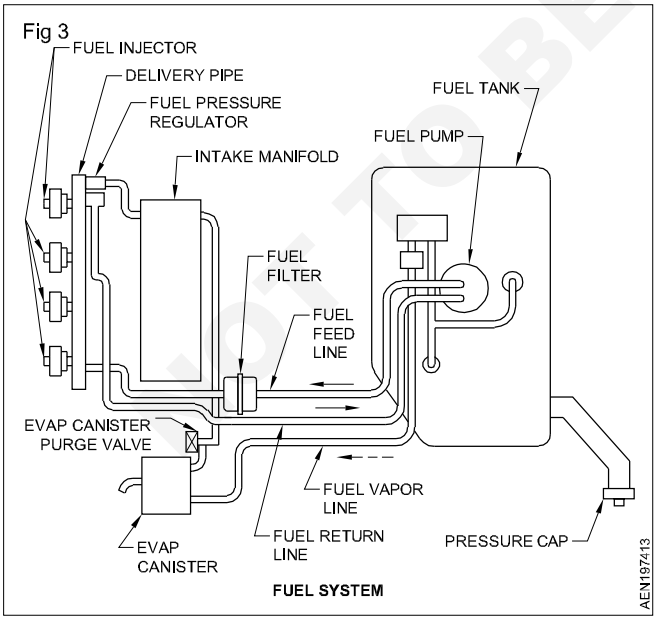
MULTI-POINT FUEL INJECTION

Throttle body: The throttle body consists of the main bore, air bypass passage and the following parts. Throttle valve, which is interlocked with the accelerator pedal and controls the amount of the intake air. TP sensor which detects the throttle valve opening and sends a signal to ECM. IAC valve, which supplies the bypass, air depending on engine condition.

Idle air control valve: The IAC valve controls opening of the bypass air passage. The air bypass the throttle valve through bypass passage and is finally drawn into the intake manifold. Opening and closing of the valve itself is determined by operation of the magnet, which is connected to it. The magnet operates according to electric current from ECM.

Fuel delivery system (Fig 3): The fuel in the fuel tank is pumped up by the fuel under pressure to each injector through the delivery pipe.

Fig 3



FUEL SYSTEM

As the fuel pressure applied to the injector is always kept a certain amount higher than the pressure in the intake manifold by the fuel pressure regulator, the fuel is injected into the intake port of the cylinder head when the injector opens according to the injection signal from ECM. The fuel relieved by the fuel pressure regulator return through the fuel return to the fuel tank.

Fuel pump: The electrical fuel pump located on the fuel tank consists of armature, magnet, impeller, brush, check valve etc. The ECM controls its operation. When the power is supplied to the fuel pump, the motor in the pump runs and so does the impeller. This causes a pressure difference to occur between both sides of the impeller, as there are many grooves around it. Then the fuel is drawn through the inlet port, and with its pressure increases, it is discharged through the outlet port, the fuel pump also has a check valve to keep some pressure in the fuel feed line even when the fuel pump is stopped.

Electronic control system: The electronic control system consists of various sensors which detect the state of engine and driving conditions, ECM which controls various devices according to the signals from the sensors and various controlled devices. The systems are,

1 Fuel injection control system,

2 Idle speed control system

3 Fuel pump control system

4 Ignition control system

5 Radiator fan control system.

Fuel injection control system: The electronic fuel injection system supplies the combustion chambers with air/fuel mixture of optimized ratio under widely varying driving conditions. It uses the sequential multi-port fuel injection system, which injects fuel into each intake port of the cylinder head. In this system ECM controls the time and timing of the fuel injection from the fuel injector into the cylinder head intake port according to the signals from the various sensors so that suitable air/fuel mixture is supplied to the engine in each driving condition.

The factors to determine the injection time are the basic injection time which is calculated on the basis of the engine speed and the intake manifold pressure and various compensation which are determined according to the signals from various sensors that detect the state of the engine and driving conditions.

Idle speed control system: This system controls the bypass airflow by means of ECM & IAC valve for the following purposes. To keep the engine idle speed as specified at all times. The engine idle speed can vary due to load applied to engine, to improve starting performance of the engine to compensate air fuel mixture ratio when decelerating to improve drivability while engine is warmed up. IAC valve operates according to duty signal sent from ECM.

ECM detects the engine condition by using the signals from various signals and switches and controls the bypass airflow by changing IAC valve opening. When the vehicle is at a stop, the throttle valve is at the idle position and the engine is running, the engine speed is kept at a specified idle speed.

Fuel pump control system: ECM controls ON/OFF operation of the fuel pump by turning it ON, the fuel pump relay under any of the conditions. For two seconds after ignition switch ON. While cranking engine (while engine start signal is inputted to ECM). While crankshaft position sensor or camshaft - position sensor signal is inputted to ECM.

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.

Ineria sensors: Ineria 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.

EFI engine management system

Objectives: At the end of this lesson you shall be able to
- **define engine management system**
- **explain function of the each part of the engine management**
- **explain function of each part of ECU**
- **explain each sensor used in EFI.**

Definition: Engine management system includes the fuel system, airflow system, ignition, injection, temperature and emission control system having sensors, ECM and other gauges and controls.

Modes of EFI: A mode of injection describes the timing and sequence of injecting fuel.

Electronic fuel injection (EFI): EFI is now the most common fuel system, the injectors spray fuel into the air/ intake ports for combustion inside the engine.

Idle speed control system: Idle speed control systems maintain a suitable idle speed to prevent stalling, when additional loads are placed on the engine.

Feed back and looping: Feedback from the exhaust gas oxygen sensor is used to maintain closed loop control of the air - fuel mixture.

Cold start system: Cold start systems provide additional fuel during starting conditions, according to engine temperature.

Air measurement: The vane - type airflow sensor measures the quantity of air flowing into the engine by deflecting a spring - loaded vane across a potentiometer. This provides a signal voltage to the ECU.

Air flow monitoring: Depending on the application, different kinds of sensors measure different properties of the air entering the engine, including its temperature, volume, density and mass.

Variable intake manifold system: Variable intake manifold systems vary the effective manifold pipe length, to extend the torque curve over a wider RPM range.

Electrical functions: The ECU continuously receives information from sensors in the form of electrical signals, to determine injector pulse width.

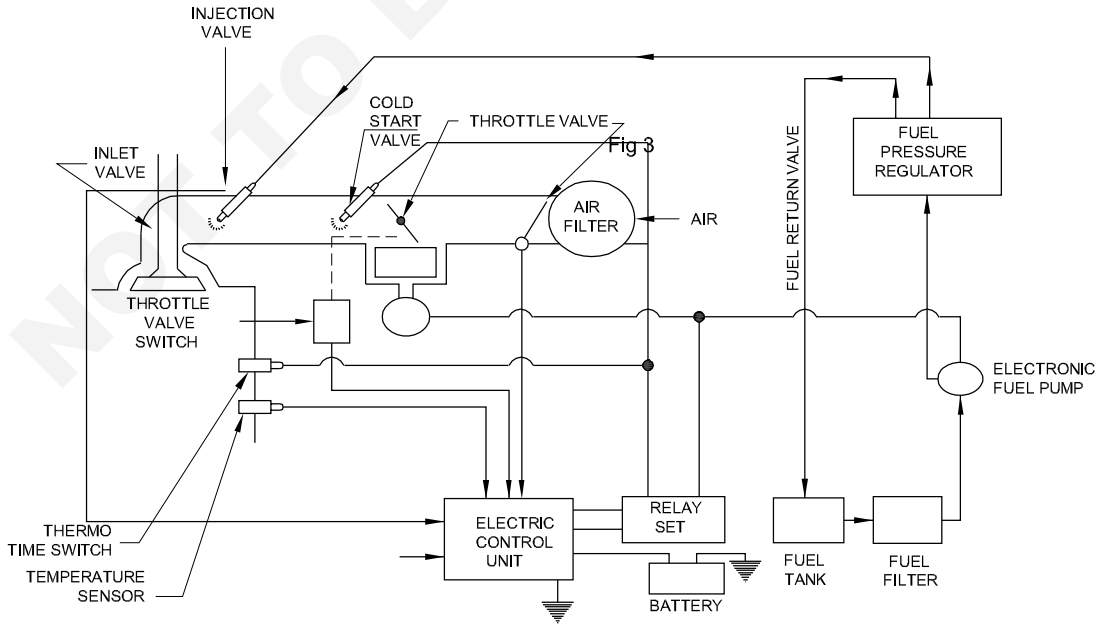
EFI wiring diagram (Fig 1): In electronic fuel system, fuel supply and timing are controlled by electronic means. Electronic fuel injection has developed with the development of solid - state electronic devices such as diodes, transistor.

This system consists of following units;

1 **Fuel delivery system:** This system consists of an electrically driven fuel pump which draws fuel from the fuel tank through filter and forces it into the pressure line at the end of which is situated a fuel regulator. The pressure difference is kept constant so the fuel injected depends only on the injection open time.

2 **Air induction system:** The incoming air from atmosphere flows initially through air filter and then through air flow sensor. This air flow sensor measures the amount of air flow in the manifold and generates a voltage signal which is dependent on the amount of air flow.

Fig 1



ELECTRONIC FUEL INJECTION SYSTEM

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Spiral coil spring is used to return back the rectangular plate placed in the air flow meter.

3 **Sensors and air flow system:** A cold start valve is fitted just behind the injection valve to inject additional fuel or cold start. This valve has exceptionally good atomization characteristics. The extra fuel needed by ordinary starting and warm up period is also supplied by this valve. This signal results in additional fuel required for acceleration through electronic control unit.

Advantages

1 A very high fuel distributions is obtained.

2 Increased volumetric efficiency and hence increased power and torque.

3 Freedom from blow backs and icing.

4 Lower specific fuel consumption due to better distribution of mixture to each cylinder.

5 Better starting and acceleration.

Electronic control unit: The basic function of the ECU is to control the pulse width of the injector. In engine management systems, the ECU controls additional functions, such as idle speed ignition timing, and fuel pump operation.

ECU settings: The ECU corrects ignition timing to achieve the optimum setting for each operation condition.

Engine speed limiting: An ECU can control engine speed limiting, the fuel pump, exhaust gas recirculation, idle speed control, a variable intake manifold, and the evaporative emission container.

Malfunction indicator lamp: A check engine lamp or a data scanner can be used to indicate problems in the engine management system. A code indicates where the fault may be.

Types of sensors and their applications

Objectives: At the end of this lesson you shall be able to
- **define the sensors**
- **state the names of sensors**
- **explain their applications.**

Definition: Sensor are essential components of automotive electronic control systems. Sensors are defined as "devices that transform or transduce physical quantities such as mass, pressure, volume, temperature, or acceleration (called measurement) into output signals (usually electrical) that serve as inputs for control systems.

Various types of sensors

1 Air-fuel ratio sensor

2 Blind spot sensor

3 Crankshaft position sensor

4 Curb sensor, used to warn driver of curbs

5 Defect sensor, used on railroads to detect axle and signal problems in passing trains.

6 Engine coolant temperature sensor, or ECT sensor, used to measure the engine temperature.

7 Hall effect sensor, used to time the speed of wheels and shafts.

8 MAP sensor, manifold absolute pressure used in regulating fuel metering.

9 Mass flow sensor, or mass airflow (MAF) sensor, used to tell the ECU the mass of air entering the engine.

10 Oxygen sensor, used to monitor the amount of oxygen in the exhaust.

11 Parking sensors, used to alert the driver of unseen obstacles during parking manoeuvres.

12 Radar gun, used to detect the speed of other objects.

13 Speedometer, used measure the instantaneous speed of a land vehicle.

14 Speed sensor, used to detect the speed of an object.

15 Throttle position sensor, used to monitor the position of the throttle in an internal combustion engine.

16 Tire-pressure monitoring sensor, used to monitor the air pressure inside the tires.

17 Torque sensor, or torque transducer or torque transducer or torque meter measures torque (twisting force) on a rotating system.

18 Transmission fluid temperature sensor, used to measure the temperature of the transmission fluid.

19 Turbine speed sensor (TSS), or input speed sensor (ISS) used to measure the rotational speed of the input shaft or torque converter.

20 Variable reluctance sensor, used to measure position and speed of moving metal components.

21 Vehicle speed sensor (VSS), used to measure the speed of the vehicle.

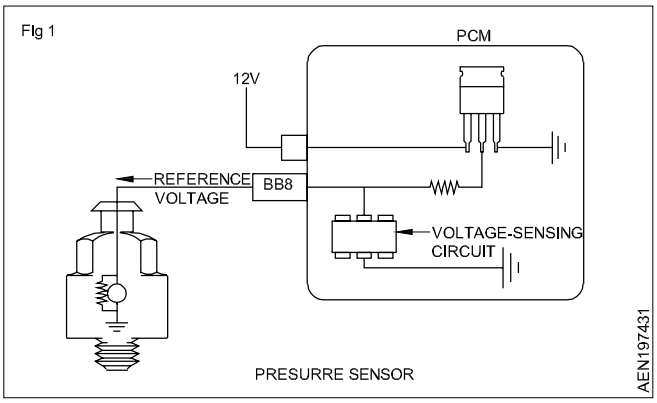
22 Water sensor or water in fuel sensor, used to indicate the presence of water in fuel.

23 Wheel speed sensor, used for reading the speed of a vehicle's wheel rotation.

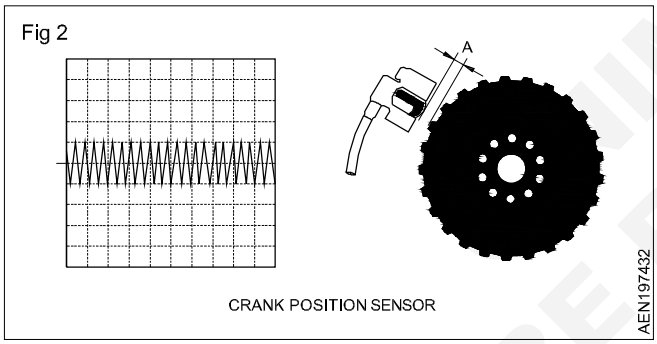
Application of some commonly used sensors

1 Temperature sensor: This type of sensor monitor the intake air temperature, engine coolant temperature. Once the temperature shoots they lose the resistance and supply more voltage so that the ECM senses the problem and cut of the necessary supply and gives signal.

2 **Pressure sensor (Fig 1):** This sensors monitors, senses, manifold air pressure, atmospheric pressure, in cylinder pressure and fuel injection pressure. Once change in the pressure level adversely they send single to the ECM in terms of milli volts. Thus the engine can be monitored by the ECM.



3 **Crank, cam shaft position sensor (Fig 2):** These sensors are located in the crank case, crank pulley. Mainly these sensors are used to monitor the injection timing and ignition timing of the engine depend upon the speed of the vehicle. So that the qualitative and quantitative analysis and control can be done and the efficiency can be monitored.



4 **Throttle position sensor:** It is located in the throttle body; it is used to record the angle of rotation of the throttle valve and the speed of its movement. This information is required to measure the engine load, timing, delivery, EGR, converter clutch operation.

5 **Mass air flow sensor:** It is located in the intake manifold or throttle body on MPFI it is used to find out the volume and density of air entering the engine at any given time. This information is very vital to balance and deliver correct fuel mass to the engine.

6 **Engine knocking sensor:** It is located in the engine block, cylinder head or intake manifold. It is used to sense vibrations caused by the engine knock. This information is very useful to set the injection and ignition timing in diesel and petrol engine respectively.

7 **Oxygen sensor:** It is located at the exhaust manifold. It is used to measure the free oxygen in the exhaust gas, it is very vital in deciding the timing and quantity of the fuel.

8 **Hall effect sensor:** It is a device that is used to measure the magnitude of a magnetic field, its output voltage is directly propotional to the magnetic field strength through it. H.E. sensors are used for proximity sensing, positioning, speed, detection and current sensing application.

9 **Vehicle speed sensor (V.S.S):** This sensor monitors vehicle speed so the computers can regulate torque converter, clutch lock up, shifting etc., The sensor located on transmission, transaxle or speedometer head.

10 **Air vertex sensor:** This sensor detects these vortices which are converted to an electrical frequency signal.

11 **Voltage sensor:** This sensor manage manages the idling speed of the car and ensures the speed is increased or decreased as necessary

Scan tool data

Objectives: At the end of this lesson you shall be able to
- **use a scan tool data.**

Obtaining and interpreting scan tool data: OBD I & II stands for on board diagnostics second generation super standing that of OBD I, OBD II is a system that was mandated by the federal EPA and was developed by the society of automotive electronic diagnostics, technicians can use the scan tool to test all makes and model of automobiles with special adopters or factory seamers.

When the EPA mandated OBD II computer systems, they also mandated that all manufacturers would also mandated that anybody. Scanner could have access to the computer system with the proper software and adopters.

The information would have the same code terminology data parameters, freeze frame data and system monitors updated scanner software will usually have OBD II generic mode and allow you to retrieve codes, data, monitor information and freeze frame data without having to buy specific software for that manufacturer.

Standardisation of OBD computer system

- Universal diagnostic test connector or data link connector (OBD - II)
- Standard location for the DLC (dash board)
- Standardised list of generic diagnostic trouble code (DTC)
- The ability to clear all hard and pending codes with a scan tool
- The ability of the computer system to record a frame of data as a fault occurs within the computer system known as freeze, frame data

Obtain an OBD II scan tool (Fig 1)

- Locate the diagnositic link connector in your vehicle.
- Insert the scan tool connecter or code reactor into the DLC
- Enter your vehicle information
- Find the menu

Fig 1

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Malfunction Indicator lamp (MIL): The MIL is that terrible little light in the dash that indicates a problem with the car. There are a few variations, but they all indicate an error found by the OBD -II protocol.

Scan tool letter codes

First unit identifies the type of error code

- **Pxxxx** for power train
- **Bxxxx** for body
- **Cxxxx** for chassis
- **Uxxxx** for class 2 network

Second digit shows whether the code is manufacturer unique or not

- **x0xxx** for government - required code
- **x1xxx** for manufacturer - specific code

Third digit shows us what system the trouble code references

- **xx1xx/xx2xx** show air and fuel measurements
- **xx3xx** shows ignition systems
- **xx4xx** shows emissions systems
- **xx5xx** references speed / idle control
- **xx6xx** deals with computer systems
- **xx7xx/xx8xx** involve the transmission
- **xx9xx** notates input/ output signals and controls

Digits four and five show the specific failure code

- xxx00 to xxx99 - these are based on the systems defined in the third digit.

Learn the letter with code number

For example

P0XXX - Models

P1XXX - Manufacturer

P07XX - Transmission

Read engine fault code - P0301 - Misfire on No.1 cylinder.

Terminology: Before we get too much farther, let's make sure we understand all the keywords used in these protocols.

Engine/Electronic Control Unit (ECU): The ECU can refer to a single module or a collection of modules. These are the brains of the vehicle. They monitor and control many functions of the car.

These can be standard from the manufacturer, reprogrammable, or have the capability of being daisy-chained for multiple features. Tuning features on the ECU can allow the user to make the engine function at various performance levels and various economy levels. On new cars, these are all typically microcontrollers.

Some of the more common ECU types include

- Engine Control Module (ECM) - This controls the actuators of the engine, affecting things like ignition timing, air to fuel ratios, and idle speeds.
- Vehicle Control Module (VCM) - Another module name that controls the engine and vehicle performance.
- Transmission Control Module (TCM) - This handles the transmission, including items like transmission fluid temperature, throttle position, and wheel speed.
- Power train Control Module (PCM) - Typically, a combination of an ECM and a TCM. This controls your powertrain.
- Electronic Brake Control Module (EBCM) - This controls and reads data from the anti-lock braking system (ABS).
- Body Control Module (BCM) - The module that controls vehicle body features, such as power windows, power seats, etc.

Diagnostic Trouble Code (DTC): These codes are used to describe where an issue is occurring on the vehicle and are defined by SAE . These codes, can either be generic or unique to the vehicle manufacturer.

Using a Diagnostic Car Code Reader: Diagnose car problems with an auto code reader. Simply plug it into the car's computer system, then interpret the trouble code readout.

Plug your car code reader into the diagnostic link connector under the dash (engine off). Then start the vehicle and follow the auto code reading procedure in the instruction manual.

An engine code reader/scanner can help you make the drive/no drive decision and even help you fix the problem. It works by plugging into the car's computer system and displaying a "trouble code."

An engine code reader/scanner is worth buying if you're a fairly competent amateur mechanic who understands how an engine works. But it's not a silver bullet that will always tell you exactly what's wrong. An auto code reader give you a head start, but you'll still have to do some detective work before you start pulling and replacing parts (more on this later).

The least expensive auto code reader units are simple car code readers that burp up an alphanumeric trouble code but no information about what it means. You'll have to look up the code in a reference book or search the Internet. Mid priced units actually display the problem on the screen, like "P0115 Engine Coolant Temperature Circuit Malfunction."

One model even accesses the Internet, so you can upload the trouble code to a Web site that has information on the most likely cause of the problem.

Here are three ways to get to the root of a problem without replacing good parts.

1 Go to the car code reader/scan tool manufacturer's Web site to see if it has information on your trouble code.

2 Take advantage of Internet forums. Just search for your car's model and add "forum" to the search term. Register for the site (usually free) and post your question, including your vehicle's year, mileage, code number and what you've done so far. You'll be surprised by the number and quality of responses you get.

3 Subscribe to an online shop manual. It will have not only all the carmaker's technical service bulletins listed but also the complete diagnostic procedure for your particular code. It will walk you through the testing procedure, telling you which wires to check and what voltages you should see. The services also include component locators to help you find the part in your vehicle, and wiring diagrams showing the connector position for each wire.

Required Tools for this Project: You'll need a code reader or scanner, along with a computer with internet access for interpreting the trouble codes.

Interpreting generic scan data: Generic scan data provides an excellent foundation for OBD II diagnostics./ Recent enhancements have increased the value of this information when servicing newer vehicles.

One of the best places to start is with a factory scan tool.

Example

The Mass Airflow (MAF) Sensor, if the system includes one, measures the amount of air flowing into the engine. The PCM uses this information to calculate the amount of fuel that should be delivered, to achieve the desired air/fuel mixture.

The MAF sensor should be checked for accuracy in various rpm ranges, including wide-open throttle (WOT), and compared with the manufacturer's recommendations, volumetric efficiency and help with MAF diagnostics.

When checking MAF sensor readings, be sure to identify the unit of measurement. The scan tool may report the information in grams per second (gm/S) or pounds per minute (lb/min).

For example, if the MAF sensor specification is 4 to 6 gm/S and your scan tool is reporting .6 lb/min, change from English units to metric units to obtain accurate readings. Some technicians replace the sensor, only to realize later that the scan tool was not set correctly. The scan tool manufacturer might display the parameter in both gm/S and lb/min to help avoid this confusion.

Oxygen Sensor Output Voltage B1S1, B2S1, B1S2, etc., are used by the PCM to control fuel mixture. Another use for the oxygen sensors is to detect catalytic converter degradation. The scan tool can be used to check basic sensor operation. Another way to test oxygen sensors is with a graphing scan tool, but you can still use the data grid if graphing is not available on your scanner.

Most scan tools on the market now have some form of graphing capability.

The process for testing the sensors is simple: The sensor needs to exceed 8 volt and drop below. 2 volt and the transition from low to high and high to low should be quick. In most cases, a good snap throttle test will verify the sensor's ability to achieve the .8 and .2 voltage limits.

If this method does not work, use a bottle of propane to manually rich the fuel mixture to check the oxygen sensor's maximum output. To check the low oxygen sensor range, simply create a lean condition and check the voltage. Checking oxygen sensor speed is where a graphing scan tool helps.

The sensor should be tested with a lab scope to verify the diagnosis before you replace it.

Repair manuals

The automobile manufacturer are supplying workshop repair manuals for each type of vehicle produced them. The workshop manual gives more basic informations to skilled/ unskilled technicians to improve their technical knowledge.

Workshop repair manuals give details about the sequence operation of the vehicles each part it gives part number and dismantling and assembling procedures in details. Everyone can understand it easily.

Electronic power steering

Objective: At the end of this lesson you shall be able to
- **state the working principle of electronic power steering.**

Electronic power steering (Fig 1): There is a provision to protect the electric motor from being overloaded and also from the voltages surges from a faulty alternator or charging problem.

The electronic steering control unit is capable of self diagnosing faults by monitoring the system's inputs and outputs and the driving current of the electric motor. In case of a problem, the control unit turns off the entire system by actuating a fail-safe relay in the power unit, the system reverts back to manual steering and warning light on the dashboard alerts the driver.

An electronic power steering has the following advantages over the hydraulic power steering, due to which it is being increasingly used in modern cars.

1 No problem of leakage of fluid.

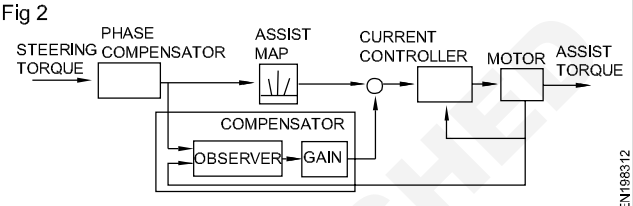
2 Energy being consumed only while steering.

3 Steering assistance available even when the engine is not running.

4 While steering manually lesser force is required compared to a hydraulic system since there is no fluid to forced through valves.

In an electronic power steering system (Fig 2), steering sensor consisting of in fact two sensors, viz, a 'torque sensor' that converts the steering torque input and its direction into voltage signals, and a 'rotation sensor' that converts the rotation speed and direction into voltage signals, is located on the input shaft of the steering-gear box.

Fig 2



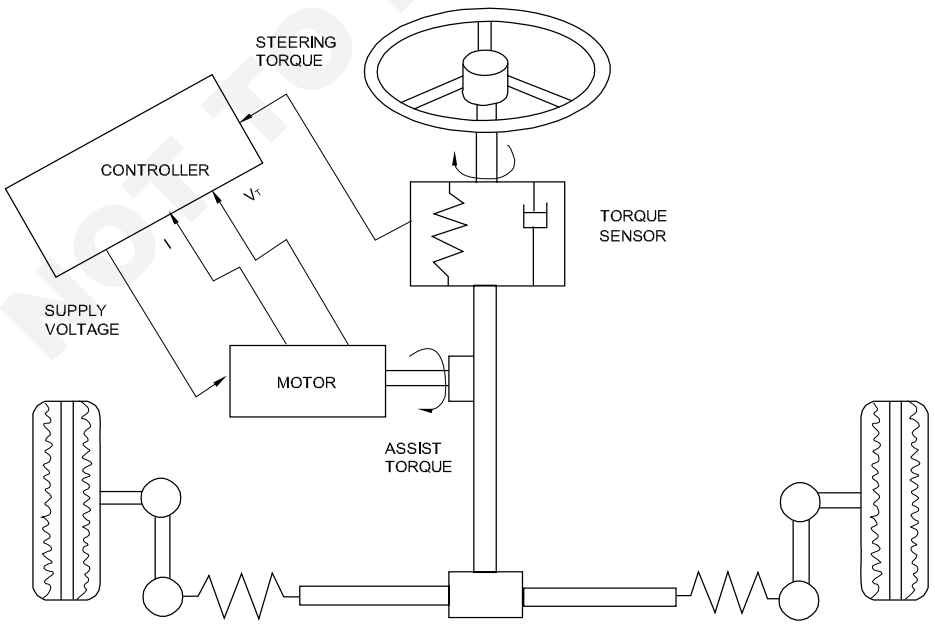
ELECTRONIC STEERING CONTROL UNIT

Inputs from the steering sensor and the vehicle speed sensor are fed to a microprocessor control unit where these are compared with a pre programmed force assist map. The control unit then sends out the appropriate command signal to the current controller which supplies the appropriate current to the electric motor. The motor pushes the rack to the right or left depending on in which direction the current flows. Increasing the current to the motor increases the amount of power assist.

Electronic adjustable - shock absorbers (Fig 3)

The electronic adjustable - 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.

Fig 1

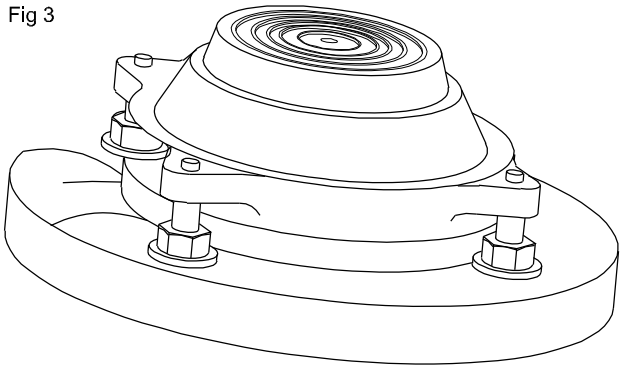


ELECTRONIC POWER STEERING SYSTEM

Adjustable 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 3



COIL SPRING REAR SUSPENSION

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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 travelling 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.

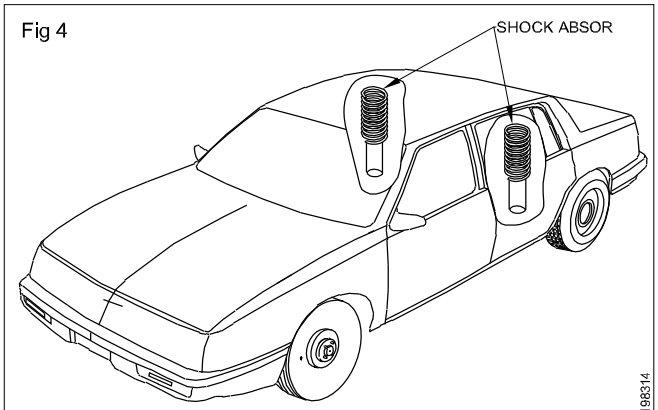
Automatic load - adjustable shock absorbers (Fig 4)

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-levelling.

When vehicles carry heavy loads, their suspension is compressed, causing the rear of the vehicle to be lower than normal.

Fig 4



AUTOMATIC LOAD - ADJUSTABLE SHOCK ABSORBERS

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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 lowered 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 airbag 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 pressurized shock absorber	Shock absorber 'dissolve' can be reduced by pressuring the fluid with nitrogen.
Load - adjustable shock absorbers	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.
Manual adjustable rate valves in shock absorbers	In a manual adjustable -rate shock absorber, the position of the 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 the 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.

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 hold mode**
- **state normal braking**
- **state electronic brake distribution advantage**
- **state traction control system.**

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 sideways.

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.

Types of ABS systems

4-Sensor 4-Channel type: This type is generally used for FF (Front engine Front driving) car. This type has four wheel sensors and four hydraulic control channels and controls each wheel independently.

4-Sensor 3-Channel type: This type is generally used for FR (Front engine Rear driving) car. This type has 2 channels for front wheels and the other one is for rear wheel control.

3-Sensor 3-Channel type: In this type the front wheels are controlled independently but rear wheels are controlled together by one wheel speed sensor (ex. On differential ring gear)

1-Sensor 1-Channel type: In this type only the rear wheels pressure are controlled by one sensor.

How ABS Detects wheel lock up condition

ABSS has got wheel speed sensors on all the four wheels. It continuously calculates the slip ratio of all the four wheels.

Slip ratio: It is the percentage ratio between difference of vehicle speed and wheel speed to vehicle speed.

$$\text{Slip ratio} = \frac{(\text{Vehicle speed} - \text{Wheel speed})}{\text{Velocity}} \times 100$$

While wheel speed information is directly taken from wheel speed sensor, vehicle speed information is not attained directly from vehicle speed sensor. There is no vehicle speed sensor information to ABS. It is attained with some logic using wheel speed sensor information only. The reason being exact vehicle speed cannot be attained from sensor, when the wheel is locked and vehicle skidding.

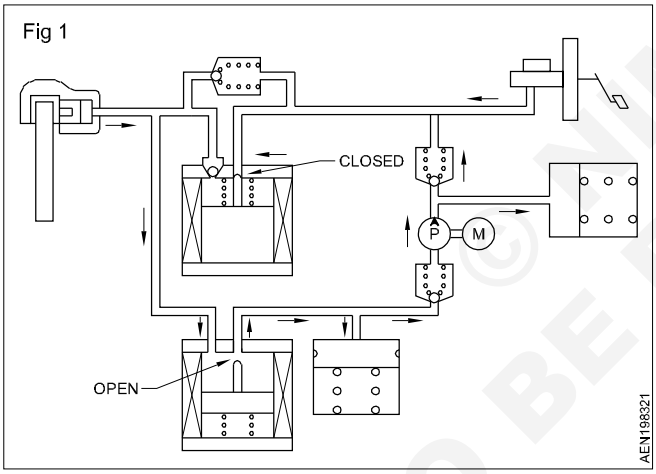
How Abs calculates vehicle speed

At the time of braking the speed of individual wheels differ hence slip ratio also differs. Two wheel drive vehicles uses the maximum wheel speed as vehicle speed at the time of wheel lockup. This gives a fairly correct information above vehicle speed, because the vehicle will tend to propel at that speed.

For ex: At braking if the wheel speed information from all the four wheels in car are 20, 30, 20, 20 Kmph. Then vehicle speed is taken as 30 Kmph for calculating slip ratio of individual wheels.

Dump mode (Fig 1)

Fig 1



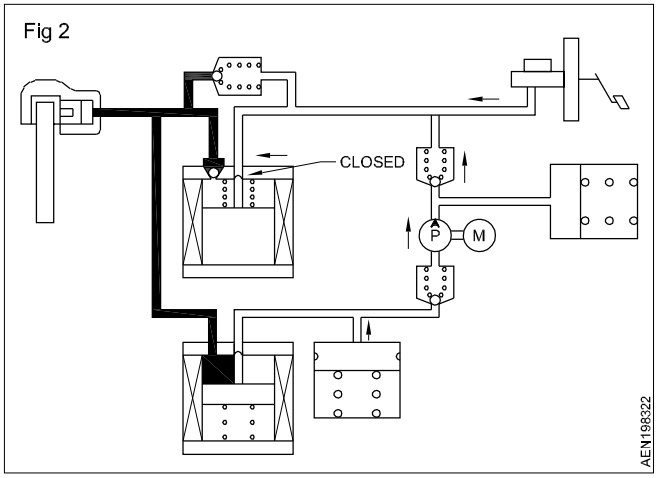
When ABS unit detects a wheel lock up condition it tries to avoid wheel lockup by releasing pressure from wheel cylinder. In this case Solenoid Valve - In, Solenoid valve - Out and motor is ON. Solenoid Valve - In closes the passage from master cylinder. Solenoid Valve - Out opens the passage to pump, which pumps the fluid out reducing the pressure at wheel cylinder.

Hold mode (Fig 2)

Once the pressure is released to some extent to avoid wheel lock up condition, pressure is locked inside wheel cylinder by switching off the Solenoid Valve - Out alone i.e. Solenoid Valve - Out closes the passage from wheel cylinder to pump locking the pressure inside wheel cylinder.

In four wheel drive vehicles since torque is transmitted to all four wheels the chances of four wheel lockup in low friction surfaces are more. Calculation of vehicle speed from wheel speed gives wrong result. Hence four wheel drive vehicle use additional "G" sensor to calculate vehicle speed.

Fig 2



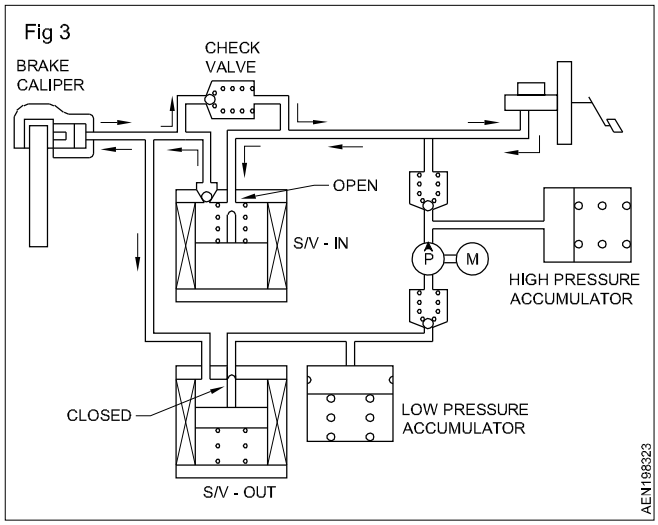
G-Sensor (Acceleration sensor)

G-Sensor is used by the ABS for measuring the deceleration rate of the vehicle whenever brakes are applied. G-Sensor signal output is directly proportional to the Acceleration/ Deceleration of the vehicle. Using wheel speed sensor logic has its own disadvantages as there are chances of all the four wheels getting locked up during braking on very low friction surfaces like on ice or slippery surfaces. Under these conditions, it is impossible to calculate the deceleration rate of the vehicle from the wheel speed sensors. In this case, ABS cannot perform efficiently.

Normal Braking (Fig 3)

In normal braking Solenoid Valve - In, Solenoid Valve - Out and motor is off. Brake pressure applied to the master cylinder goes to wheel cylinder through Solenoid valve - In Solenoid valve - IN is normally open type (NO) i.e. it is open when it is off. Solenoid Valve - OUT is normally closed type (NC) i.e. it is closed when it is off. Brake fluid return to master cylinder through check valve in Solenoid valve - IN. This is like conventional braking. ABS operates in normal mode till lockup condition is detected. Once wheel lockup condition is detected ABS comes into operation i.e. Dump, Hold and Increase mode are executed.

Fig 3



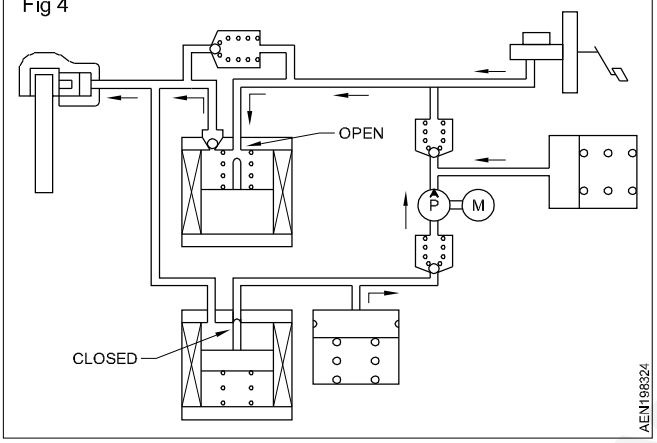
Dump mode

When ABS unit detects a wheel lock up condition it tries to avoid wheel lock up by releasing pressure from wheel cylinder. In this case Solenoid Valve - In, Solenoid Valve

- Out and motor is ON. Solenoid Valve - In closes the passage from master cylinder. Solenoid valve - Out opens the passage to pump, which pumps the fluid out reducing the pressure at wheel cylinder.

Increase mode (Fig 4): In this mode pressure is increased to compensate for the released pressure. The Solenoid Valve condition is similar to normal mode except motor is ON. The pump pushes brake fluid into master cylinder circuit to increase the brake pressure applied to wheel cylinder. The pedal pressure applied by the driver and the motor pressure together from the pressure applied to wheel cylinder. Once the ABS unit does the dumping operator (pressure release) the pressure increase is done in steps of hold and increase for better steering control, stability and better stopping distance.

Fig 4



EBD (Electronic Brake-force Distribution)

The EBD system is a sub-system of the ABS system, it is very effective in controlling the effective adhesion utilization by the rear wheels. It controls the slip of the rear wheels in the partial braking range. The brake force is moved even closer to the optimum range, thus dispensing with the need for a mechanical proportioning valve.

The mechanical proportioning valve has its limitations when speaking about achieving the idea brake force distribution to both the front and rear wheels.

EBD doesn't have any new components in face the same ABS components like wheel speed sensor, electronic unit are used. It is only a logical extension of ABS logic in ECU memory. EBO system provide the solenoid valves to reduce the brake pressure to the rear wheels when the slip ratio of rear wheels are more than that of front wheels. EBD failure is indicated by glowing the parking lamp.

EBD advantage (Fig 5)

– Function improvement of the base-brake system

– Appropriate brake force distribution to front and rear wheels with respect to load variations

– Possible to achieve ideal brake force distribution with EBD

– Compensation for the different friction coefficients

– Elimination of the mechanical proportions valve

– Failure indication through warning lamp in cluster.

Maintenance of ABS Brake Systems

The following table should only act as a guide; the manufacturer's recommendations should always be followed.

Traction control system (TCS) (Fig 6)

The TCS system prevents the drive wheels spinning when pulling away and accelerating.

This stabilises the vehicle in the longitudinal direction, the cornering stability is maintained and the vehicle is prevented from breaking away at the powered axle.

The TCS is an enhancement of ABS. Both systems use common sensors and actuators and often have a common ECU where the data exchange is usually carried out via a CAN bus. When the vehicle is being driven with snow chains, the TCS can be deactivated. A distinction can be made between:

- TCS systems with engine intervention.
- TCS systems with brake intervention, otherwise known as ELSD Electronic Limited Slip Differential.
- TCS systems with engine and brake intervention.

TCS/ELSD brake circuit of a wheel

Advantages

- Improvement of traction when pulling away or accelerating.
- Increase of driving safely at high motive forces.
- Automatic adjustment of engine torque to the grip rates.
- Driver information about reaching dynamic limits.

TCS with brake intervention/electronic limited slip differential ELSD

An electro-hydraulic system is used as a starting off aid. The lock effect is created as a result of brake intervention on the spinning wheel in order to achieve better traction.

Structure

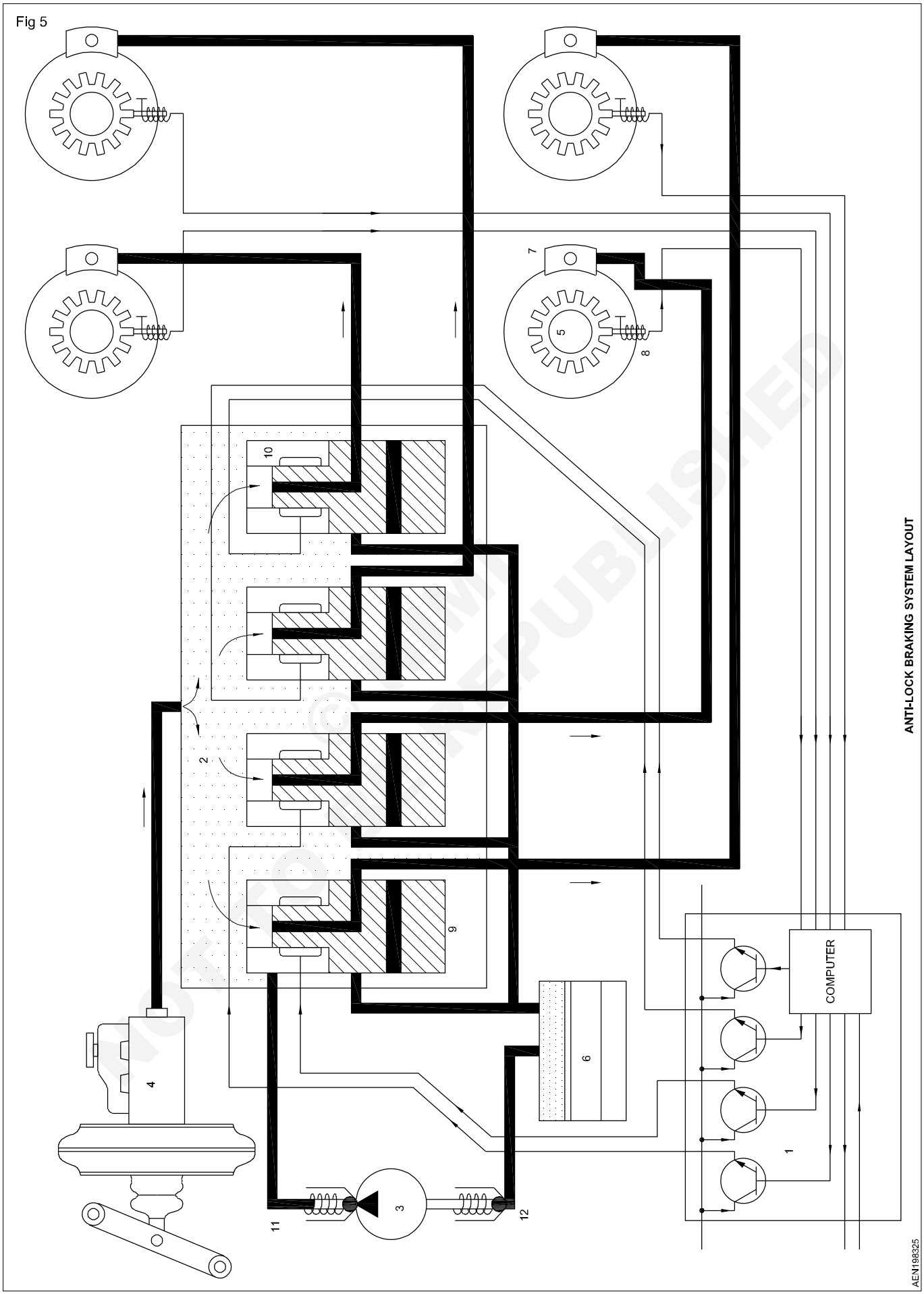
Hydraulic system: This is composed of a hydraulic pump with suction and delivery valves inter and outlet valves, a hydraulic changeover valve and a check valve with pressure limiter.

Electrical system: This is composed of ABS/TCS (ELSD) ECU and wheel speed sensors.

Operating principle

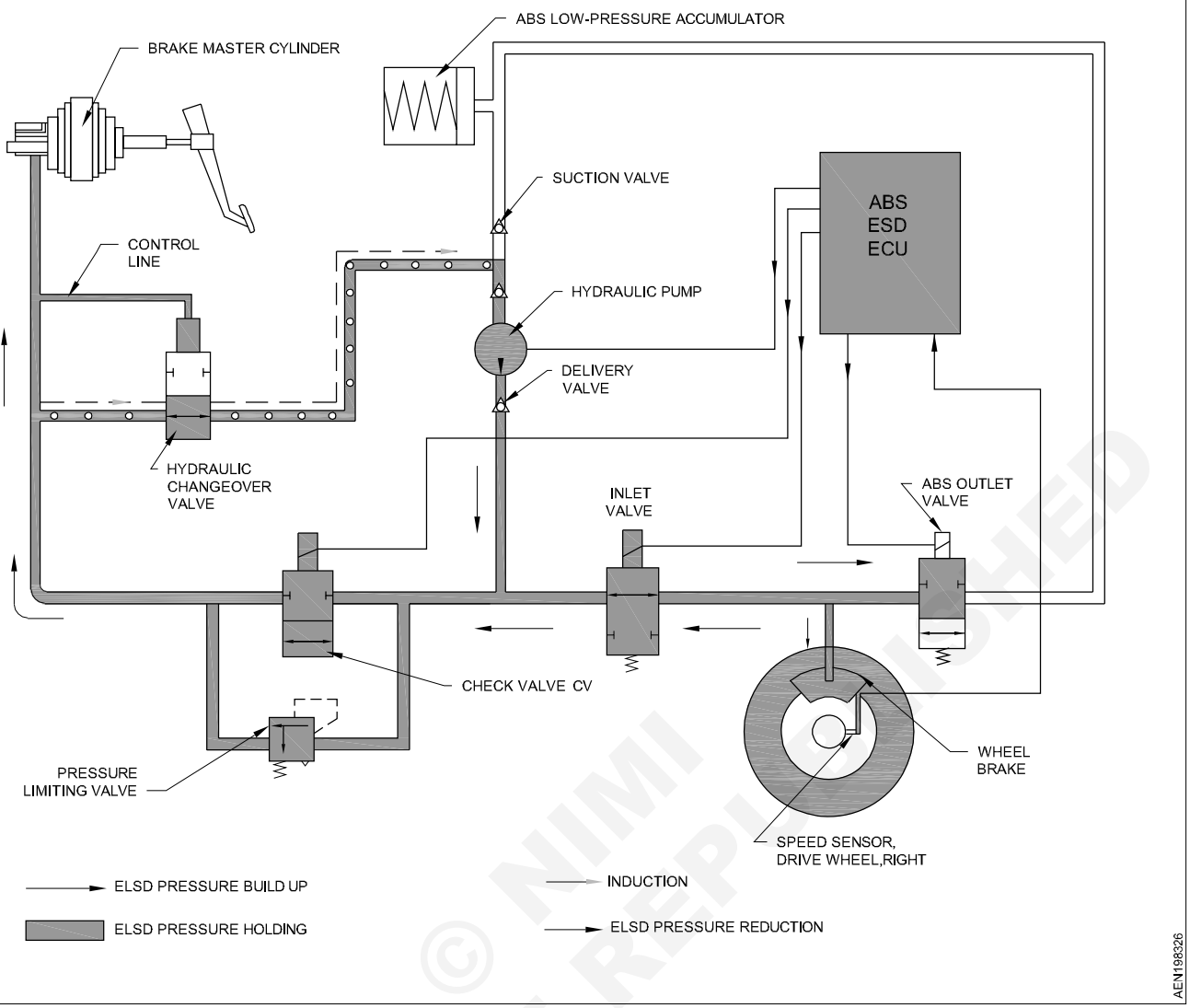
Pressure build-up: If a driven wheel spins, this is detected by the ECU with a speed sensor. It activates the hydraulic pump and the check valve. The check valve (CV) closes and the pressure generated by hydraulic pump P brakes the spinning wheel.

Fig 5



ANTI-LOCK BRAKING SYSTEM LAYOUT

Fig 6



Pressure holding the inlet valve (IV) is closed

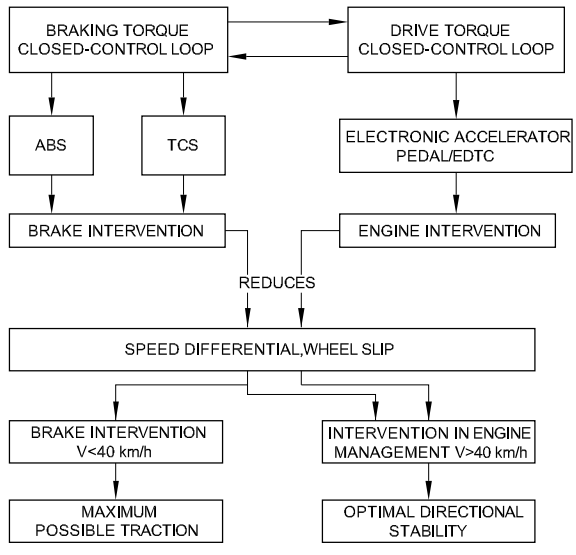
Pressure reduction

If the wheel has stopped spinning, then the inlet and check valves are opened and the pressure is relieved to the expansion tank via the master cylinder.

TCS with engine and brake intervention (Fig 7)

The system works with engine or brake intervention, according to the driving situation. The block collaboration of engine and brake intervention for preventing unreliable wheel slip when pulling away. (TCS operation/ELSD operation) or in overrun mode. (EDTC operation)

Fig 7



TCS BLOCK DIAGRAM

Automatic transmission

Objectives: At the end of this lesson you shall be able to
- **define automatic transmission**
- **state the controlling variables of the automatic transmission**
- **identify the major components**
- **explain the working principle of automatic transmission**
- **state the electro hydraulic transmission control.**

Definition

Automatic transmission of an automobile is defined as to shift the gears automatically depending upon the speed and load of the vehicle.

Controlling parameters of the automatic transmission

The main controlling variables are

- Selector lever position
- Driving speed
- Engine load (accelerator pedal position)

Major automatic transmission components

- Torque converter (Fig 1)
- Planetary gear unit
- Electro hydraulic control

Advantages of Automatic transmission

- Simple driving control
- Improved acceleration and hill climbing
- Reduced fuel consumption
- Less wear and tear due to planetary gearing
- Less fatigue to operator
- No need clutch pedal and gear lever
- Vehicle smooth running under all conditions due to automatic gear change
- Noiseless gear shifting
- Longer life
- No jerky driving

Torque converter

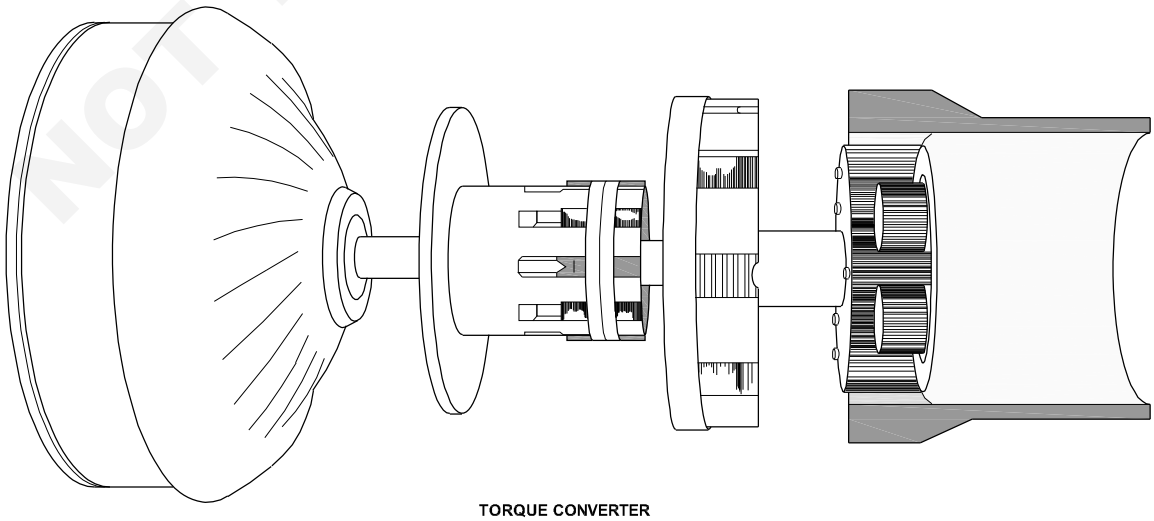
Torque converter is used to transfer power from the engine to the transmission input shaft. It acts as an automatic clutch to engage and disengage the engine and the transmission. It allows the engine to run idle when the vehicle is standing still.

The torque converter is mounted on the transmission input shaft and connected with the fly wheel of the engine.

Functions of torque converter

- It convert and transmit the engine torque
- It facilitate smooth, comfortable starting
- It damp the engine torsional vibrations
- The major components of torque converter are
- Impeller
- Turbine
- Stator

Fig 1



TORQUE CONVERTER

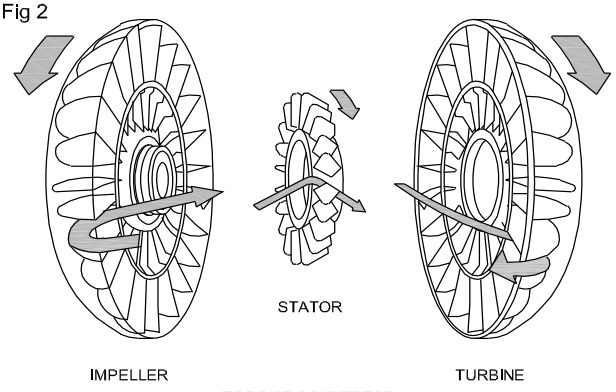
AEN198711

The impeller, turbine wheel and stator are designed as curved blade wheels and operate in an enclosed housing which is filled with hydraulic fluid.

The impeller is driven by the engine flywheel. Guide rings are provided on the inner edges of the vanes to provide smooth fluid flow. When the impeller is driven by the engine, the centrifugal force causes the fluid to flow outward towards the turbine.

The input shaft of the transmission is attached with the turbine hub which is splined. The curvature of the vanes in the turbine is opposite is opposite of the impeller vanes. This makes the turbine to rotate when the fluid is forced from the impeller vanes. Therefore the turbine is also starts rotating in the direction of engine rotation. (Fig 2)

Fig 2



The stator is located in between the impeller and the turbine. It is mounted on the reaction shaft which is fitted to the transmission case. The vanes of the stator catch the fluid as it leaves the turbine and redirects it back to the impeller. This gives the impeller an added torque.

The over running clutch drive in the stator allows the stator to rotate in one direction. Normally it rotates in the direction of the crank shaft. The over running clutch drive does not allow the stator to rotate in opposite direction.

Working principle

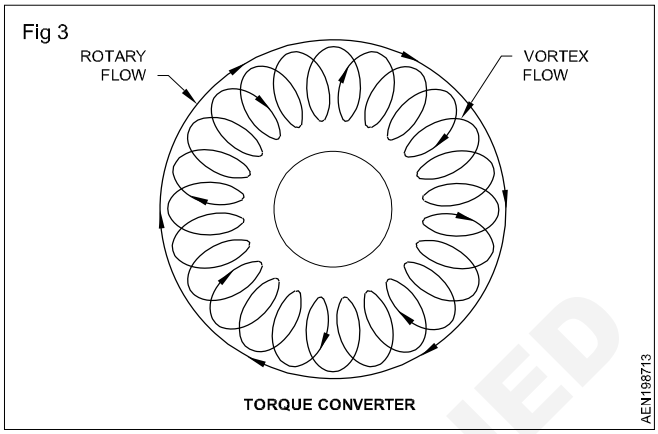
During starting, the impeller rotates at the engine speed, while the turbine wheel and stator are stationary. The fluid flows from the impeller to the turbine wheel, dissipates its energy to the turbine and it deflected in the process.

During idling speeds the speed of the impeller is low and the fluid flow will not be able to rotate the turbine. But when the engine sped increases, the fluid moves fast and rotates the turbine.

There are two types of fluid flow (Fig 3). Vortex flow and radial flow. The flow will be vortex till the speed of the impeller and the turbine is not same. Vortex flow is a spiralling flow. Radial flow is fluid flow which circulates with the converter body rotation. This radial flow usually happens when the speed of the impeller and the turbine will be same.

When the engine is accelerating, the speed difference in the impeller and the turbine will be very high and the flow is called high vortex. During this time, fluid from the impeller directed towards the outer surface of the turbine and from the turbine it strikes the front of the vanes of the stator and locks it on the stator reaction shaft, preventing it from rotating in the anti-clockwise direction. The fluid passing through the stator is redirected by the shape of the vanes and strikes on the back of the vanes of the impeller which increase the torque of the impeller.

Fig 3



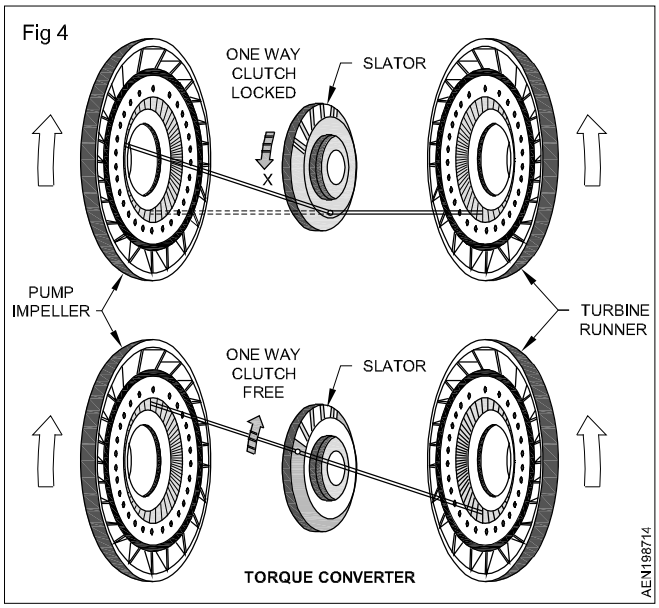
When the flow is rotary, the fluid from the turbine strikes the stator which allows the stator to rotate in the clockwise direction. This happens normally when the speed of the impeller and the turbine are in the same speed.

The rotary flow inside the torque converter happens when the vehicle is running in constant speed. This is called the coupling point.

Lock up clutch mechanism (Fig 4 to 6)

When the impeller and turbine are in the same speed, there is no torque multiplication takes place. The ratio is almost 1:1. However, it is not possible to get 100% power transmission in the torque converter, there is some power loss. The lock up clutch mechanically connects the impeller and the turbine when the vehicle speed is 60kmph and above. Thus 100% power transmission is possible.

Fig 4



The lock up clutch is fitted on the turbine hub. The lock up clutch is normally in disengaged position. When the clutch is operating, it engages the turbine with the torque converter case. It operates with the fluid. Relay and signal valves are control the hydraulic fluid flow.

Fig 5

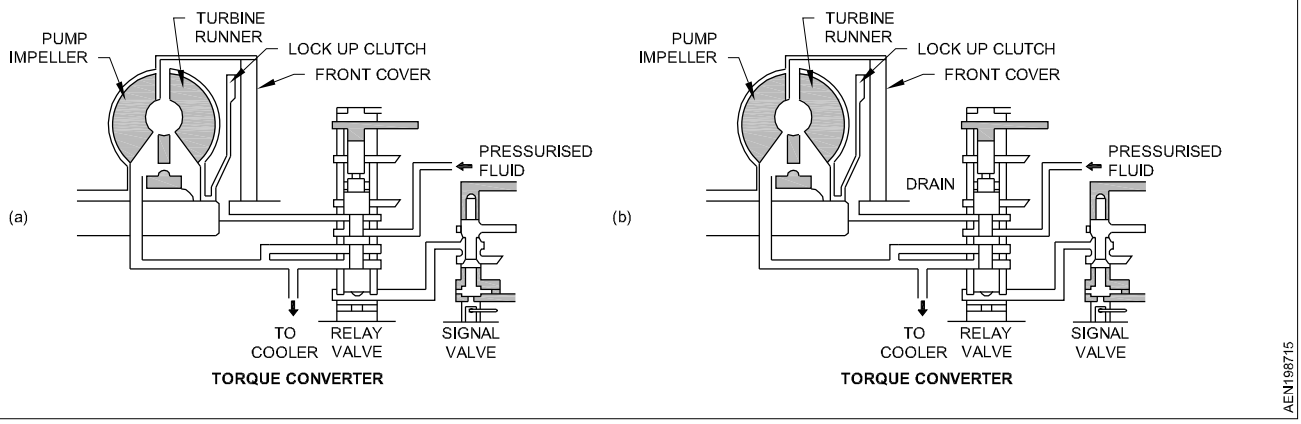
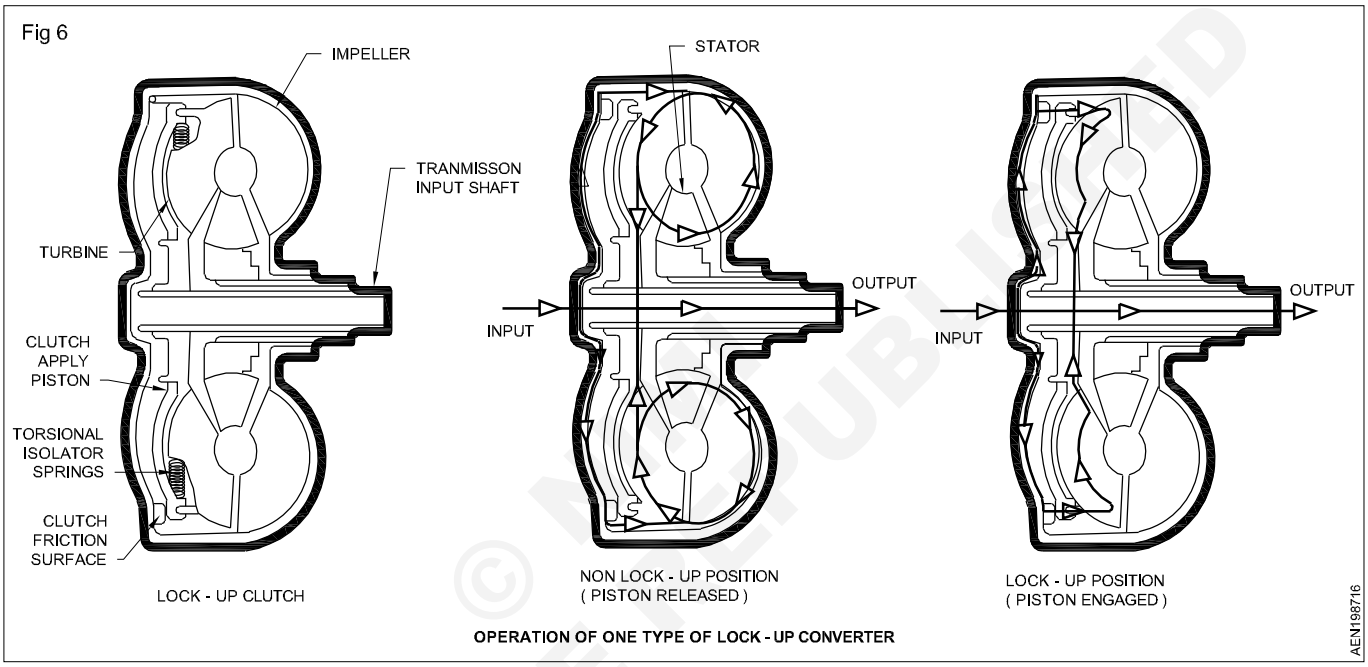


Fig 6



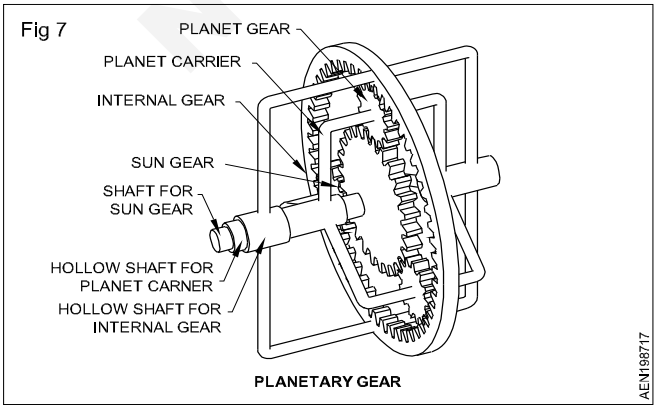
OPERATION OF ONE TYPE OF LOCK - UP CONVERTER

When the vehicle is running at low speeds, the pressurized fluid flows in to the front of the lock up clutch and the clutch is disengaged. (Fig 5a)

When the vehicle is running at medium and high speeds, the pressurized fluid flows in the other side of the lock up clutch, creating low pressure in the front side of the lock up clutch. The difference in pressure makes the lock up clutch engaged (Fig 5b). As a result, the turbine and the case rotate together.

Planetary gear (Fig 7)

Fig 7



PLANETARY GEAR

A simple planetary gear set consists of

- Sun gear
- Planet gears
- Ring gear
- Planet carrier

The planet gears are supported with their axis in the planet carrier. The planet gears circulate on the internal teeth of the ring gear and the outer teeth of the sun gear. All gears are constantly meshed. The sun gear, planet carrier and ring gear are driven and braked. Output is effective through the ring gear or the planet carrier. Different gear ratios are achieved by this planetary gear set.

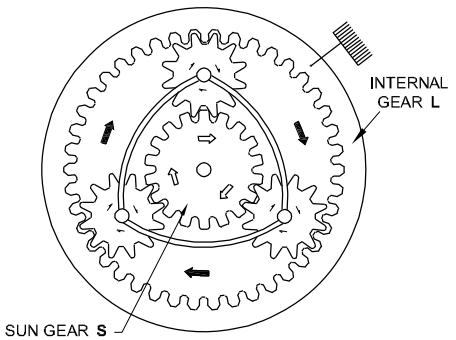
Three different forward gear ratios and one reverse gear radio are possible in this type. The drive of the planetary gears is set through the multi plate clutch. Different gear ratios and directional change are obtained by braking any one of the component.

Working principle of planetary gear set

1st gear (Fig 8)

The sun gear is the driving gear and the sun gear blocked. The planet gears circulate on the inner teeth of the ring gear. The power transmitted to the output shaft through the carrier. A larger gearing down takes place.

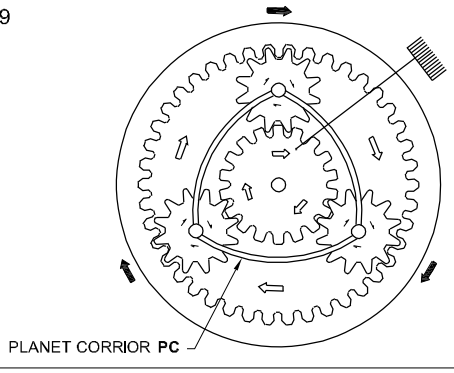
Fig 8



2nd gear (Fig 9)

The ring gear is the driving gear and the sun gear blocked. The planet gears circulate on the outer teeth of the sun gear. Power output from the carrier. The smaller gearing down takes place.

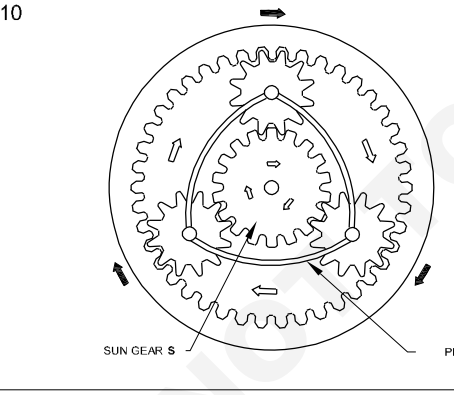
Fig 9



3rd gear (Fig 10)

The planetary gear set is blocked the planet gears stop rotating and act as drivers. The output rotates same as input and power flow takes from planet carrier.

Fig 10



Reverse gear (Fig 11)

The planet carrier is braked. The sun gear is the driving gear and planet gears reverse the direction of rotation of the ring gear. A large gearing down takes place.

Shifting logic

The table 1 shows the shifting logic for a simple planetary gear set with three forward and one reverse speed.

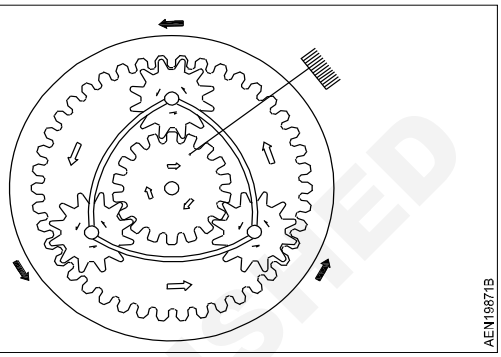
Normally two or three planetary gear sets are used to get sufficient gear ratios.

Table 1 - Shifting logic, 3 gear planetary gear

Gear	Input	Braked	Output
1st gear	S	I	PC
2nd gear	I	S	PC
3rd gear	S+1	–	PC
Rear	S	PC	I

S-Sung gear, I-Internal gear PC-Planet Carrier

Fig 11



Electro hydraulic transmission control

The electro hydraulic transmission control involves sensors, solenoid and hydraulic valves. The sensors recording specific operating status. The solenoid valves operate hydraulic valves which control the hydraulic pressure to the respective shift elements. The gear shifting is effected by driving and braking of different shift elements.

The electronic gear box control unit (EGS) processes the input signals from the sensors and other ECUs.

Vehicle side signals

Select lever contains

- P - Park
- R - Reverse
- N - Neutral
- D - Drive (all forward gears)
- Gear box side signals
- Gear box input speed
- Driving speed
- Transmission fluid temperature
- Engine side signals
- Acceleration pedal position
- Engine load
- Engine speed
- Coolant temperature

The gear shift sequences are selected using stored program in the EGS. The gear shift process and the

control of the lock up clutch are effected by solenoid valve.

Shift elements

- Multi plate clutches
- Brake clutches
- Overrunning clutches

These are used to lock the sun gear, planet carrier or ring gear. These are all actuated by the electronic gear box control unit. By operating this, any one of the planet gear set component can be braked.

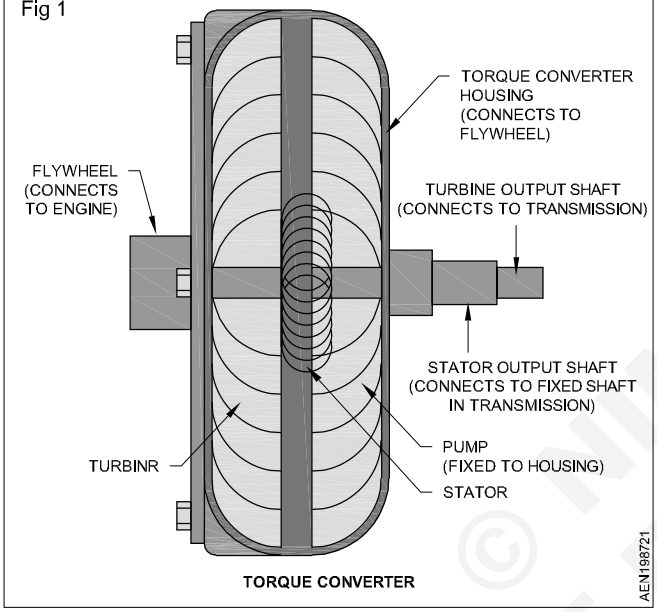
Hydraulic system and control

Objectives: At the end of this lesson you shall be able to
- **list out the hydraulic parts in the auto transmission**
- **state the parts and function of hydraulic controls of auto transmission**
- **explain various types of valves and their function.**

Hydraulic system and control

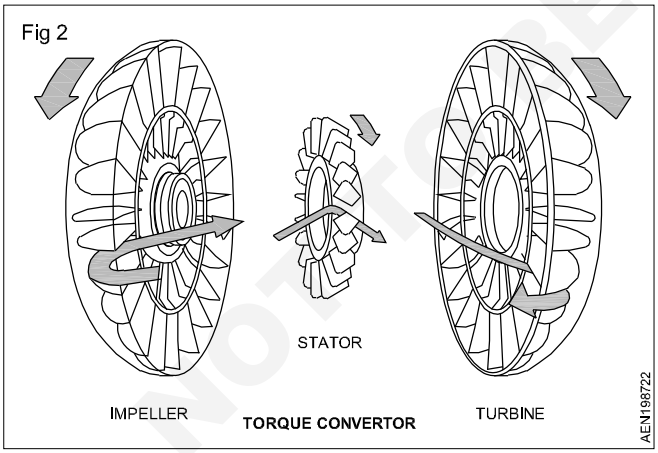
1 Hydraulic pump
2 The governor
3 Valves
4 Modulator
5 Clutches
6 Planetary gears
7 Torque convertors (Fig 1 & 2)
8 Fluid fly wheel

Fig 1



TORQUE CONVERTER

Fig 2



TORQUE CONVERTOR

Hydraulic pump

The pump is called as neat pump or gear pump. It is usually located in the cover of the transmission case. It draws the fluid from the sump in the bottom of the transmission and feeds it to the hydraulic system. It also feeds the transmission cooler and the torque convertor.

The inner gear of the pump shown in the fig hooks up to the housing of the torque convertor. It spins same speed of the engine. The outer gear is turned by the inner gear and as the gears rotate, the fluid is drawn up from the sump on one side of the crescent and forced out in to the hydraulic system on the other side.

The governor

The governor is a clever valve that informs the transmission how fast the vehicle is moving. It is connected to the output, so the faster the vehicle moves, the governor responds to that speed and spins. Inside the governor there is a spring loaded valve that opens in proportion to how fast the governor is spinning. The faster the governor spins, the more the valve opens. Fluid from the pump is feed to the governor through the output shaft.

So the speed of the vehicle, the valve openings of the governor and pressure of the fluid feed in to the transmission are interrelated.

Valves

There are various types of valves available in the automatic transmission namely, check valves, shuttle valves, shift valve and a manual valve is also there to function the automatic transmission system.

In some of the automatic transmission system the function of the valve is performed by the modulators. Instead of values modulators are fitted and they perform the duty of the valves.

Generally these modulators are vacuum operated. The modulators sense the manifold pressure, which increases when the engine is under greater load.

Clutches

Stator or one way clutch

When the vehicle approaches the cruise speed the turbine begins to catch up with the impeller. The fluid leaving the turbine is moving at about the same speed as the impeller. The fluid leaving the turbine is moving at about the same speed as the impeller. The fluid could pass directly into the impeller without stator action. The fluid is striking the back sides of the stator vanes. To allow the stator vanes to move out of the way, the stator mounts on a one way clutch.

Torque convertor clutch TCC

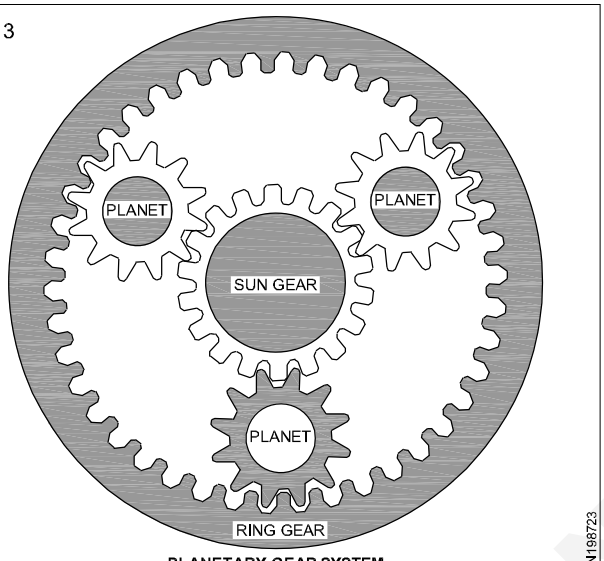
A lockup torque convertor eliminates the 10% slip that takes place between the impeller and turbine at the coupling stage. The engagement of a clutch between the impeller and the turbine assembly greatly improves fuel economy and reduces operational heat and engine speed.

Planetary gears (Figs 3)

Epicyclic gearing or planetary gearing is a gear system consisting of one or more outer gears, or planet gears, revolving about a central, or sun gear. Typically, the planet

gears are mounted on a movable arm or carrier which itself may rotate relative to the sun gear. Epicyclic gearing systems also incorporate the use of an outer ring gear or annulus, which meshes with the planet gears. Planetary gears are typically classified as simple and compound planetary gears. Simple planetary gears have one sun, one ring, one carrier, and one planet set. Compound planetary gears involve one or more of the following three types of structures: meshed planet (there are at least two more planets in mesh with each other in each planet train), stepped - planet (there exists a shaft connection between two planets in each planet train), and multistage structures (the system contains two or more planet sets).

Fig 3



PLANETARY GEAR SYSTEM

Compared to simple planetary gears, compound planetary gears have the advantages of larger reduction ratio, higher torque-to-weight ratio, and more flexible configurations.

Epicyclic gearing is also available which consists of a sun, a carrier, and two planets which mesh with each other. One planet meshes with the sun gear, while the second planet meshes with the ring gear. For this case, when the carrier is fixed, the ring gear rotates in the same direction as the sun gear, thus providing a reversal in direction compared to standard epicyclic gearing.

Torque convertor

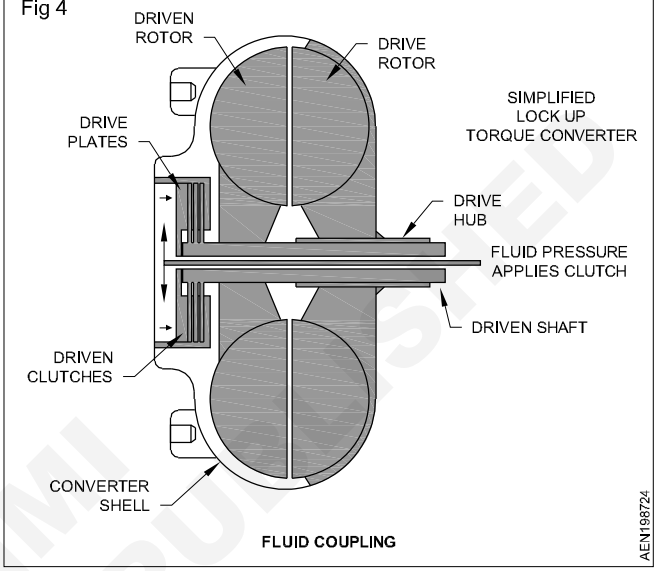
If you have read about manual transmissions, you know that an engines connected to a transmission by way of a clutch. Without this connection, a car would not be able to come to a complete stop without killing the engine. But cars with an automatic transmission have no clutch that disconnects the transmission from the engine. Instead, they use an amazing device called a torque converter. It may not look like much, but there are some very interesting things going on inside.

In a torque converter there are at least three rotating elements: the impeller, which is mechanically driven by the prime mover; the turbine, which drives the load; and the stator, which is interposed between the impeller and turbine so that it can alter oil flow returning from the turbine to the impeller. The classic torque converter design dictates that the stator by prevented from rotating under any condition, hence the term stator. In practice, however, the stator is mounted on an overrunning clutch, which prevents the stator from counter-rotating with respect to the prime mover but allows forward rotation.

Fluid fly wheel/coupling (Fig 4)

A fluid coupling is a two element drive that is incapable of multiplying torque, while a torque converter has at least one extra element-the stator-which alters the drive's characteristics during periods of high slippage, producing an increase in output torque.

Fig 4



FLUID COUPLING

Planetary compound gear set

One simple planetary-gear set cannot be used for automatic gearboxes because in practice it practice it does not deliver sufficiently useable gear ratios and two output are shifted in succession.

Ravigneaux set (Fig 5)

This consists of

- a common internal gear
- a common planet carrier
- two different-sized sun gears and
- short and long planet gears

The different gear-ratio stages are achieved as in the simple planetary-gear set by driving and braking specific parts or by blocking the entire planetary-gear set.

Electronic control transmission

Output can be effected either via the internal gear or via the planet carrier.

The ravigneaux set shown in Fig 5 facilities 3 for ware gears and 1 reverse gear.

C1 Driving clutch - drives small sun gear **S1**

C2 Driving clutch - drives large sun gear **S2**

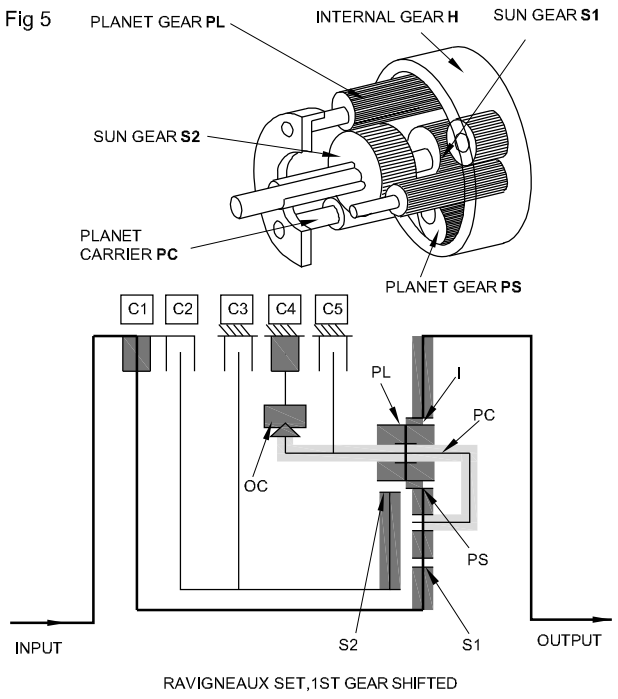
C3 Brake clutch - brakes sun gear **S2**

C4 Brake clutch - brakes overrunning clutch **OC**

C5 Brake clutch - brakes planet carrier **PC**

OC Overrunning clutch - supports planet carrier **PC**

Fig 5



RAVIGNEAUX SET,1ST GEAR SHIFTED

C1 DRIVING CLUTCH-DRIVES SMALL SUN GEAR **S1**
C2 DRIVING CLUTCH-DRIVES LARGE SUN GEAR **S2**
C3 BRAKE CLUTCH-BRAKES SUN GEAR **S2**
C4 BRAKE CLUTCH-BRAKES OVERRUNNING CLUTCH **S2**
C5 BRAKE CLUTCH-BRAKES PLANET CARRIER **PC**
OC OVERRUNNING CLUTCH-SUPPORTS PLANET CARRIER **PC**

Example of 1st gear

C1 and C4 are shifted. C4 holds the planet carrier in one direction of rotation overrunning clutch.

Table 1: Shifting logic, Ravigeaux set

Gear	C1	C2	C3	C4	C5	OC
1st gear	•			•		•
2nd gear	•		•			
3rd gear	•	•				
R gear		•			•	

Power-flow progression:

Input ® C1 ® S1 ® PS ® PL ® 1 ® Output

Simpson set (Fig 6) this consists of

S Common sun gear

11,12 2 internal gears (outer & inner internal gears)

PC1, PC2 2 planet carriers

P1, P2 Planet gears (same dimensions)

C1, C2 Driving clutches

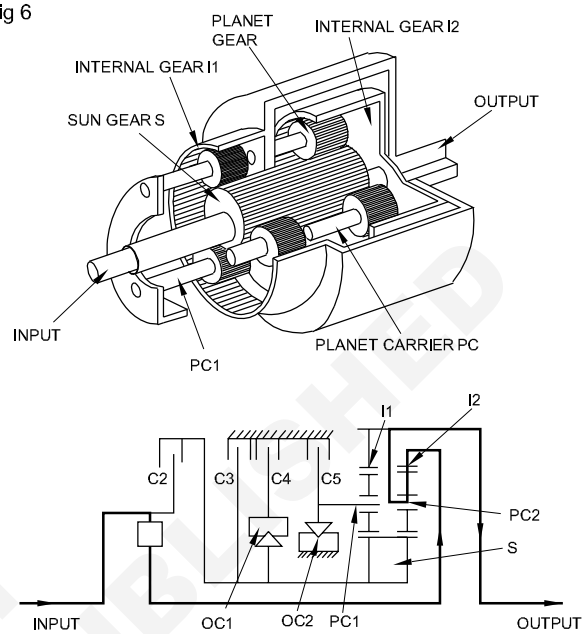
C3, C4, C5 Brake clutches, **C3** brakes S, **C4** brakes OC1, **C5** brakes PC1.

OC1, OC2 Overrunning clutches, OC1 supports S when **C4** is shifted OC2 supports PC

Output is effected via the outer internal gear (I1).

The Simpson set is used for example in 4-speed automatic gearboxes in conjunction with a simple planetary-gear set.

Fig 6



S	COMMON SUN GEAR
I1,I2	2 INTERNAL GEARS (OUTER & INNER)
PC1,PC2	2 PLANET CARRIERS
P1,P2	PLANET GEARS (SAME DIMENSIONS)
C1,C2	DRIVING CLUTCHES,
C1	DRIVES I2,C2 DRIVES S
C3,C4,C5	BRAKE CLUTCHES,C3 BRAKE S,
C4	BRAKES OC1,C5 BRAKES PC1
OC1,OC2	OVERRUNNING CLUTCHES,OC1 SUPPORTS S WHEN C4 IS SHIFTED. OC2 SUPPORTS PC

Table 2: Shifting logic, Ravigeaux set

Gear	C1	C2	C3	C4	C5	OC1	OC2
1st gear	•						•
2nd gear	•		•	•			•
3rd gear	•	•		•			
R gear		•			•		

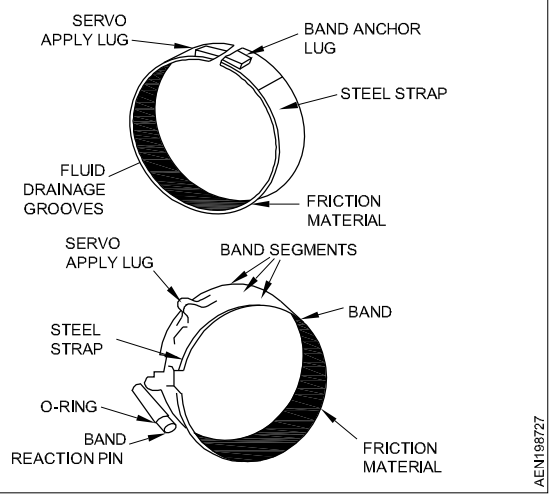
• By adherence for selection-lever position D

In selection-lever position 2 C3 is shifted S is torsinnally resilient

Transmission brake band (Fig 7)

A band is a braking assembly positioned around a stationary or rotating drum or carrier. The band brings a drum to a stop by wrapping itself around the drum and holding it. The band is hydraulically applied by a servo assembly. The purpose of a band is to hold a member of the planetary gear member stationary.

Fig 7



When a band closes around a rotating drum, a wedging action takes place to stop the drum from rotating. The wedging action is known as self-energizing action. A typical band designed to be larger in diameter than the drum it surrounds. This design promotes self disengagement of the band from the drum. A friction material is bonded to the inside diameter of the band.

The lining material of a band is a semi metallic compound, paper-based lining.

Band lugs are either spot welded or cast as a part of the band assembly. The purpose of the lugs is to connect the band with the servo through the actuating (apply) linkage and the band anchor (reaction) at the opposite end. The band's steel strap is designed with slots or holes to release fluid trapped between the drum and the applying band.

The bands used in automatic transmissions are rigid, flexible, single wrap, or double wrap types. Steel single wrap bands are used to hold gear train components driven by high-output engines. Self-energizing action is low because of the rigidity of the band's design. Thinner steel bands are not able to provide a high degree of holding power, but because of the flexibility of design, self-energizing action is stronger and provides more apply force.

The double wrap band is a circular external contracting band normally designed with two or three segments. As the band closes, the segments align themselves around the drum and provide a cushion. The steel body of the double wrap band may be thin or thick steel strapping material. Modern automatic transmissions use thin single or double wrap bands for increased efficiency. Double wrap bands made with heavy thick steel strapping are required for high output engines.

Electro hydraulic transmission control

Electro hydraulic transmision control involves sensors recording specific operating states. These states are processed by the electronic gearbox control unit. Solenoid valves are electrically activated, depending on the driving situation.

These valves actuate hydraulic valves, which control the hydraulic pressure to the respective shift elements. The gear change in the automatic gear box is effected by driving and braking of different shift elements. (Fig 8)

Features

- High gearshift comfort.
- Short shifting times.
- Common utilisation of sensors.
- Optimisation of exhaust emissions and consumption.
- Shift-curve selection possible, e.g. Economic, Sport, Winter, Manual (Tiptronic, Steptronic).
- Shift-program matching to diver type possible (**ATS** - adaptive transmission control or **DSP** - dynamic shift-program selection).
- Simple realisation of various safety functions, e.g.selector-lever interlock.

Design of control system

The control system consists of

- Sensors, e.g. selector lever with multifunction switch, accelerator-pedal-travel sensor (load signal) speed sensor (these sensors from the main controlled variables)
- Electronic gearbox control unit, which among other things communicates via the CAN bus with other ECUs, e.g. engine control unit.
- Electro hydraulic control unit with solenoid valves and hydraulic switching and control valves.
- Shift elements e.g. multi-plate clutches, band brakes, overrunning clutches.

Basic operating principle

Electronic gearbox control unit (EGS). This processes the input singles of the different sensors and switches as well as single from other ECUs via the CAN bus.

Vehicle-side signals

- **Selectors lever**

  P - Park

  R - Reverse

  N - Neutral

  D - Drive (all forward gears)

  1st gear to 4th gear

  1st to 3rd gear

  2nd - ½ gear

- Triptonic function **=** manual shifting
- **Program selector switch**

  Spott - S

Economic - E

Winter - W

starting eg. in 2nd gear

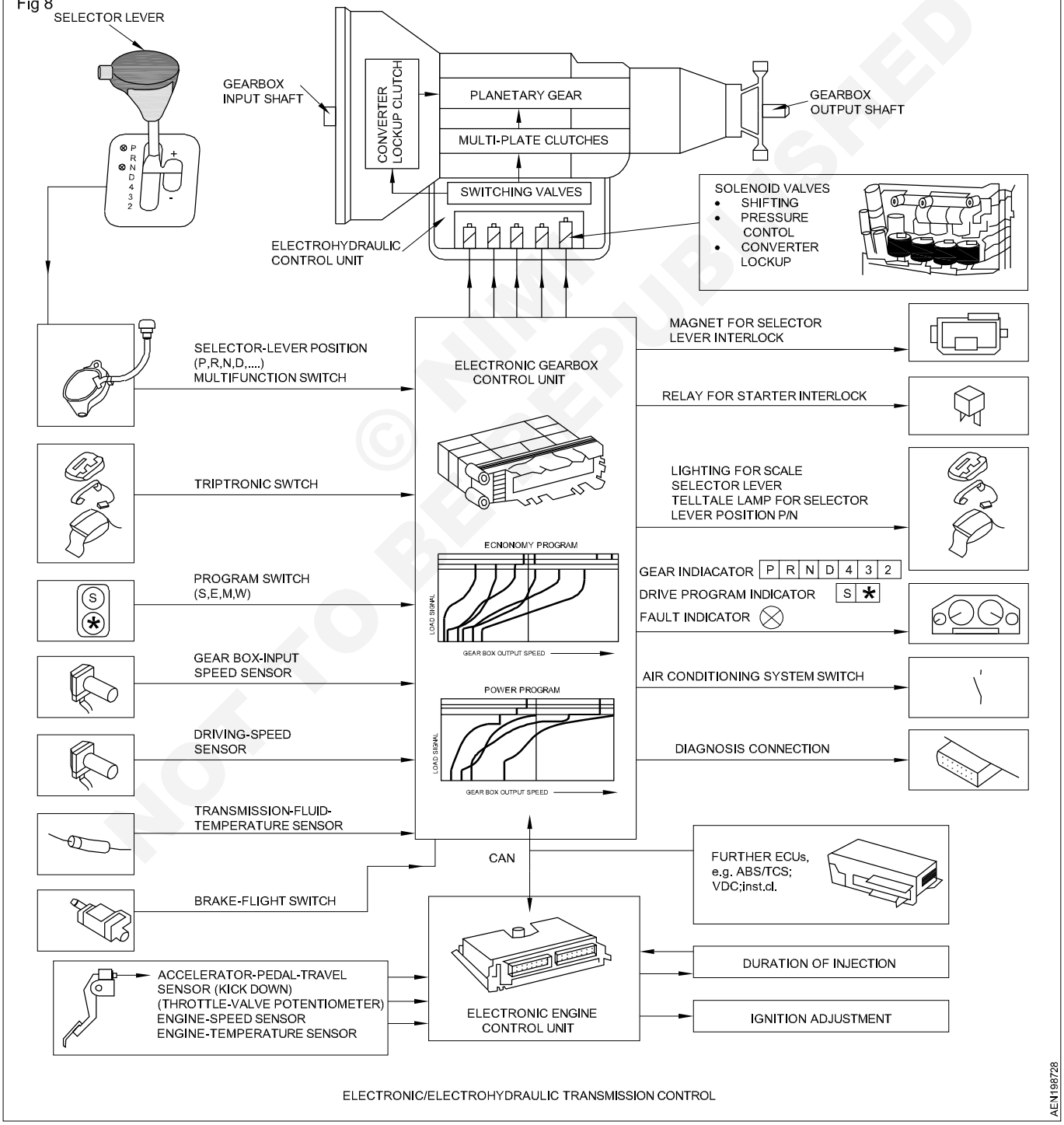
- Brake - light switch
- Signals from other vehicle systems, e.g. ABS/TCS, ESP, vehicle-speed controller **Gearbox-side signals**
- Gearbox input speed
- Gearbox output speed / driving speed
- Transmission-fluid temperature

Engine-side signals

- Accelerator-pedal position with kickdown (throttle valve position)
- Engine load (injection time)
- Engine speed
- Coolant temperature

The gearshift sequences are selected using stored program maps in the electronic gearbox control unit in accordance with the vehicle's current operating state. The relevant gearshift process and the control of the converter lockup clutch are effected by electric activation of solenoid valves in the **electro hydraulic control unit.**

Fig 8



ELECTRONIC/ELECTROHYDRAULIC TRANSMISSION CONTROL

Additional functions of electronic gearbox

control unit EGS

Activation of display in instrument cluster. Gear, program and fault indicators.

Engine intervention: In order to improve shift quality and extend the service life of the shift elements (multi-plate clutches), the engine torque is reduced running the gear shift processes by brief ignition retardation in spark-ignition engines. In diesel engines, the injected fuel quantity is reduced briefly.

Downshift protection: Selector-lever downshifts are only executed if these do not result in excessively high engine speeds.

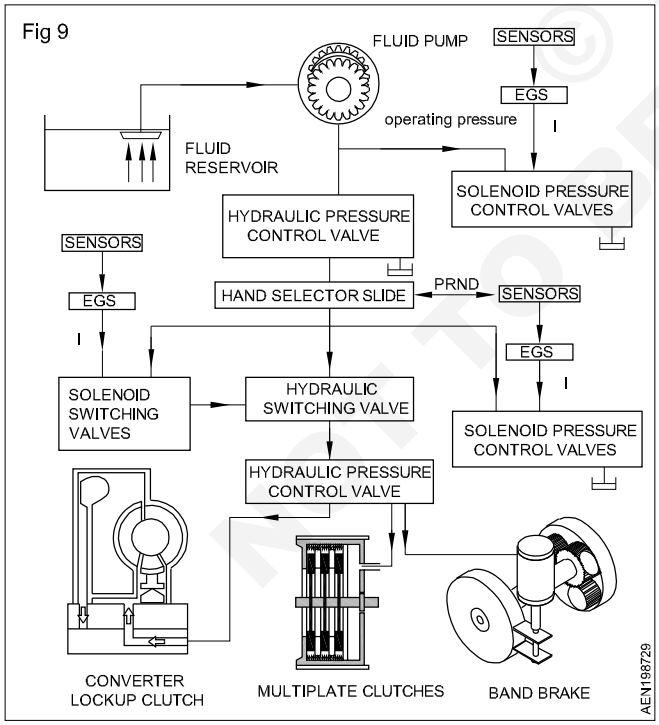
Selector-lever interlock-shift-lock: Only after the ignition is switched on can the selector lever be moved with the brake applied from the **P** or **N** position to a new position so that vehicle cannot move off unintentionally. An actuator solenoid is activated by the electronic gearbox control unit for this purpose.

R / P interlock. At speeds generally in excess of 10 km/h, the selector lever cannot be moved from **R** to **P.** This prevents mechanical gearbox damage.

Starter interlock. In order to start the engine, the selector lever must be in the **P** or **N** position and the brake pedal must be actuated. Otherwise the start-locking relay is not actuated by the electronic gearbox control unit.

Electro hydraulic system (Fig 9): The electro hydraulic system consists of

Fig 9



- Fluid pump for pressure generation.
- Pressure-control valve for operating pressure control.
- Control valves for shift pressure control.
- Hand selector slid for distributing fluid flow to the respective valves.
- Switching valves for controlling multi-plate clutches, band brakes and converter lockup clutch.

Shift elements

These connect or brake corresponding components of the planetary-gear set.

There are the following different types

- Drive clutches (multi-plate clutches)
- Brake clutches or band brakes
- Overrunning clutches

Drive clutch

Clutch closed: The operating pressure is directed by the switching valve and acts on the plunger. The plunger actuates the disc spring, which compresses the plate pack. The frictional / adherent connection is establish.

Clutch released: There is no acting operating pressure; the plunger is pressed back by the disc spring. The power flow is interrupted.

By means of appropriate control of the shift pressure, the clutch can be both fully closed and operated with slip. This enables the shift quality to be improved.

The shift pressure is replaced by the operating pressure at the end of the shift process.

Front clutch (FC) Servo (Fig 10): When pressurized, fluid is supplied to the front clutch piston chamber. The piston will move over to the right and through the leverage of the disc spring will clamp the plates together with considerable thrust. The primary sun gear will now be locked to the input turbine shaft and permit torque to be transmitted from the input turbine shaft to the central output shaft and primary sun gear.

Rear clutch (RC) Servo: When pressurized, fluid is released from the front clutch piston chamber and transferred to the rear clutch piston chamber. The servo piston will be forced directly against the end plate of the rear clutch multiplate pack. This compresses the release spring and sandwiches the drive and driven plates together so that the secondary sun gear will now be locked to the input turbine shaft. Torque can now be transmitted from the input turbine shaft to the secondary sun gear.

The working principles of one-way clutch: One-way sprage clutch resembles a roller bearing but instead of cylindrical rollers, non-revolving shaped sprag are used. When the unit rotates in one direction the rollers slip or free-wheel, when a torque is applied in the opposite direction, the rollers tilt slightly, producing a wedging action and binding because of friction. The sprage are spring-loaded so that they lock with very little backlash.

The components of one way clutch (Fig 11): A one-way clutch consists of outer race, inner race, cage, sprage and so on.

Overrunning clutch (Fig 12): Its function is to connect with each other specific parts of the planetary-gear set.

Fig 10

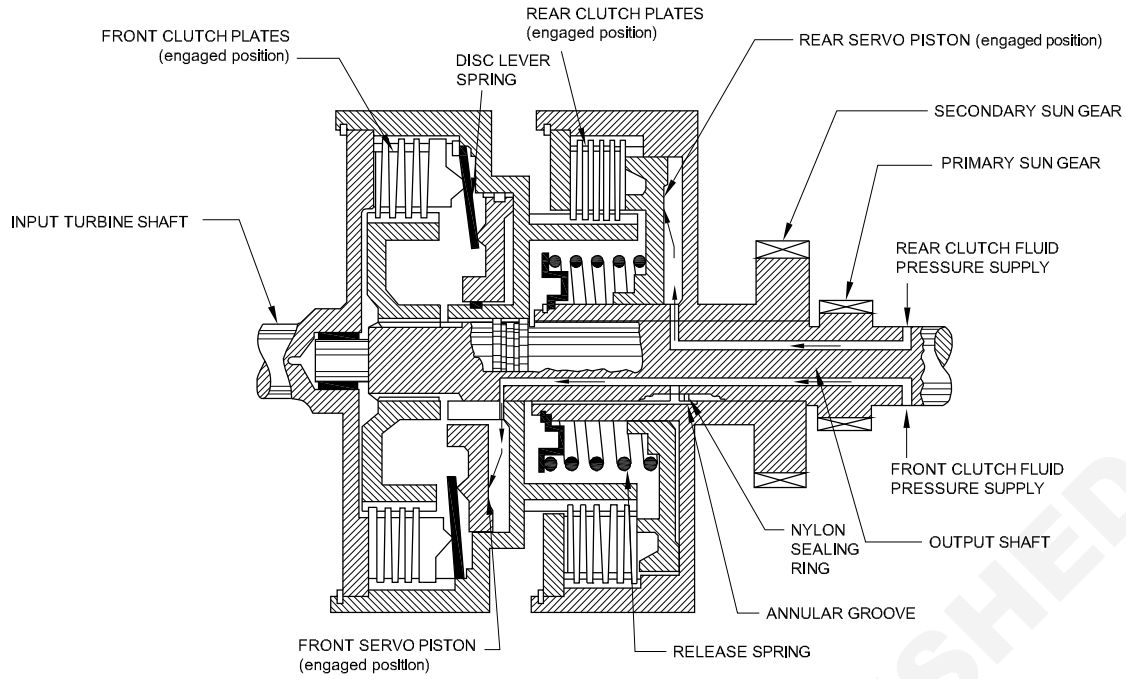


Fig 11

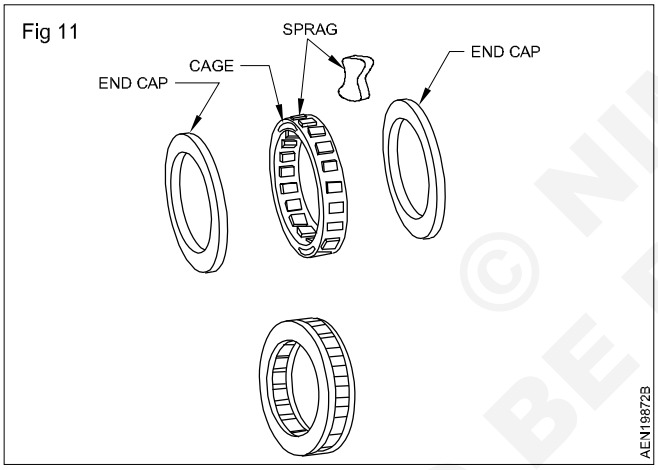
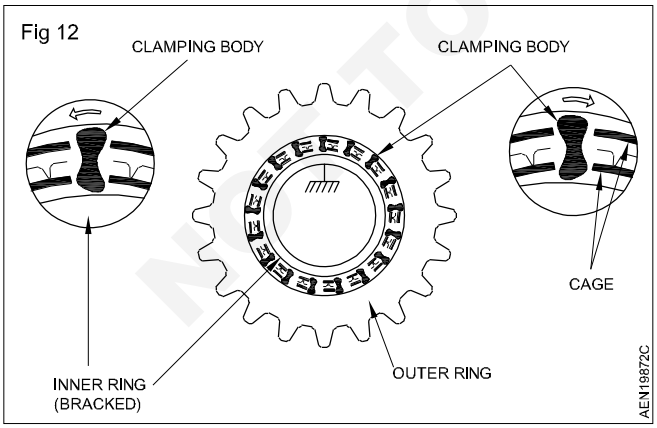


Fig 12



The clamping-body overrunning, clutch shown in Fig 12 consists of an outer ring, an inner ring and the clamping bodies supported in a cage.

When the outer ring rotates in a clockwise direction while the inner ring is braked, the clamping bodies assume an upright position and establish the torque proof connection. The connection is released when the outer ring rotates in an anticlockwise direction.

Band brake: This consists of a steel band, friction lining, plunger rod, plunger, housing, spring, and adjuster.

Operating principle. When the operating pressure acts on the plunger surface from the right, the plunger rod tightens the brake band and brakes the brake drum.

3-speed automatic gearbox with Ravigneaux set (Fig 13): The shifting logic (Table 1) shows which shift elements (clutches, band brake, overrunning clutch) are shifted in the different gears and which parts of the planetary-gear set are driven or braked by them.

Influence of different operating parameters on shift program and shift-point control

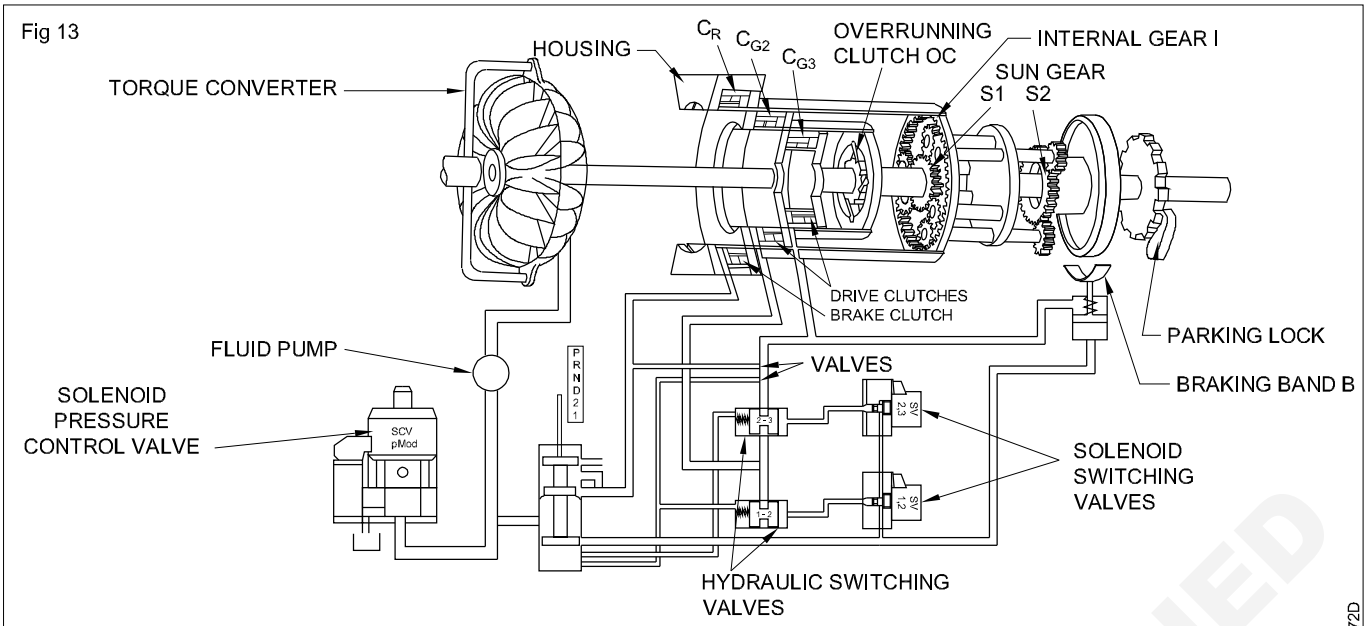
The basic shift program with up shift and down shift points is dependent on the main controlled variables of selector-lever position, accelerator-pedal position driving speed.

The shift program/shift curve selection can be adapted to different operating parameters, eg. transmission-fluid temperature, coolant temperature, program-selector-switch position, kickdown, driving style, uphill/downhill gradient, trailer operation, vehicle-speed-controller operation, road-surface condition.

Load signal and driving speed

These two main controlled variables essentially determine the shifting points. The further, for example, the accelerator pedal is pressed takes place. Downshifts generally take place at lower driving speeds than upshifts. In this way, a constant shifting back and forth (gear hunting) between two gears is avoided. (Fig 14)

Fig 13

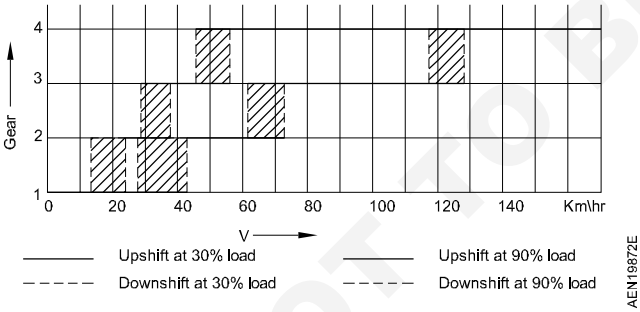


3 - SPEED AUTOMATIC GEARBOX WITH ELECTROHYDRAULIC CONTROL

Table 1: Shifting logic

Gear	Input	Fixed	Output	B	C_{G2}	C_{G3}	OC	C_R
1	S1	S2	PC	•			•	
2	1	S2	PC	•	•			
3	S1+1	-	PC		•	•		
R	S1	1	PC			•		•

Fig 14



Program selector switch

(Economy, sport, winter, manual). In the sport program as opposed to the Economy program upshifts are carried out only at higher driving speeds. In this way, the vehicles has a better acceleration response, but this is accompanied by an increase in fuel consumption. In the winter program the vehicle is started in a higher gear, e.g 2nd gear, in order to reduce the drive the drive torque and thus prevent the wheels from spinning. In the manual program the driver can shift up (**M+**) and down (**M-**) by means of a special selector-lever gutter by touching the selector lever. There is no automatic shifting.

Kickdown (forced downshift)

When the accelerator pedal is fully depressed, either a kickdown switch is actuated or the signal is determined by the accelerator-pedal-travel sensor. Where possible, a down-shift by one or two gears takes place. The shifted gears are then driven flat out upto the maximum engine revs in each case in order to improve the vehicle's acceleration response.

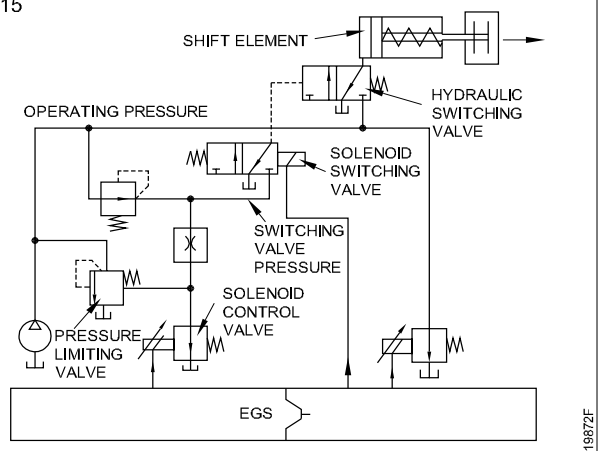
Transmission-fluid temperature When a specific critical fluid temperature is reached, shifting is only performed at higher engine speeds. This increases the amount of repumped fluid.

Hydraulic diagram for shift-pressure control-shift quality control

In the interests of avoiding gearshift jolts, the multi-plate clutches and the converter lockup clutch are activated by means of solenoid control valves with a load-sensitive, metered shift pressure.

In Fig 15 shift-pressure controls is shown schematically in a simplified electro hydraulic circuit diagram. At the shifting point the 3/2 way solenoid switching valve is electrically actuated by the electronic gear box control unit (EGS). The hydraulic 3/2-way switching valve is then pressurised with switching-valve pressure and switches. It actuates a working cylinder, which actuates, for example, the multi-plate clutches. In order that the working cylinder is not pressurised immediately with full operating pressure, a solenoid control valve actuated by the EGS reduces the shift pressure during the shift phase. The extent of the operating pressure is then set as a function of load to the highest currently required pressure. A solenoid control valve with an upstream pressure-limiting valve is actuated by the EGS for this purpose.

Fig 15



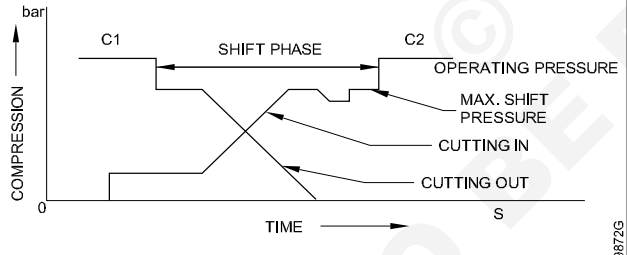
Overlap control (Fig 16)

Here the pressure is reduced in the shifted clutch C1 and at the same time increased in the clutch to be shifted C2. Shifting can be performed with slip without interrupting the power flow.

Operating parameters for controlling converter lockup clutch.

This is activated by a valve as a function of gearbox output speed (driving speed), engine speed, gearbox input speed, brake-light switch and engine temperature.

Fig 16



PRESSUR CONTROL WITH OVERLAP CONTROL

Converter lockup clutch is usually opened order...

- to achieve a high starting torque in low gears.
- to avoid vibrations in the driven train when the engine is cold at low vehicle speeds.
- when operating the brake pedal to prevent the engine from stalling during braking.

It is possible to operate converter lockup clutches with slip control with the aid of electro hydraulic transmission control. In this way, vibrations in the drive train are avoided, while converter efficiency is improved.

Special functions

Interlock (key lock): Here the ignition key can only be removed from the ignition lock when the selector lever is in the **P** position. This is effected, for example, mechanically via a cable. This prevents the vehicle from moving/rolling after the ignition key has been removed.

Adaptive transmission control (ATS): This makes use of different criteria to select automatically a suitable shift program, e.g optimised consumption or sporty, from a range of several programs.

Circuit-diagram example of electronic automatic gear box control (Fig 17): The circuit diagram shows a simplified example of electronic 4-speed automatic gearbox control without a CAN bus with two solenoid switching valves, converter lockup control and pressure control for the operating pressure.

Power supply: The ECU is supplied via pin 18 by terminal 30 with continuous positive and via pin 17 by terminal 15 (+) with power. Pins 22 and 35 are connected to terminal 31 (earth/ground).

Starting process: The vehicle can only be started with the selector lever in the **P** or **N** position. The start-locking relay is actuated via terminals J and K. At the same time the brake-light switch **S4** must be actuated by the foot brake. The ECU is actuated with positive via pin 11 in the process. This prevents the vehicle from being started unintentionally.

Selector-lever position (Table 2): The selector-lever position switch **S1** is connected via pins 9,10,27,& 28 to the EUC. Depending on its respective position, positive is connected via terminals A,B,C and E to the respective pin. The logic is specified in the circuit diagram.

Table 2 - Pin activation with positive

Pin	P	R	N	D	3	2	1
9	⊕	⊕			⊕	⊕	
10		⊕	⊕	⊕	⊕		
27	⊕		⊕		⊕		⊕
28				⊕	⊕	⊕	⊕

Hydraulic System: A hydraulic system uses a liquid to perform work. In an automatic transmission, this liquid is automatic transmission fluid (ATF).

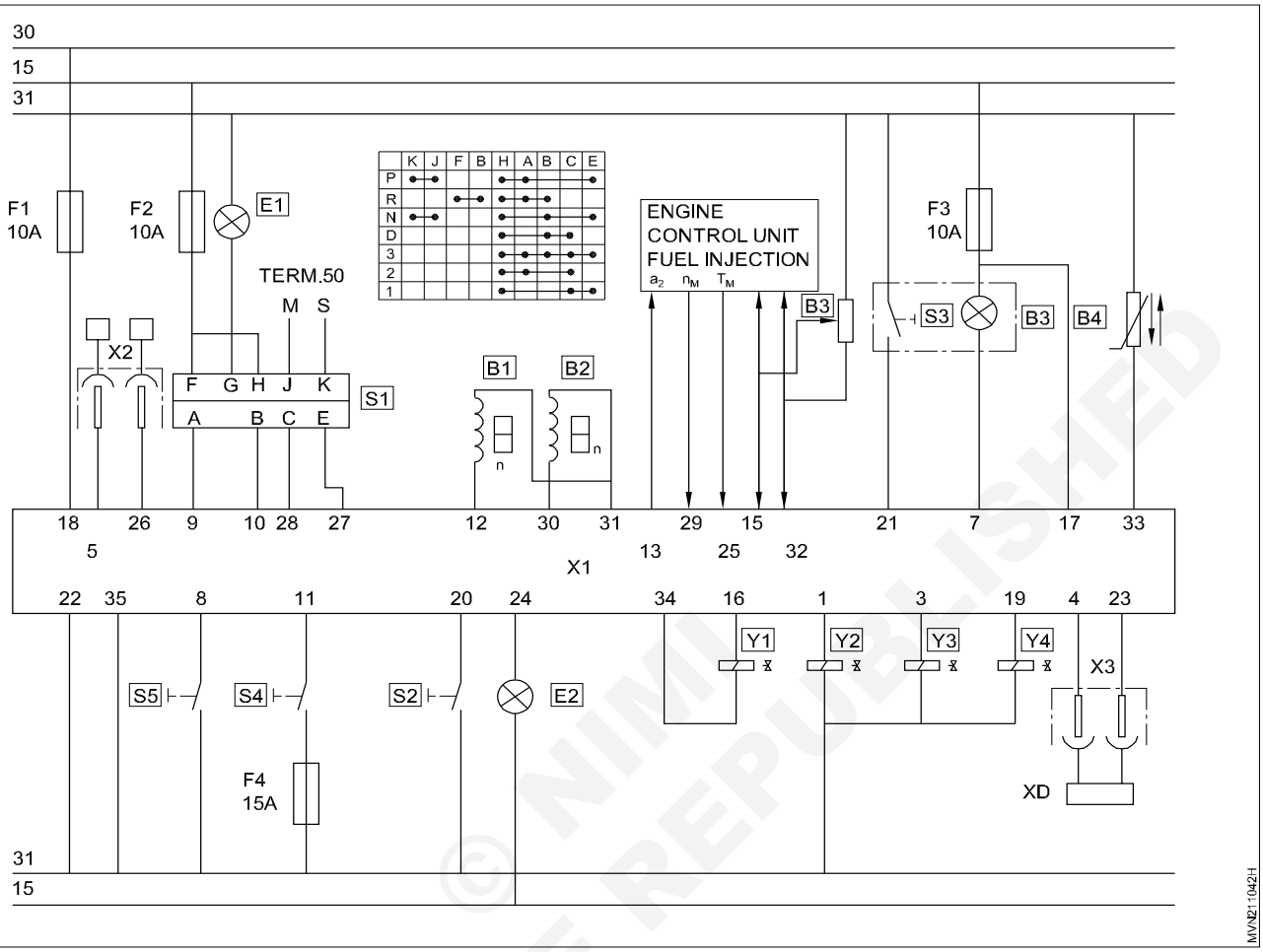
The transmission's pump is the source of all fluid flow in the hydraulic system. It provides a constant supply of fluid under pressure to operate, lubricate, and cool the transmission. **Pressure regulating valves** change the fluid's pressure to control the shift quality of a transmission and the shift points of the transmission equipped with a governor. **Flow-directing valves** direct the pressurized fluid to the appropriate apply device to cause a change in gear ratios. The hydraulic system also keeps the T/C filled with fluid.

The reservoir for ATF is the transmission's oil pan. Fluid is drawn from the pan and returned to it. The pressure source is the oil pump. The valve body contains control valve to regulate or restrict the pressure and flow of fluid within the transmission. The output devices for the hydraulic system are the servos or clutches operated by hydraulic pressure.

Hydraulic Principle: An automatic transmission uses ATF fluid pressure to control the action of the planetary rear sets. This fluid pressure is regulated and directed to change gears automatically through the use of various pressure and control valves.

Fluids work well in increasing force because they are perfect conductors of pressure. Fluids cannot be compressed. Therefore, when a piston in a cylinder moves and displace fluid, that fluid is distributed equally within the circuit.

Fig 17



Functions of ATF: The ATF circulating through the transmission and torque converter and over the parts of the transmission cools the transmission. The heated fluid moves to a transmission fluid cooler, where the heat is removed. As the fluid lubricates and cools the transmission, it also cleans the parts. The dirt is carried by the fluid to a filter, where the dirt is removed.

Another vital job of ATF shifting gears. ATF moves under pressure throughout the transmission and causes various valves to move. The pressure of the ATF changes with changes in engine speed and load.

ATF is also used to operate the various apply devices (clutches and bands) in the transmission. At the appropriate time, a switching valve opens and sends pressurized fluid to the apply device that engages or disengages a gear. The valve and hydraulic circuits are contained in the valve body.

Reservoir: A fluid reservoir stores fluid for the system. In an automatic transmission, the reservoir is the pan, located the bottom of the transmission case. A transmission dipstick placed within a filler tube is used to check the level of the fluid and to add ATF to the transmission.

Venting: The reservoirs have an air vent that allows atmospheric pressure to force the fluid into the pump when the pump creates a low pressure at its inlet port. The pans of many automatic transmissions vent through the handle of the dipstick; or a vent in the transmission case. Transmission must also be vented to allow for the exhaust of built-up air pressure that results from heat and moving components inside the transmission.

Transmission coolers: The removal of heat from ATF is extremely important to the durability of the transmission. Excessive heat causes the fluid to break down. Once broken down, ATF no longer lubricate well and has poor resistance to oxidation. Oxidized ATF may damage transmission seals. When a transmission is operated for some time with overheated ATF, varnish is formed inside the transmission. Varnish build up on valves can cause them to stick or move slowly. The result is poor shifting and glazed or burned friction surfaces. Contributed operation can lead to the need for a complete rebuilding of the transmission.

It is important to note that ATF is designed to operate at 175°F (80°C). At this temperature, the fluid should remain effective for 100,000 miles (160,000 km). However, when

the operating temperature increases, the useful life of the fluid quickly decreases. A 20°F increase in operating temperature will decrease the life of ATF by one-half !

Transmission housing are fitted with ATF cooler lines that direct the hot fluid from the torque converter to the transmission cooler, normally located in the vehicle's radiator. The heat of the fluid is reduced by the cooler and the cool ATF returns to the transmission. In some transmissions, the cooled fluid flows directly to the transmission's bushings, bearings, and gears. Then, the fluid is circulated through the rest of the transmission.

The cooled fluid in other transmission is returned to the oil pan, where it is drawn into the pump and circulate throughout the transmission. Some vehicles, such as those designed for heavy duty use, are equipped with an auxiliary fluid cooler, in addition to the one in the radiator. This cooler removes additional amounts of heat from the fluid before it is sent back to the transmission.

Valve Body: For efficient transmission operation, the bands and multiple-disc packs must be released and applied at the proper time. The **valve body** assembly is responsible for the control and distribution of pressurized fluid throughout the transmission. This assembly is made of two or three main parts: a valve body, separator plate, and transfer plate. These parts are bolted as a single unit to the transmission housing.

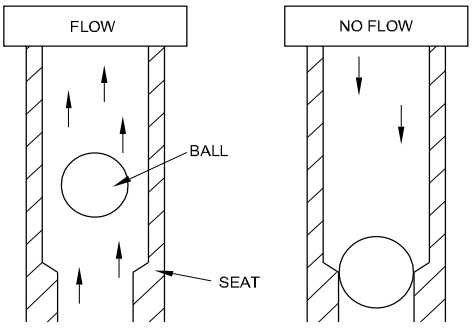
The valve body is machined from aluminium or iron and has many precisely machined bores and fluid passages. Various valves are fitted into the bores, and the passages direct to various valves and other parts of the transmission. The separator and transfer plates are designed to seal off some of these passages and to allow fluid to flow through specific passages.

The purpose of a valve body is to sense and respond to engine and vehicle load as well as to meet the needs to the driver. Valve bodies are normally fitted with three different types of valves: spool valves, check ball valves, and poppet valves. The purpose of these valves is to start, to stop, or to use movable parts to regulate and direct the flow of fluid throughout the transmission.

Check Ball Valve (Fig 18): The check ball valve is a ball that operates on a seat located on the valve body. The check ball operates by having a fluid pressure or manually operated linkage force it against the ball seat to block fluid flow. Pressure on the opposite side unseats the check ball. Check balls and poppet valves can be normally open, which allows free flow of fluid pressure, or normally closed, which blocks fluid pressure flow. At times, the check ball has two seats to check and direct fluid flow from two directions, being seated and unseated by pressures from either source.

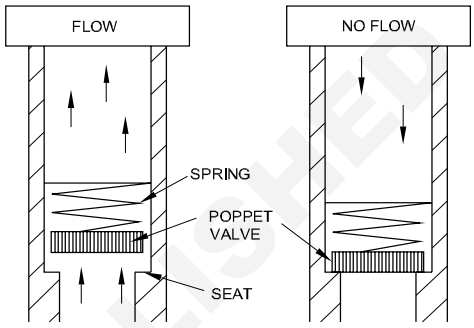
Poppet valve (Fig 19): A poppet valve can be a ball or a flat disc. In either case, the poppet valve blocks fluid flow. Often the poppet valve has a stem to guide the valve's operation. The stem normally fits into a hole acting as a guide to the valve's opening and closing. Poppet valves tend to pop open and closed, hence their name. Normally poppet valves are held closed by a spring.

Fig 18



CHECK BALL VALVE

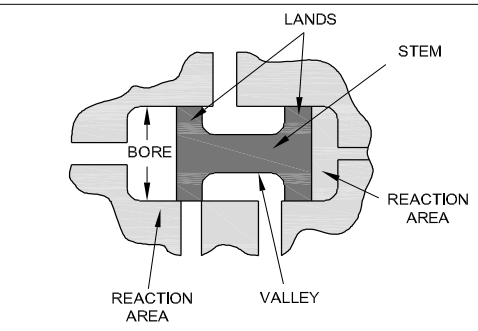
Fig 19



POPPET VALVE

Spool Valve (Fig 20): The most commonly used valve in a valve body is the spool valve. A spool valve looks similar to a sewing thread spool. The large circular parts of the valve are called the lands. There is a minimum of two lands per valve. Each land of the assembly is connected by a stem. The space between the lands and stem is called the valve. Valleys form a fluid pressure chamber between the spools and valve body bore.

Fig 20



SPOOL VALVE

The fluid reaction area, also known as the face, is the space at the outside of the lands at the end of the valve. Forces acting against the reaction area that cause the valve to move include spring tension, fluid pressure, or mechanical linkage.

Oil Pump: The source of fluid flow through the transmission is the oil pump. Three types of oil pumps are commonly used in automatic transmission: gear type, rotor type, and vane type. Oil pumps are driven by the pump drive hub of the T/C or oil pump shaft converter cover or transaxles. Therefore whenever the T/C cover is rotating, the oil pump is driven. The oil pump creates fluid flow throughout the transmission.

Pressure regulator valve: Transmission pumps are creating excepting fluid pressure that may cause damage the system therefore, transmission is equipped with a pressure regulator valve, which is normally located in the valve body. Pressure regulating valves are typically spool valves that toggle back and forth in their bores to open and close an exhaust passage. By opening the exhaust passage, the valve decreases the pressure of the fluid. As soon as the pressure decreases to a predetermined amount, the spool valve neutralized.

Governor assembly: The governor assembly is driven by the transmission's output shaft, senses road speed, and sends, a fluid pressure signal to the valve body to either up shift or downshift. When vehicle speed is increased, the pressure developed by the governor is directed to the shift valve. As the speed increases, the spring tension and throttle pressure on the shift valve are overcome and the valve moves. This action causes an up shift. Likewise, a decrease in speed results in a decrease in pressure and a downshift.

Pressure boosts: When the engine is operating under heavy load condition, fluid pressure must be increased to increase the holding capacity of a hydraulic member. Increasing the fluid pressure holds the band clutch control units tighter to reduce the chance of slipping while under heavy load. This is accomplished by sending pressurized fluid to one side of the pressure regulator's spool valve. This pressure works against the spool valve's normal movement to open the exhaust port and allows pressure to build to a higher point than normal.

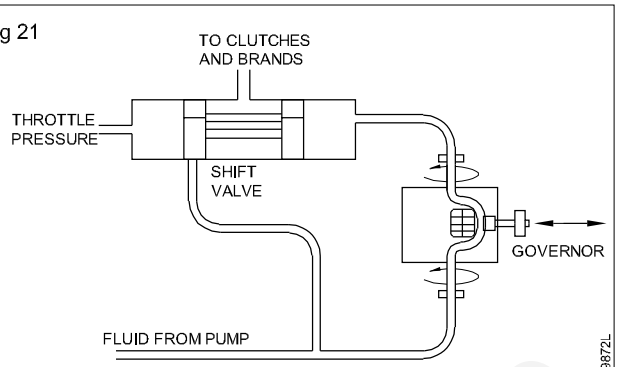
Engine load can be monitored electronically by various electronic sensors (primarily the TP and MAP sensors) that send information to an electronic control unit, which in turn controls the pressure at the valve body. Load can also be monitored by throttle pressure. Throttle pedal movement moves a **throttle valve** in the valve body via a throttle cable. When the throttle plate is opened, the throttle valve opens and applies pressure to the pressure regulator. This delays the opening of the pressure regulator valve, which allows for an increase in pressure. When the driver lets off the throttle pedal, the pressure regulator valve is free to move and normal pressure is maintained.

Automatic transmissions - Valves and modulators (Fig 21): To shift properly, the automatic transmission has to know how hard the engine is working. There are two different ways that this is done. Some cars have a simple cable linkage connected to a throttle valve in the transmission. The further the pedal is pressed, the more pressure is put on the throttle valve. Other cars use a vacuum modulator to apply pressure to the throttle valve. The modulator senses the manifold pressure, which increases when the engine is under a greater load.

The manual valve is what the shift lever hooks up to. Depending on which gear is selected, the manual valve feeds hydraulic circuits that inhibit certain gears. For instance, if the shift lever is in third gear, it feeds a circuit that prevents overdrive from engaging.

Modulator pressure valve: The hydraulic modulator allows an electric current to control hydraulic force. When power is applied the solenoid, magnetic force open and closes the valves in the modulator, controlling the flow of fluid.

Fig 21



Shift valves: Shift valves supply hydraulic pressure to the clutches and bands to engage each gear. The valve body of the transmission contains several shift valves. The shift valve determines when to shift from one gear to the next. For instance, the 1 to 2 shift valve determines when to shift from first to second gear. The shift valve is pressurized with fluid from the governor on one side and the throttle valve on the other. They are supplied with fluid by the pump and they route that fluid to two circuits to control which gear the car runs in.

The shift valve will delay a shift if the car is accelerating quickly. If the car accelerates gently, the shift will occur at a lower speed.

MAP Sensor: Engine load can be monitored electronically through the use of various electronic sensors that send information to an electronic control unit, which in turn controls the pressure at the valve body. The most commonly used sensor is the MAP sensor. The MAP sensor senses air pressure in the intake manifold.

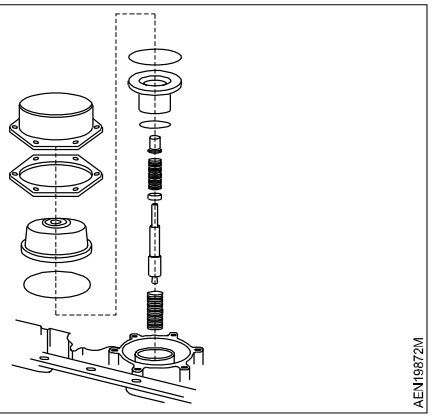
The control unit uses this information as an indication of engine load. A pressure sensitive ceramic or silicon element and electronic circuit in the sensor generates a voltage signal that changes in direct proportion to pressure. A MAP sensor measures manifold air pressure against a precalibrated absolute pressure: therefore, the readings from these sensors are not adversely affected by changes in operating altitudes or barometric pressure.

Kickdown valve: The valve body is also fitted with a **kickdown** circuit, which provides a downshift when the driver requires additional power. When the throttle pedal is quickly opened wide, throttle pressure rapidly increases and directs a large amount of pressure onto the kickdown valve. This moves the kickdown valve, which opens a port and allows mainline pressure to flow against the shift valve. The spring tension on the shift valve, the kickdown pressure, and throttle pressure will push on the end of the shift valve, causing it to move to the downshift position and forcing quick downshift.

Shift quality (Fig 22): All transmissions are designed to change gears at the correct time according to engine and vehicle speed, load, and driver intent. However,

transmissions are also designed to provide for positive change of gear ratios without jarring the driver or passengers. If a band or clutch is applied too quickly, a harsh shift will occur. Shift feel is controlled by the pressure at which each hydraulic member is applied or released, the rate at which each is pressurized or exhausted, & the relative timing of the apply and release of the members.

Fig 22



To improve shift feel during gear changes, a band is often released while a multiple-disc pack is being applied. The timing of these two actions must be just right or both components will be released or applied at the same time, which would cause engine flare-up or clutch and band slippage. Several other method are used to smooth gear changes and improve shift feel.

Multiple friction disc packs sometimes contain a wavy spring - steel separator plate that helps smooth the application of the clutch. Shift feel can also be smoothed out by using a restricting orifice or an accumulator piston in the band or clutch apply circuit to restricts fluid flow and slows the pressure increase at the piston by limiting the quantity of fluid that can pass in a given time. An accumulator piston by diverting a pressure build up at the apply piston by diverting a portion of the pressure to a second spring-loaded piston in the same hydraulic circuit. This delays and smoothest the application of a clutch or band.

Manufacturers have also applied electronics to get the desired shift feel. One of the most common techniques is the pulsing (turning on and off) of the shift solenoids, which prevents the immediate engagement of a gear by allowing some slippage.

Shift timing: Shift timing is determined by throttle pressure and governor pressure acting on opposite ends of the shift valve. When a vehicle is accelerating from a stop, throttle pressure is high and governor pressure is low. As vehicle speed increases, the throttle pressure decreases and the governor pressure increases. When governor pressure overcomes throttle pressure and the spring tension at the shift valve, the shift valve moves to direct pressure to the appropriate apply device and the transmission up shifts.

Gear Range: **Neutral and park**

Gear Selector **Position: N and P**

Throttle Position: **0 to10 psi (0 to 70 kPa) (approximately closed)**

Pump pressure leaves the transmission pump and is directed to the pressure regulator valve and manual valve. At the pressure regulator valve, pump pressure is regulated to become line pressure. Line pressure enters the pressure the pressure regulator valve and leaves as converter pressure, flowing to the switch valve. The switch valve allows line pressure to enter the torque converter. Converter pressure circulates from the switch valve to fill the torque converter from the switch valve to fill the torque converter and returns to the switch valve to become cooling and lubrication pressure.

From the pressure regulator valve, line pressure flows to the manual valve. line pressure seats check ball 9 and flowing around clock ball 8 to stop at the land of the closed throttle valve. Throttle pressure is low because the throttle valve is not open. Line pressure flows to the accumulator to cushion the engagement of the planetary controls when the gear selector to moved to D or R ranges. The accumulator is basically a hydraulic shock absorber designed to absorb the shock of engaging planetary controls.

In neutral, line pressure is maintained by the pressure regulator valve and flows to the manual and throttle valves.

Gear Ranges: D first gear

Selector position: D

Torque Converter Mode: Unlock

Planetary Controls Engaged: Rear check over clutch

Approximate Speed: 8 mph (13 km/h)

Throttle position: Half throttle: In pressure between the manual valve and pressure regulative valve is considered to be line pressure. The line pressure circulates to the switch valve. Since the switch valve is held in the torque converter unlocked position, line pressure flows no further.

Line pressure: Beginning at the first manual valve outlet 1, line pressure seats check ball and flows past check ball to enter the throttle valve and establish throttle pressure. Line pressure also flows to the pressure regulator valve to regulate pressure. Line pressure moves the accumulator piston against coil spring tension, cushioning the engagement of the rear clutch. At outlet part 2 of the manual valve, line pressure fills the worm track, which engages the rear clutch and flows to the governor assembly. When the rear clutch is engages and the governor assembly is filled with line pressure, the forward circuit is ready to drive the vehicle forward.

Torque converter controls and pressure: The torque converter lockup clutch assembly a controlled by the PCM. When the PCM reserves signals from the different sensors confirming the requirements for lockup have been met, clutch engagement begins. These sensors, include an engine coolant sensor, vehicle speed sensor, engine vacuum sensor and the throttle position sensor.

When the clutch is disengaged, a check ball is beld off its seat by the fluid pressure. The unseated check ball prevents line pressure from building until it is high tension of the spring inside the switch valve. The converter clutch

is never engaged in reverse gear and its action during reverse is similar to other times when it is not engaged.

Drive range : Reverse gear

Gear selector position: R

Torque converter mode: Unlock

Planetary controls engaged: Low and reverse rear band; from clutch.

Approximate vehicle speed: 5 mph (8 km/h)

Throttle position: Part throttle

Line pressure from the outlet of the manual valve outlet that was not used before circulated through a bypass around the manual valve. Line pressure circulates to the low & reverse servo and front clutch. During the process of engaging the low and reverse servo and from clutch, the numbers 4 & 3 check balls are seated by the pressure.

Line pressure: Line pressure from between the pressure regulator and manual valve circulated around the pressure regulative valve. After flowing through a restriction to the seat number 8 check hall, the pressure enters the throttle valve, which produces line-to-throttle pressure. With the throttle valve open, throttle pressure charges the kickdown valve and strokes the throttle plug to its extreme left position at the pressure regulator valve. Line pressure from the manual valve does not flow to the pressure regulator valve to oppose spring tension. The pressure regulator valve coil spring pushed the pressure regulator valve over to close the exhaust port. Line pressure build to approximately 200to 300 psi (1,380 to 2.070 kpa)

Throttle pressure: Throttle pressure circulated to the shift valve area to keep both the 1-2 and 2-3 shift valves down shiften. Throttle pressure also keeps the shuttle valve throttle plug tits seat in the valve body.

Converter pressure: In reverse, the transaxle need the torque multiplication of vortex, flow to start the vehicle moving from a stop. Therefore, the switch valve maintains the position and holds the torque converter piston in the unlocked position.

Lockup clutch engagement: The lockup relay is energised when the PCM ground the circuit. The lockup relay sends 12 volts to energize the lockup solenoid. When the lockup solenoid is energized, it seats the check ball, which stops the exhaust of line pressure. Line pressure builds up on the reaction area of the switch valve and moves the valve against spring tension to begin lockup engagement.

Drive range: D third gear

Gear selector position: D

Torque controls engaged: Rear clutch; front clutch

Approximate vehicle speed: 40 mph

Throttle position: Half throttle

In drive range third gear lockup, the transaxle operater in the same manner as third gear unlock.

The coolant sensor reports to the computer that the engine has reached a temperature of at least 150°F (66°C). The vehicle's speed is monitors by a VSS. When the vehicle has a speed of more than 40 mph (65 km/h), it is at the desired engagement speed. Before engagement of initiated, the vacuum transducer must report to the PCM that engine vacuum is between 4 and 22 in. Hg (102 to 560 mm Hg). Based on these inputs, the PCM energies the clutch relay and lockup solenoid to move the solenoid check ball into its seat.

The check ball steps the exhausting of line pressure. The increasing line pressure forces the switch valve to move against spring tension. Line pressure from the switch valve is directed to the pump drive hub and stator support to fill the torque converter with fluid. Fluid in the torque converter during lockup operation resides there to become the cooling and lubricating pressure. Line pressure flows from the impeller and turbine to fill the space behind the torque converter clutch piston and force engagement.

Throttle pressure: As line pressure passes through the valley of the throttle valve, it becomes throttle pressure. Throttle pressure circulates around the kickdown valve, a very quick downshift response to full-throttle operation is provided. Throttle pressure is directed to the pressure regulator throttle plug spring. The result is that the pressure regulator valve chooses the exhaust port, which results in a line pressure increase. Throttle pressure moves to act on the spring end of the 1-2 shift valve. The throttle pressure and coil spring tension work together to hold the shift valve and governor plug in the downshift position against governor pressure. Throttle pressure passes check ball 5, which is acting on the spring end of the 2-3 shift valve. From the 2-3 shift valve, throttle pressure flows to hold the shuttle valve throttle plug against its stop in the valve body.

Governor pressure: Governor pressure developed from line pressure leaves the governor assembly terminating at the shuttle valve spool land. Government pressure also acts on the 2-3 and 1-2 shift valve governor plugs. Because the vehicle is travelling at 8 mph (13 km/h), governor pressure is not strong enough to overcome throttle pressure and spring tension at the opposite end of the shift valves. Therefore, the transmission stays downshifted in drive range first gear.

Converter pressure: From the pressure regulator valve, converter pressure is directed to the converter pressure control valve. From the converter pressure control valve, converter pressure flows through the switch valve valley and enters the torque converter turbine shaft to keep the lockup piston disengaged. Converter pressure entering between the impeller and turbine fills the torque converter. Converter pressure flows back to the switch valve and enters the cooler to become cooler pressure. When cooler pressure returns to the transmission, it cools and lubricates transmission parts.

Drive rage: D second gear

Gear selector position: D

Torque converter mode: Unlock

Planetary controls engages: Rear clutch, front kickdown band.

Fundamentals of air conditioning

Objectives: At the end of this lesson you shall be able to
- **state that typical air conditioning system**
- **define the operating principle in air conditioning**
- **state the parts of an auto air conditioning system.**

Fundamentals of air conditioning

Air conditioning lowers the temperature of the incoming air before it enters the inside of the vehicle. It therefore cools and dehumidifies the air space in the driver passenger compartment and when rapidly de-mist the insides of the surrounding window. As a result an improvement in comfort, alertness and reduction in driving fatigue is achieved for both driver and passenger.

Operating principle

Air conditionings main principles are **Evaporation and Condensation,** then **Compression and Expansion.**

Evaporation: Heat take away from the object.

Eg. If you rub a little surgical spirits on your hand, then you hand will feel cold. It is because the spirits on the back of your hand start to evaporate. As the spirit evaporates, it takes away heat from the surface of your skin. It's evaporation.

Condensation: It is the change of water from its gaseous form (water vapor) into liquid water.

Eg: When somebody walks in form the cold, their glasses steam up?. The moist air of the take away cools as it contacts the cold surface of the glasses and the air has less capacity to hold moisture, so it condenses into water on the glasses. It's condensation.

Heat of compression: Have you ever noticed when you pump up a bicycle tyre with a hand pump, that the end of the pump gets hot? This is because the energy that you have put into the air by pumping it has not only compressed it, but has also caused the air molecules to push closer together so giving off heat with the friction.

Compression: At some point all gases will eventually become liquid

Eg: Deodorant - its liquid inside the can (because you can hear it when you shake it) but is a gas when it comes out and hits your underarm. The pressure inside the can is higher, so the propellant inside is liquid.

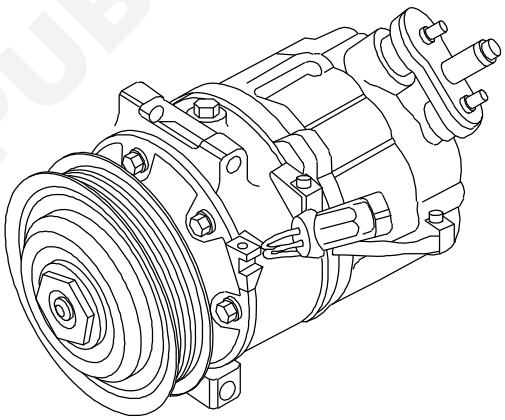
Cooling by expansion: Going back to the deodorant, you will notice also how cold it feels that's because the propellant has just expanded in volume quickly.

Basic components of A/C system

1 Compressor
2 Magnetic clutch
3 Condenser
4 Drier/receiver
5 Evaporator
6 Blower
7 Expansion valve

1 Compressor: The compressor (Fig 1) takes low-pressure, cool refrigerant and makes it hot by compressing it. Two to six pistons that resemble the ones in your engine do the actual compressing. A V-belt from the engine drives the unit, and a magnetic clutch on its front disconnects it when the air conditioner is switched off. (Some systems cycle the compressor on and off to control the temperature inside the car. In these the magnetic clutch is wired to the on/off switch and a thermostat.

Fig 1



COMPRESSOR

AEN1108911

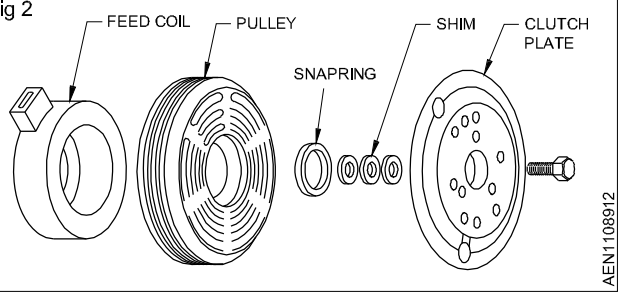
The compressor should be easy to find. Look for a comparatively large object with a pulley and fan belt, two rubber hoses about an inch in diameter, and valves on top that took like the ones on your tires. When you find it, track down the compressor clutch wire there should be only one wire going to the compressor), and see if there's fuse inline nearby. If so, note its rating, and buy a replacement to keep as a spare in the glove compartment.

2 Magnetic clutch (Fig 2)

- **Function:** A magnetic clutches is used to connect or disconnect the drive to the compressor.
- **Operation:** When the voltage is applied to the clutch field coil, the clutch plate (which is connected to the compressor shaft) is drawn into contact with the pulley and the compressor rotates.

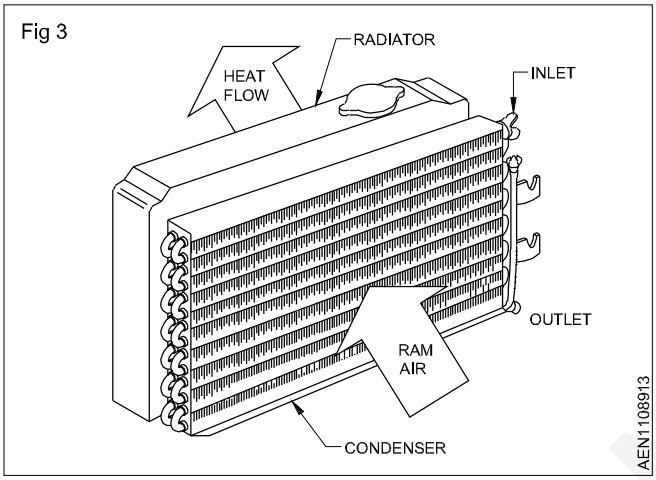
When voltage is disconnected from the clutch field coil the clutch plate is released and the compressor ceases to rotate.

Fig 2



3 Condenser (Fig 3): The condenser is very similar to evaporator except for the fact it is used to cool the refrigerant i.e hot refrigerant (high pressure high temperature) vapour is converted into liquid by air flowing over the tubes also made of brazed copper or aluminium tubes.

Fig 3



Function: The function of the condensor is to cool the hot refrigerant vapour ensuring it condenses into a liquid.

Operation

– Condenser receives refrigerant vapour from the compressor under high pressure.

– The refrigerant vapour enters the top of the condenser and flows down through the condenser tube.

– As cool air passes the condenser fins the refrigerant is cooled and it condenses before leaving the bottom of the condenser as liquid.

4 Drier / receiver (Fig 4)

Function

1 The primary function is to ensure that only liquid refrigerant is passed on the expansion valve.

2 Filters the impurities in the system

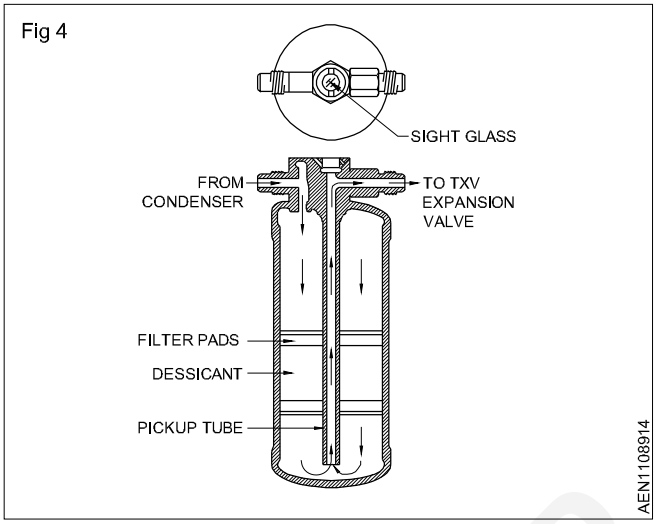
3 Absorbs moisture in the system

Operations

1 High pressure liquid refrigerant passes from the condenser through the inlet line into the drier, and a drying element absorbs moisture from the refrigerant and filters foreign matter/particles.

2 From the drier the refrigerant reaches the expansion valve.

Fig 4

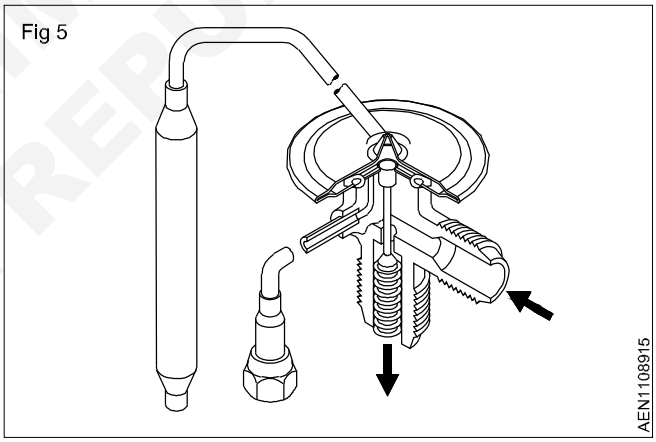


5 Expansion valve (Fig 5): Expansion valve controls refrigerant flow into evaporator.

A temperature sensitive power element bulb is attached to the evaporator outlet, a capillary tube (length of tubing of small diameter which acts as a throttle on refrigerant) control.

Accumulator drier dehydrator is located in system low-pressure side, between evaporator and compressor. The receiver - dehydrator filters and removes moisture through means of a desiccant (drying agent).

Fig 5



Function

1 Controls the flow of refrigerant into the evaporator.

2 Ensures complete evaporation of the liquid refrigerant.

Expansion valves are not adjustable and are changed as a complete service unit.

Expansion device

There must be a flow restriction between condenser and evaporator, so that there exists a pressure difference with which the refrigerant will flow. The refrigerant should be at low pressure in an evaporator so that it gets converted to vapour taking up heat, this is achieved by means of an expansion device.

The flow restriction is produced by two devices

i Orifice tube.

ii Thermostatic expansion valve.

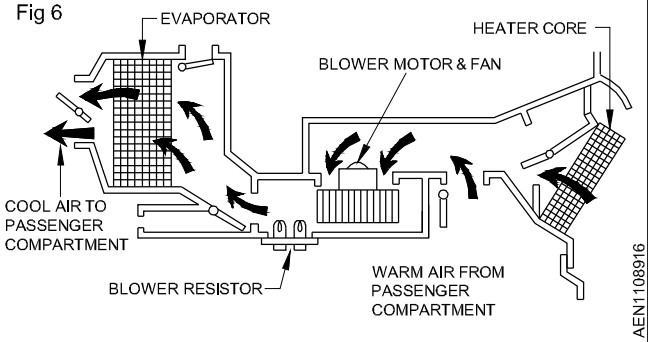
iii Orifice tube is a fixed diameter tube through which refrigerant flows. It is mainly used in domestic refrigerators.

iv Thermostatic expansion valve.

6 Evaporator (Fig 6)

Purpose evaporator: A heat exchanged which removes the heat from air circulating in the passenger compartment air distribution system and transfer that heat to the refrigerant in the A/C system.

Fig 6



Purpose - blower motor assembly (Fig 7)

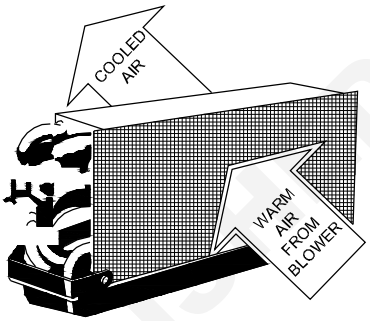
The blower, which is always an integral part of the heater/ air conditioning case assembly, performs two functions:

1 It pulls air from the passenger compartment, or from outside of the vehicle, into the heater and air conditioners case assembly. (ventilating system)

2 It flows air through the heater core or the evaporator, or by passes both the flows it straight out the dash vents depending on the position of the doors in the heater case. (heating system)

The motor input ranges from 60V(5A) to 150W(12.5A) the motor speed is controlled by resistors in 3 to 6 steps.

Fig 7



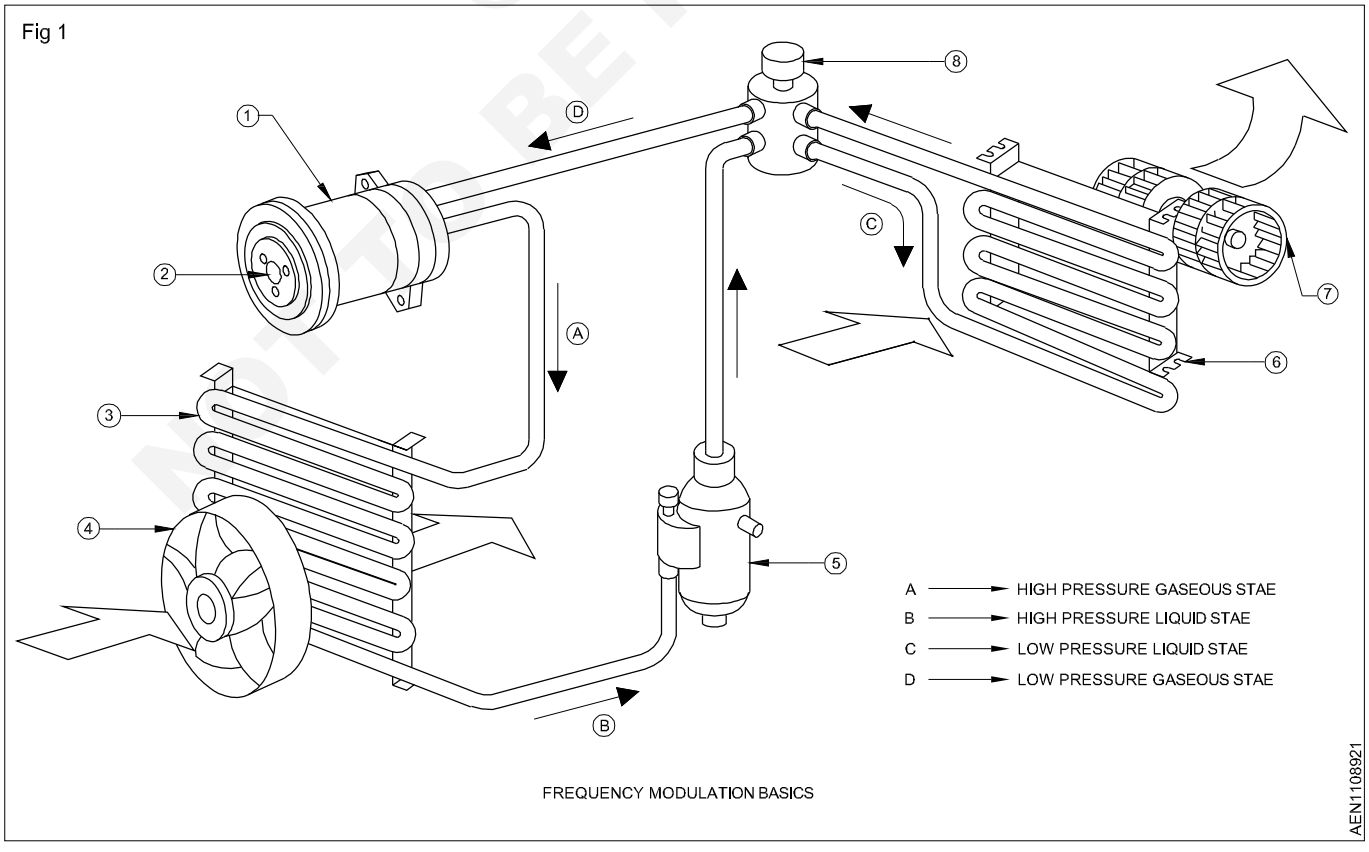
Working of car A/C system

Objectives: At the end of this lesson you shall be able to
- **describe working of an air-conditioner**
- **locate the A/C controls.**

The layout of refrigeration system for car air condition is shown in Fig 1

When the A/C knop is turned on, magnetic clutch (2) connected in the compressor (1) drawn into contact with

Fig 1



the pulley and the compressor (1) rotates. The compressor (1) circulates a fluid called refrigerant R134a through a system. The compressor draws a low pressure and low temperature refrigerant vapour from Evaporator (6). Then it compresses this refrigerant vapour, the pressure and temperature of refrigerant increases. This high pressure refrigerant vapour is sent to the condenser (3).

The air produced while driving and by the action of engine fan are allowed to flow across the condenser. At this stage vapour loses heat to air passing through the air passage in the condenser. Due to the loss of heat, the vapour condenses to a liquid.

The air from the condenser is flown into the receiver/driver (5), where it stores the liquid refrigerant and it is passed through dehydrator that extracts any moisture from the this liquid. Now the refrigerant liquid is completely dry.

Dry refrigerant from receiver / driver (5) is made pass through expansion valve (8).

Expansion valve (8) permits the refrigerant liquid to expand to low pressure in the evaporator (6). This expansion process makes the refrigerant to evaporate. As it evaporates, it takes the heat from air passing through the air passage in the evaporator (6), where cooling effect achieves. Blower (7), is used to throw the cooling effect to the cabin. Condensed moisture with the impurities from the evaporator drip into a tray and the. same is drained out from there.

Due to the above process, the refrigerant pressure and it vaporizes, thus refrigerant is low pressure and the cycle low temperature vapour which flows to compressor and the cycle rotates.

Fig 2

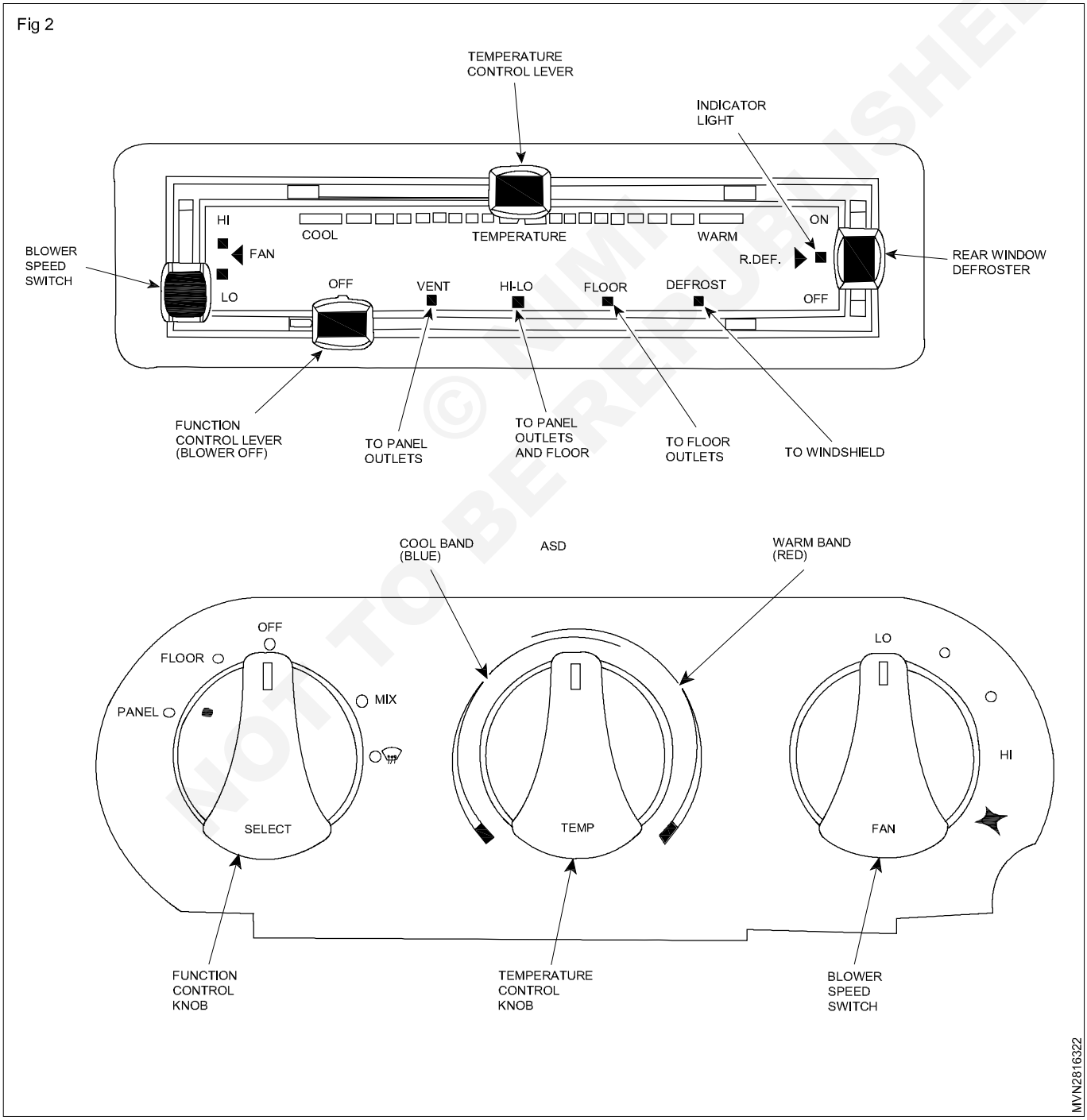
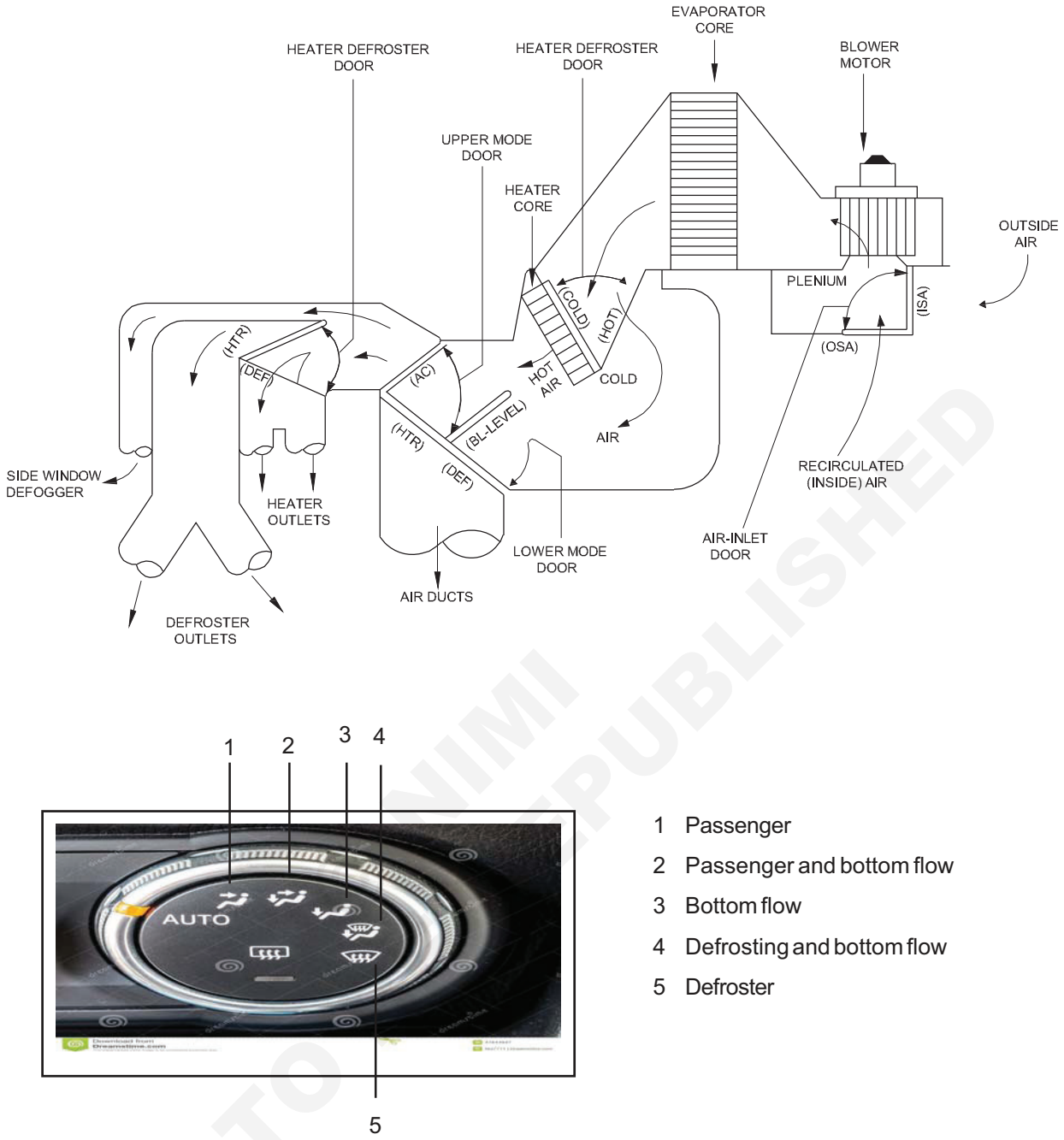


Fig 3



A/C controls

The Fig 2 shows the air distribution in an air-conditioning system. The different controls are

1 A/C control

i Blower alone ON

ii Blower and A/C ON

2 Air flow mode

i Air under fresh mode

ii Air under recirculation mode

3 Air flow distribution

i Cool air to passenger cabin

ii Defroster mode

iii Cool air to passenger and on to the front passengers feet

iv Cool air to defroster and front passengers feet.

4 Blower speed

- Blower alone ON
- Blower alone ON means AC is switched off the blower just circulates atmospheric air like a fan.

A/C ON: A/C ON means compressor is working and refrigerant is circulated through the evaporator which cools the cabin air.

Flow mode: When outside is dusty and contaminated to avoid the dusty air, air inside the cabin is recirculated by moving the air flow mode to recirculation.

When going on highway or clean areas the air flow mode is kept under “fresh”.

This minimizes any contaminated air being circulated as the cabin air may be dirty.

Heater: When the A/C mode is under “Heating” the hot coolant from radiator system is circulated which heats the incoming air. This hot air is then circulated to the cabin by means of the blower.

Fig 3 shows air distribution in an automatic A/C system.

Check & replace thermostatic expansion valve, thermostat switch & driver

Objectives : At the end of this lesson you shall be able to
- **explain the function and operation of receiver drier**
- **explain about thermostat switch**
- **explain the function of thermostatic expansion valve**
- **explain the construction of thermostatic expansion valve**
- **explain the purpose of thermostat switch in an automobile A/C system.**

The fluid container and drier

The fluid container and drier in the refrigerant circuit with expansion valve, the fluid container serves as a refrigerant expansion tank and reservoir. Different amounts of refrigerant are pumped through the circuit when operating conditions such as the thermal load on the evaporator and condenser and compressor rpm are variable. The fluid container is integrated in the circuit in order to compensate for these fluctuations. the drier binds chemically moisture which has entered the refrigerant circuit during installation. The drier can absorb between 6 and 12g of water, depending on type. the amount of water that can be absorbed is temperature-dependent. The amount of water absorbed increases as the temperature drops. Abraded material from the compressor, dirt arising from installation work and similar is also deposited. High pressure liquid refrigerant passes from the condenser through the inlet line into the drier, and a drying element (Desiccant) absorbs moisture from the refrigerant and filters foreign matter/particles. From the drier the refrigerant reaches the expansion valve.

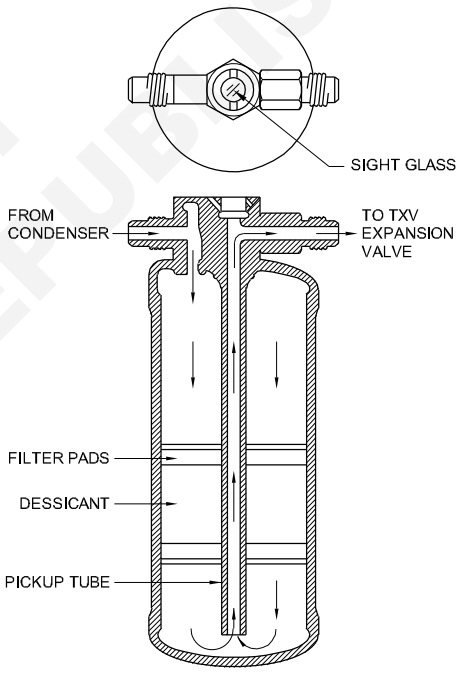
Function (Fig 1)

The liquid refrigerant coming from the condenser enters the container at the side. The refrigerant is collected in the container, then it flows through the drier and along the riser to the expansion.

Valve in an uninterrupted flow containing no bubbles. The fluid container must be kept closed as long as possible prior to installation in order to minimise absorption of moisture from the ambient air in the drier. The primary function is to ensure that only liquid refrigerant is passed on to the expansion valve. Filters the impurities in the system. Absorbs moisture in the system.

The fluid container is replaced every time the refrigerant circuit is opened.

Fig 1



Expansion valve

The expansion valve is the point where the refrigerant in the evaporator expands and cools down. It forms the interface between the high pressure side and low pressure side of the refrigerant circuit. The expansion valve is used to regulate the refrigerant flow to the evaporator. In dependence upon the temperature of the refrigerant vapour at the evaporator outlet. No more refrigerant than is necessary to maintain a steady "refrigerating climate" in the evaporator is expanded in the evaporator. The closed control loop. The refrigerant flow is controlled by the expansion valve in dependence upon temperature. When the thermostat expands. The flow rate of the refrigerant to the evaporator at the globe valve increases. When the temperature of the

refrigerant leaving the evaporator drops, the refrigerant volume in the thermostat decreases. The flow rate to the evaporator at the globe valve is reduced.

There are three forces at play in the thermostatic expansion valve.

Pressure: Expansion valve pressure in the sensor line is dependent on the temperature of the superheated refrigerant. This pressures acts upon the membrane as an opening force.

1 The evaporator pressure acts upon the membrane in the opposite direction.

2 The pressure exerted by the regulating spring acts in the same direction as the evaporator pressure.

The expansion valves are set. Their setting may not be alter. Do not bend the sensor line, because it is filled with a special gas.

Function of TXV: Thermostatic expansion valve is a constant super heated valve it is effective in large capacity plant when provides external equalizer.

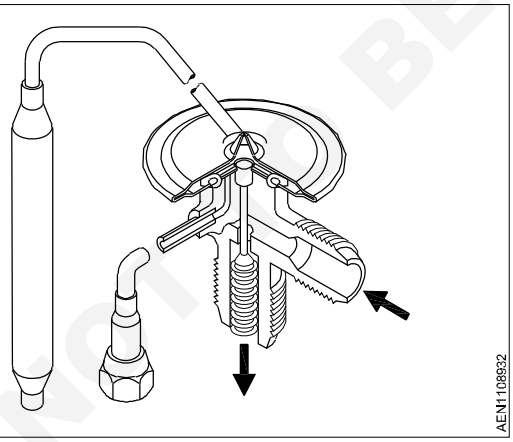
1 Controlled correct refrigerant flow at evaporator as per the load demand.

2 It modulate the refrigerant flow.

Construction of TXV: It consists of power element which may be bellow or the diaphragm. In side bellows and power elements preferably same refrigerant filled to transmit the power to open and close the valve orifice within the valve body. (Fig 2 and 3)

Expansion valves are not adjustable and are changed as a complete service unit.

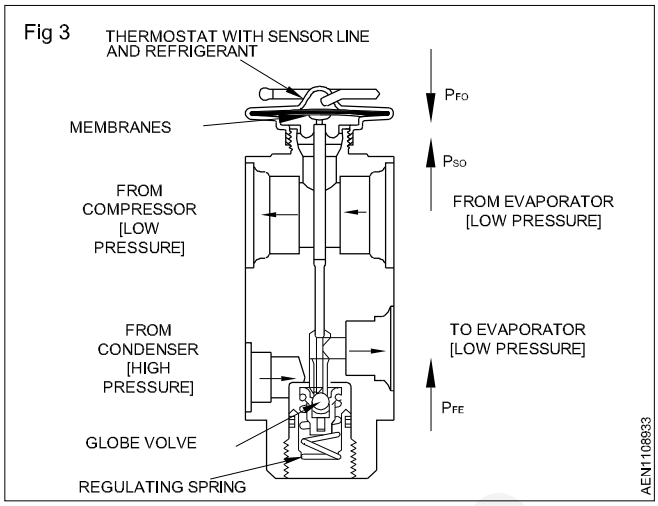
Fig 2



Thermostatic switch purpose (Fig 4)

The thermostatic switch is an evaporator temperature sensing switch. It is used with cycling clutch air conditioners. It has a temperature sensitive capillary tube which is located where is can respond to changes in the evaporator outlet temperature. The capillary tube reaction will either open or close the contacts inside the switch. This action, in turn, will cause the compressor clutch to be engaged or disengaged.

Fig 3



The thermostatic switch is built to work within a preset temperature range. It has 2 temperature preset-one for OFF and one for ON. When temperature in the evaporator coils approaches freezing, the switch contacts open, disengage the compressor clutch and allow the evaporator to absorb more heat. The temperature then rises in the evaporator due to lack of refrigerant flow. At a present high temperature, the switch closes, engages the clutch and compressor operation resumes.

Some of these switches are adjustable so the ON and OFF points can be varied according to system and operator requirement.

State of refrigerant R134a

In the cycle in an air conditioner in addition to the vapour pressure curve, the cycle shows the change of state of the refrigerant under pressure and temperature in addition to the energy balance at which the refrigerant returns to its original state. The diagram is an excerpt from the state diagram of refrigerant R134a for a vehicle air conditioner. Different absolute values are possible in dependence upon the demand of a vehicle type for refrigeration capacity. The energy content is a key factor in the design of an air conditioner. It shows what energy is required (evaporator heat, condenser heat) to achieve the intended refrigeration capacity.

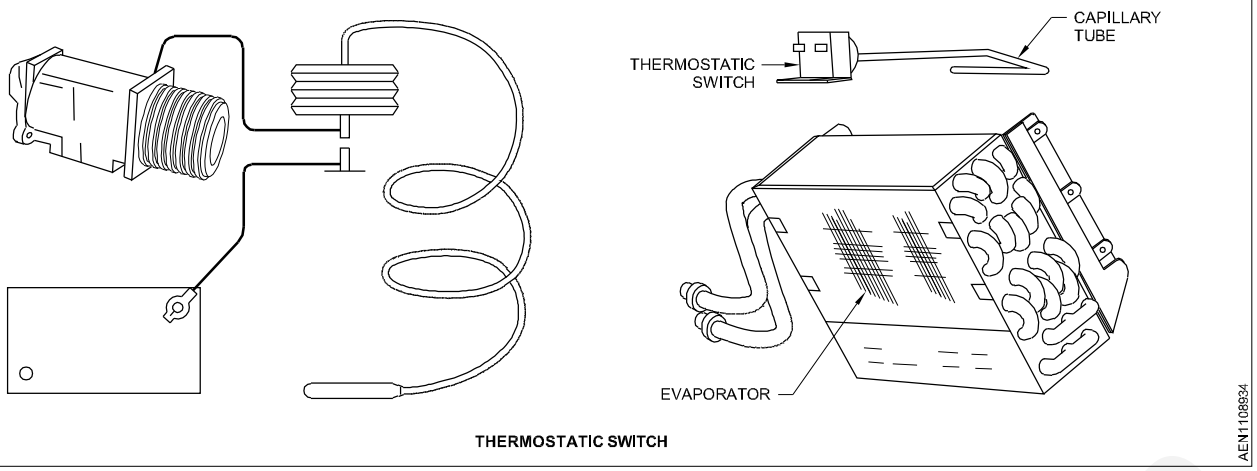
Physical data of R134a

- Boiling point:-26.5°C
- Freezing point:-101.6°C
- Critical temperature:100.6°C
- Critical pressure:4.056 MPa (40.56 bar)y.

Performance checking

Performance checking is very important after repair the unit because "in-car climate" has a direct bearing on the driver, fatigue-free driving and driving safety. A comfortable interior temperature is dependent upon the prevailing ambient temperature and upon sufficient air flow.

Fig 4



THERMOSTATIC SWITCH

- Low ambient temperature, e.g.-20°C
- Higher interior temperature 28°C
- High air flow rate: 8 kg per min.
- Moderate ambient temperature, e.g.10°C
- Low interior temperature 21.5°C
- Low air flow rate: 4 kg per min.

Air conditioning ECU: The air conditioning ECU has following controls

- Blower control
- Air outlet control
- Air inlet control
- Variable capacity compressor control
- Outer temperature indication control
- Rear window defogger control
- Micro dust and pollen filter control
- Self diagnosis

Blower control: Controls the blower motor in accordance with the airflow volume that has been calculated by the neural network control based on the input signals from various sensors.

Air outlet control: Automatically switches the outlets in accordance with the outlet mode ratio that has been calculated by the neutral network control based on the input signals from various sensors.

Air inlet control: Automatically controls the air inlet control damper in accordance with the airflow volume that has been calculated by the neutral network control.

Variable capacity compressor control: Controls the compressor to turn ON/OFF and the discharge capacity based on the signals from various sensors.

Outer temperature indication control: Based on the signals from the ambient temperature sensor, this control calculates the outside temperature, which then corrected in the air conditioning ECU and shown in the multi - information display in the combination meter and air conditioning panel.

Rear window defogger control: Switches the rear defogger on for 15 minutes when the rear defogger switch is switched on. If the switch is pressed while it is operating.

Micro dust and pollen filter control: Quickly removes pollen from the face areas of the driver and front passenger when the micro dust and pollen filter switch is pressed.

Self diagnosis: Checks the sensors in accordance with operation of air conditioning switches, then clock displays a DTC (Diagnosis Trouble Code) to indicate if there is a malfunction or not (sensor check function).

Drives the actuators through a predetermined sequence in accordance with the operation of the air conditioning switches (actuator check function).

Ambient air temperature sensor

Location

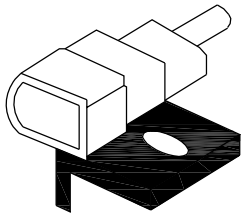
Fig 5 and 6 shows the ambient air temperature sensor is located behind the grill. It's typically located behind the grill or front bumper.

This is why they are sometimes damaged in a front end collision.

The ambient (ATC) or outside air temperature sensor is an (NTC) negative temperature coefficient sensor that informs the semiautomatic / automatic temperature control system of outside air temperature. The NTC sensor's resistance decreases as the outside air temperature increases. The computer uses this input, along with other in car temperature sensors to control temperature and blower speed. When there's a problem with this sensor, performance will suffer and the compressor's clutch may not engage.

Ambient air temperature sensor symptoms, like an inoperative clutch or input problems are diagnosed with a scan tool and a multimeter. Factory and many generic scan tools have the capability to activate certain components, the compressor clutch is one of them. If the clutch engages with the scan tool, there is likely a problem with one of the inputs. Verify any suspicious with a visual inspection of the sensor and its connector. Use a multimeter and verify manufacturer's specification, (220 - 240 ohms at 70° - 80° F), to test sensor for proper resistance.

Fig 5



AMBIENT TEMPERATURE SENSOR

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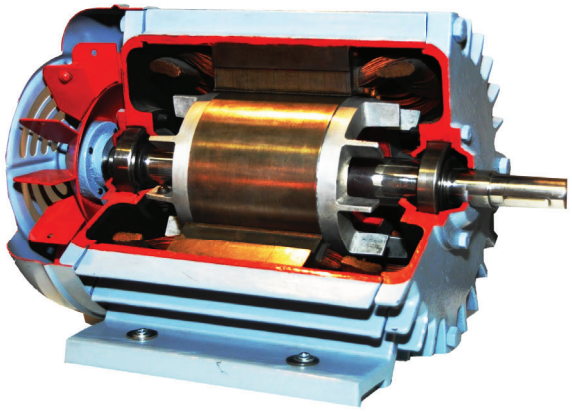
Automotive air conditioning systems use NTC sensors to monitor air temperature. The in car temperature sensor (ICTS) is an NTC that monitors the air temperature of the passenger compartment. The ambient temperature sensor (ATS) monitors the air temperature outside of the vehicle. The EATC compares these values and makes output decisions based on the difference of these air temperatures.

Servo motor (Fig 7): Servo implies an error sensing feedback control which is utilised to correct the performance of a system, generally sophisticated controller, often a dedicated module designed particularly for use with servo motors. DC motors that allows for precise control of angular position. they are actually DC motors while speed is slowly gears. The servo usually have a revolution cut-off from 90° to 180°. A few servo motors also have revolution or more. But servo motors do not rotate constantly. Their rotation is limited in between the fixed angles.

The servo motors is actually an assembly of four things:

- A normal DC motor
- A gear reduction unit
- A position sensing
- A control unit

Fig 7



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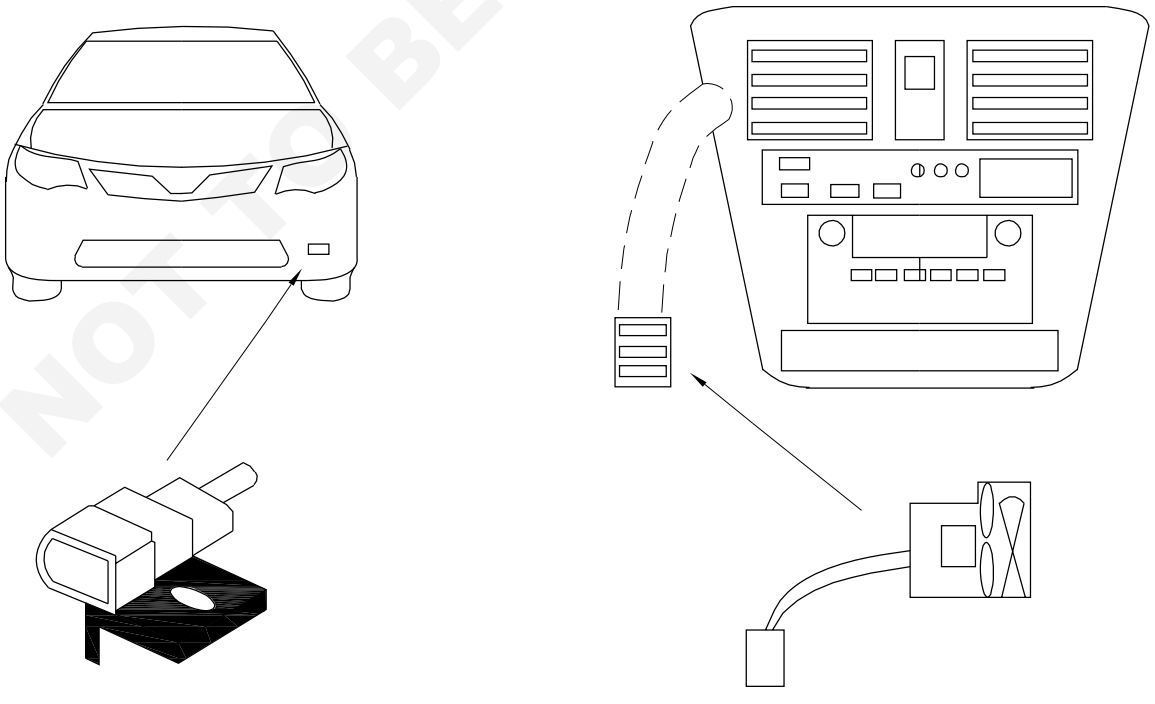
The DC motor is connected with a gear mechanism which provides feedback to a position mostly a potentiometer. From the gear box, the output of the motor is delivered via servo spline to the servo arm servo motors, the gear is normally made up to plastic whereas for high power servos, the gear is made up of plastic whereas for high power servos, the gear is made up of metal.

A servo motor consists of three wires a black wire connected to ground, a white/yellow wire connected to control unit and a red wire connected to power supply.

The function of the servo motor is to receive a control signal that represents a desired output position of the servo shaft and apply power to its DC motor until its shaft turns to that position.

It uses the position sensing device to figure out the rotational position of the shaft, so it knows which way the motor must turn to move the shaft to the instructed position.

Fig 6



AMBIENT TEMPERATURE SENSOR

IN CAR TEMPERATURE SENSOR

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The shaft commonly does not rotate freely around similar to a DC motor, however rather can just turn 200 degrees.

From the position of the rotor, a rotating magnetic field is created to efficiently generate toque. Current flows in the winding to create a rotating magnetic field. The shaft transmits the motor output power. The load is driven through the transfer mechanism. A high-function rare earth or other permanent magnet is positioned externally to the shaft. The optical encoder always watches the number of rotations and the position of the shaft.

Working of a servo motor

The Servo Motor basically consists of a DC Motor, a Gear system, a position sensor and a control circuit. The DC motors get powered from a battery and run at high speed and low torque. The Gear and shaft assembly connected to the DC motors lower this speed into sufficient speed and higher torque. The position sensor senses the position of the shaft from its definite position and feeds the information to the control circuit. The control circuit accordingly decodes the signals from the position sensor and compares the actual position of the motors with the desired position and accordingly controls the direction of rotation of the DC motor to get the required position. The Servo Motor generally requires DC supply of 4.8V to 6 V.

Controlling a servo motor

A servo motor is controlled by controlling its position using pulse Width Modulation Technique. The width of the pulse applied to the motor is varied and send for a fixed amount of time.

The pulse width determines the angular position of the servo motor. For example a pulse width of 1 ms causes a angular position of 0 degrees, whereas a pulse width of 2 ms causes a angular width of 180 degrees.

Advantages

- If a heavy load is placed on the motor, the driver will increase the current to the motor coil as it attempts to rotate the motor. Basically, there is no out-of-step condition.
- High-speed operation is possible.

Disadvantages

- Since the servomotor tries to rotate according to the command pulses, but lags behind, it is not suitable for precision control of rotation.
- Higher cost.
- When stopped, the motor's rotor continues to move back and forth one pulse, so that it is not suitable if you need to prevent vibration.

Automatic climate control (Automatic A/C) in cars (Fig 8): The automatic climate control system is the most advanced of all the air conditioning systems in cars. It effectively controls the cabin temperature and humidity levels. In climate control, you can set the cabin temperature of your choice. However, the system controls it regardless of the outside air temperature and humidity. Some advanced systems offer Dual-zone climate control with automatic re-circulation mode.

Fig 8

Automatic AC control panel

The automatic climate control system provides an individual feel-good climate for the occupants. It automatically controls the temperature, air-flow and air distribution inside the cabin. The climate control system also controls the fan speed and air circulation.

In some cases, the automatic climate control system provides electronic regulation of the air temperature, air flow rate, and air distribution. Some systems provide the defroster nozzles for the windscreen and side windows to eliminate the fogging effect. Nowadays, an automatic air-conditioner (a step-down version of automatic climate control) with touch screen panel for the ease of use (Fig 9).

Fig 9

Features of climate control system

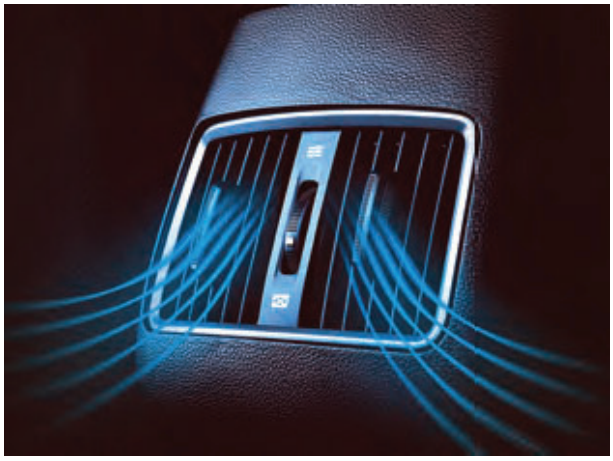
The automatic climate control system also measures the quality of the cabin air through various sensors. Some provide a separate climate control ECM to control various sensors/actuators such as cabin air quality sensor and humidity sensor. The driver and front passenger can control the temperature separately for themselves. You can also precisely adjust the temperature levels, direction and intensity of the airflow through a touch-screen.

The climate control system can also maintain the temperature depending on the sunlight and the quality of the intake air through key-coded settings. Manufacturers use custom acronyms to brand their automatic climate

control systems in cars, uses the term THERMOTRONIC for the Automatic Climate Control systems fitted in its cars.

Some manufacturers take the climate control to a new level. The driver and front passenger can independently set the temperatures of their choice for their respective areas. The rear passengers can also get better air quality with rear ventilation and re-circulation option. (Fig 10)

Fig 10



Car also provides a separate control unit with a display for the rear a/c. It also comprises of additional air outlets in the air vents in the center console and a booster blower for the purpose. This ensures that the ideal temperature is maintained at the rear. Some manufacturers also provide 'roof a/c' or blowers in the roof in some bigger models to achieve the desired effect.

Automatic Climate Control in Luxury Cars

Some ultra-luxury cars offer the state-of-the-art 4-zone air-conditioning. It includes an additional rear cabin air-conditioning unit with controls at the front and rear for fan speed and temperature. (Fig 11)

Fig 11

Rear Climate Control in Luxury cars (Fig 12)

Furthermore, some manufacturers, nowadays, provide an air-conditioned or cooled glove-box as a convenience option. So, it is getting popular among the budget car buyers. It keeps the water bottles/beverage cans cool. The cooled glove-box uses the cool air generated by the car's air conditioner to cool the stuff put in it. So, you can keep water-bottles and the cans of aerated drinks to cool them.

Fig 12

Tips for using the Climate Control effectively

1 Always keep the front grill clear of any obstructions for the proper functioning of the air conditioner.

2 Always keep the windows rolled up to maximize the efficiency of the A/c.

3 Keep the air conditioner in the recirculating mode when in use

4 Use the 'Fresh-Air' mode only when it is necessary.

5 To improve fuel efficiency, use the air-conditioner only when it is necessary.

Sensors

Infrared sensor: It measures the actual body temperatures of passengers.

Sunload sensors: Sunload sensors compensate for sunlight entering the vehicle through the glass.

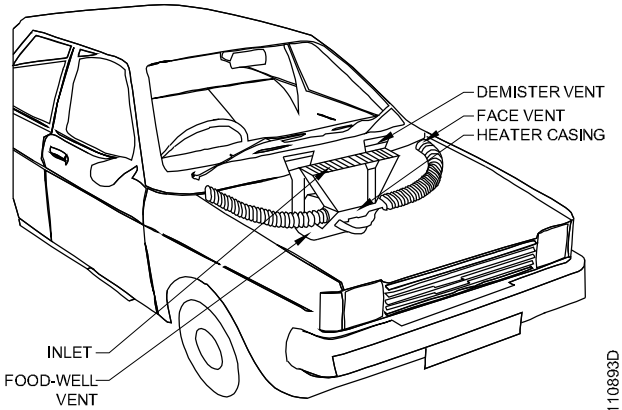
Smog sensors: Smog sensors to causes off the outside air inlet or other odours.

Interior temperature sensors: It is able to measure the interior temperature of any given moment and can send the data to the A/C system. The A/C system is able to adjust the temperature according to the wishes of the driver.

Ventilation system (Fig 13)

A typical heating system: Modern cars are designed to have a constant through-flow of fresh air that keeps the interior atmosphere pleasant even with all the windows shut. The incoming air can be heated by the engine to keep the windows clear of mist and the car interior at a chosen temperature.

Fig 13



VENTILATION SYSTEM

Air flow

Air enters a large duct at the front of the car, placed so that when the car is moving the entry point is in a high-pressure area and air is forced in. From there it goes to the heater, which warms it if required. Another common entry point is through grilles on top of the bonnet.

Air enters the car interior through the front foot-wells and through vents on the dashboard. The vents can be adjusted to point at the faces of the front-seat occupants.

Air flow ducts to the rear-seat area

Slots in the ledge at the bottom of the car windscreen (latest cars) by the front side-windows - allow a stream of warm air to be blown on to the glass to prevent misting.

On later cars, all the entry points have flaps for opening and closing them as needed.

At the rear there are exit vents to the outside. They are in an area of low pressure when the car is moving, and so extract air, thus giving a constant through-flow.

The heater

In a water-cooled car, the heater casing contains a matrix - a small radiator - that takes hot water from the engine through a hose.

Incoming air goes through the water-heated matrix and is warmed.

There is also an electric fan, which can be switched on to blow air through the system when the car is stationary, or when extra ventilation is called for.

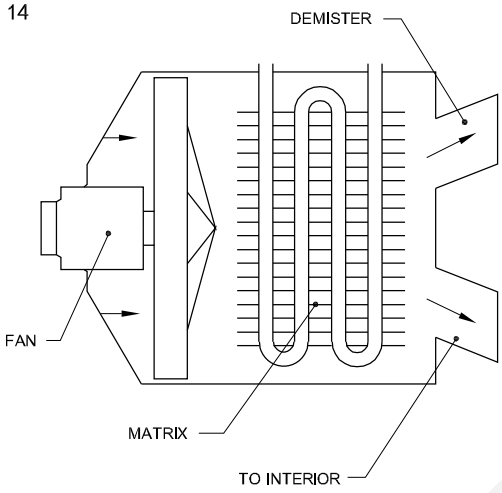
The fan can be adjusted to run at different speeds, according to need.

Two methods of heat control

Water-valve heating system (Fig 14): In a heater worked by a water valve, all the air goes through the matrix. The matrix temperature is controlled by regulating the amount of hot water going through it.

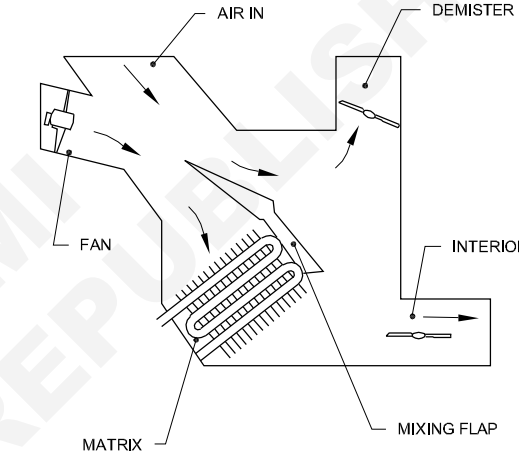
Air-blending heating system (Fig 15): In an air-blending heater the matrix is at a constant temperature - warm air from it is mixed with cool air as temperature-controlled flaps open and close.

Fig 14



WATER-VALVE HEATING SYSTEM

Fig 15



AIR-BLENDING HEATING SYSTEM

The temperature to which the air is warmed is controlled by either a water valve or an air-blending system. The water-valve type is found mainly on earlier cars.

The temperature control on the dashboard works a tap which lets either more or less hot water through the matrix. The setting is slow to respond to change and difficult to regulate exactly.

The air-blending system has a matrix that is heated constantly. The temperature control opens and closes flaps that blend heated air with cold air from outside.

With either system there may be extra flaps to admit a separate supply of cold air to the face vents, even when the rest of the system is supplying warm air.

The air-control flaps inside the heater box may be moved mechanically by sliding knobs on the control panel, which are linked to the flaps by cables.

More expensive cars may have power-assisted controls worked by the vacuum in the inlet manifold acting on a diaphragm, as in a power-brake servo (How the braking system works).

Air-cooled cars

In cars with air-cooled engines, air for the interior heater can be warmed by ducting it around fins on the hot exhaust manifold.

The warmed air is mixed to the right temperature by an air-blending system, including a heat-sensitive valve that keeps the temperature steady and at a comfortable level for the occupants.

If necessary, the air may be warmed further by an electrically ignited petrol-burning heat exchanger.

The heat exchanger also allows the heater to work with the engine off -unlike a water-heated type. The rest of the system, the way in which the heat is distributed, is like that of any other car.

The evaporative temperature sensor

It is a sensor or switch is a component commonly found on many road going vehicles. It is a part of the vehicle's A/C system and as it's name implies, detects and monitors the temperature of the A/C system evaporator.

Fan speed controller

Blower fan speed controller or low ambient fan controller is a control that is used to control the fan speed of the air cooled condenser in a heat pump direct expansion system heat pump is used in temperature.

When used as a heating mode in winter the indoor coil acts as a condense and outdoor coil as evaporator.

When the unit is set to cooling mode in summer, the indoor coil will operate as an evaporator and the out door coil as condenser.

This is accomplished by the use of 4 way valve that reverse the flow of the refrigerant in the system. Especially when the reversing valve is on the system will operates in cooling mode and when its off in heating mode.

Car has a ventilation system that provides a constant through flow of fresh air, heated by the engine to keep the windows clear of mist and the car interior at a chosen temperature.

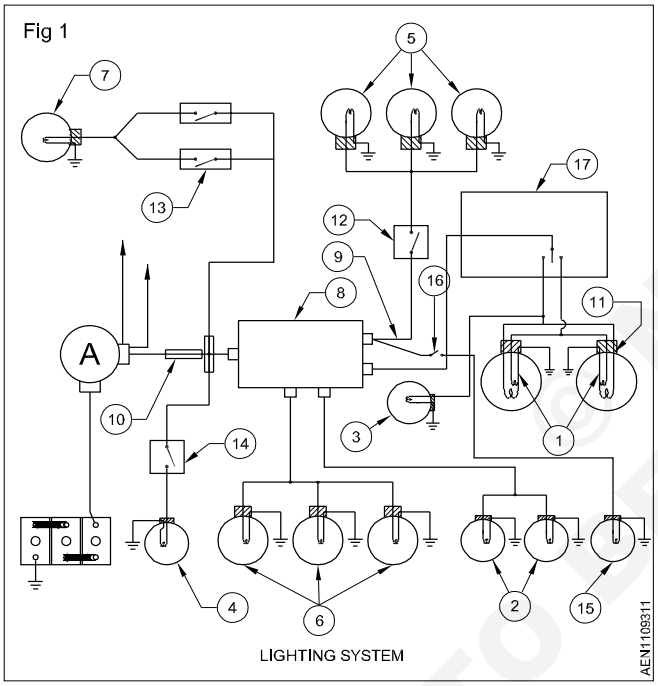
Lighting circuit

Objective: At the end of this lesson you shall be able to
- **explain the headlight and other lighting circuits.**

Introduction: Technicians must understand basic light circuits to be able to maintain, diagnose, and service these systems. When these circuits are understood, diagnosing becomes much easier and faster.

The lighting system (Fig 1) provides illumination on the road to ensure good visibility for the driver, and illumination inside the vehicle besides for other purposes. The headlamp (1), fog lamp (15), parking lamps (2), warning lamps (3), brake lamps (4), panel instrument lamps (5), tail-lamp (6) and the interior dome lamps (7) constitute the lighting system.

Fig 1



LIGHTING SYSTEM

The lighting system consists of switches (8), lamps, wiring harness (9) and fuse (10).

The different lighting systems used in the vehicle are

- headlight circuit
- panel light circuit
- fog light circuit
- reverse light circuit
- parking light circuit
- top light circuit
- stop light circuit
- flasher light circuit.

Headlight circuit

Provides illumination on the road to have enough visibility for the driver. It consists of a double filament, a pre-focused bulb (1), a reflector holder (11), a headlight switch (8), a dim and dip switch (17) and a fuse (10).

Parking light circuit: Two small lamps (2), at the front and rear of the vehicle are fitted. It is used when the vehicle is parked on the road. It is sometimes operated with the head light switch (8) or by an independent switch.

Panel light circuit: Small miniature bulbs (5) are used behind each panel board to see the working of the gauges during night, by the driver. These lamps are connected by a separate switch (12) of the panel board.

Top or dome light circuit: The dome lamp (7) is fitted at the top of the roof of the vehicle.

It is operated by a separate switch (13) located either in the panel board or door post. It provides interior illumination in the vehicle.

Fog light circuit: The ordinary head light beam is almost ineffective during snowfall (mist). The mist reflects the light backward. The fog light (15) provides effective illumination during this condition. It consists of a yellow lamp (15), a reflector and a switch (16).

Stop light circuit: In order to give indication to the traffic behind the vehicle for slowing down or for stopping the stop/brake lights (4) are fitted. It consists of a lamp (4) and brake switch (14), fitted on the master cylinder or air valve. When the brake pedal is pressed, the switch is made to close, thereby completing the circuit of the additional filament in the rear red light.

Tail-light: In order to give indication to the vehicles behind when driving in night, the tail-lights (6) are provided in the vehicles. They illuminate the back of the car, so that other vehicles coming behind can see it at nights. The tail lights will burn with the head lights i.e. whenever the head light switch is on, the tail-lights will also burn.

The reverse light circuit: Some cars are provided with reverse lights. They come into operation by the movement of the reverse gear which actuates a switch. Normally a single red lamp of 24 watts

is fitted at the rear of the vehicle. This reverse lamp has a fluted type cover which disperses the beam laterally, thereby helping the driver to see the full width of the road. (Refer to the manufacturer's Manual).

> **Some vehicles have more than one fuse and relay centre. The location of these centres is shown in the service manual. Some vehicles have the flasher(s) mounted separately from the fuse and relay centre.**

When the headlight switch is moved to the park position, voltage is supplied through the fuse and the headlight switch contacts to the park, tail, and side marker lights. Voltage is also supplied through the variable resistor to

the instrument panel lights. Each instrument panel bulb is grounded to the instrument panel. The variable resistor controls the brilliance of the instrument panel lights by varying the voltage supplied to these lights.

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. 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.

Fig 1

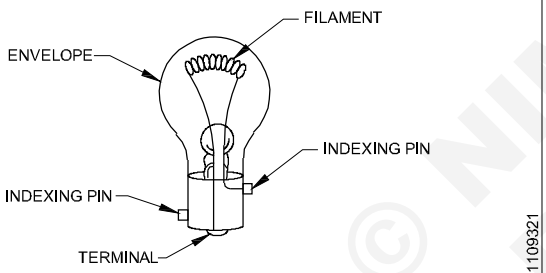
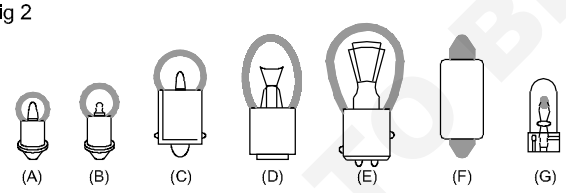


Fig 2



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 lights.

F - Cartridge type for dome lights

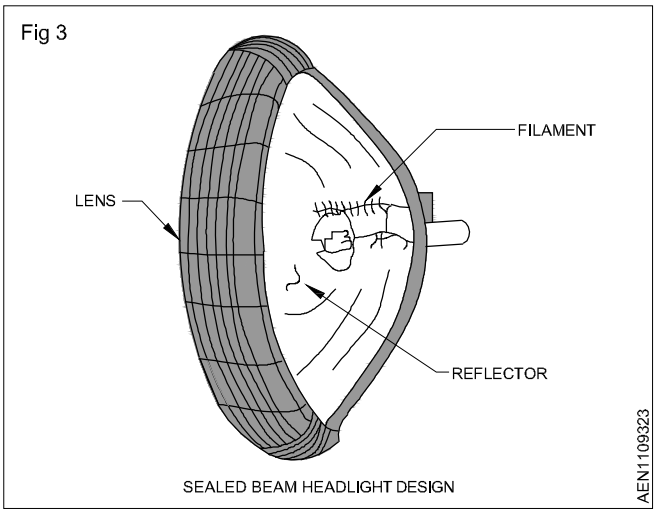
G - Wedge base for instrument lights

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. 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.

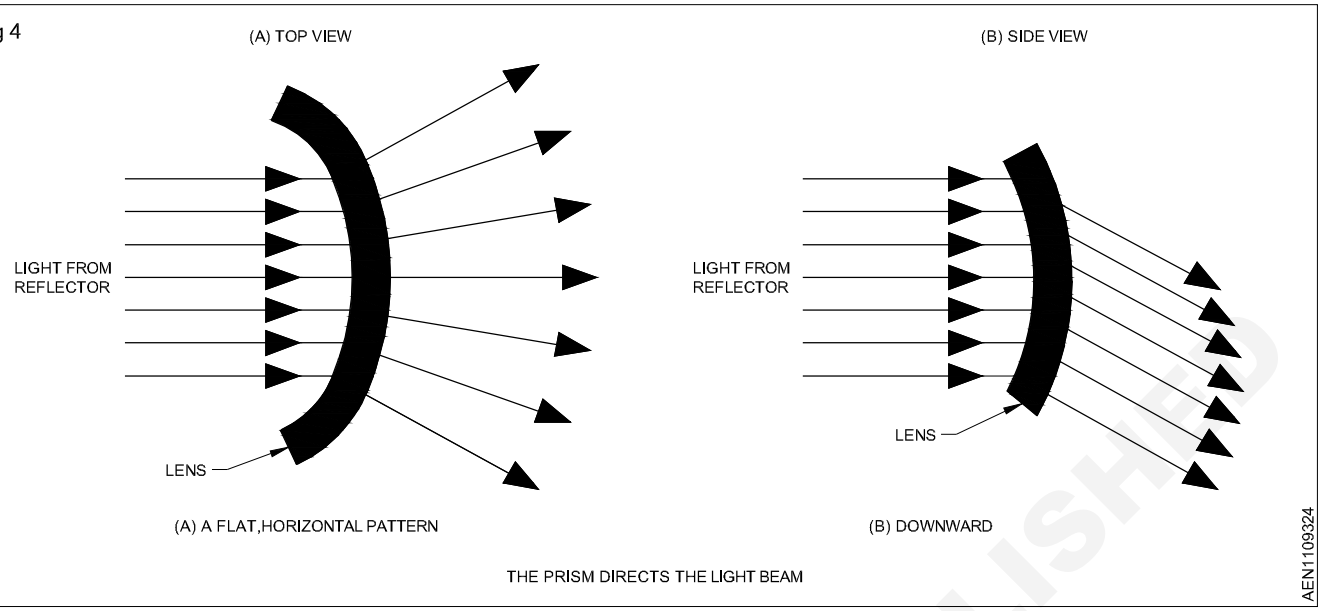
Fig 3



The light from the filament in a sealed beam is reflected from the reflector through concave prisms in the lens (Fig 4). 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)

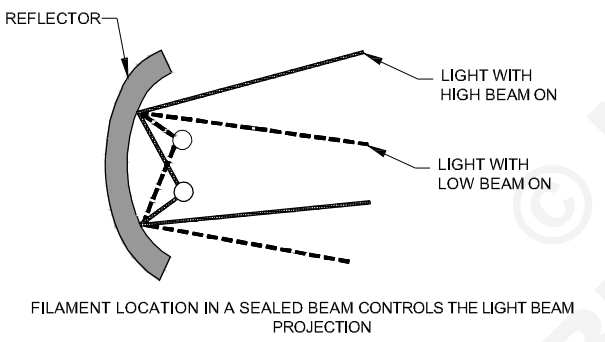
Light emitting diodes (LED). A certain number of diodes are interconnected with a physical unit according to the brightness required and the desired light colour. The multiple allocation reduces the probability of failure of the overall function. Light emitting diodes have a service life of approximately 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 4



THE PRISM DIRECTS THE LIGHT BEAM

Fig 5

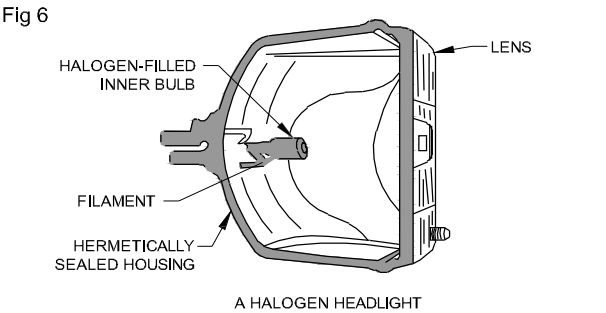


FILAMENT LOCATION IN A SEALED BEAM CONTROLS THE LIGHT BEAM PROJECTION

Halogen headlights (Fig 6): Many newer vehicles have halogen headlights. This type of headlight contains a small bulb filled with iodine vapour. The bulb has a glass or plastic envelope surrounding a tungsten filament. The bulb is installed in a sealed glass housing. 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.

Fig 6

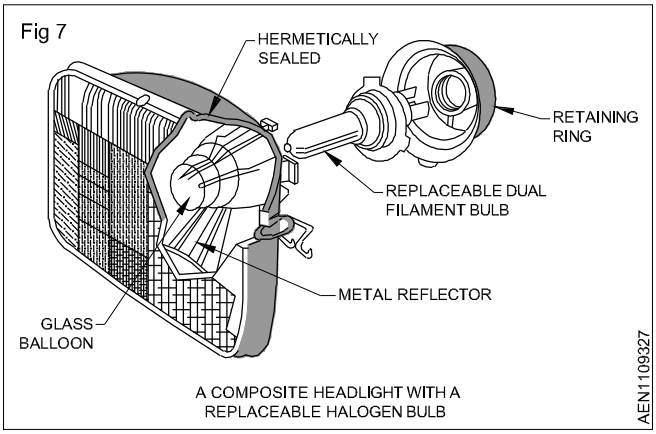


A HALOGEN HEADLIGHT

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 7). 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.

Fig 7



A COMPOSITE HEADLIGHT WITH A REPLACEABLE HALOGEN BULB

Interior lights: Lights are fitted to illuminate the interior of the vehicle usually these lights are switched on independently. In some cars interior light wires are connected with door switch, for cabin lights on, when door is opened. The earthing switches are used on each door to make an earthing contact for the lamp when the door is opened. security alarm system also utilize the door switches to trigger the alarm system.

Reading lamp: Small miniature LED bulbs are used near the passenger's seat to read the papers during night. These lamps are connected by separate switches to operate independently.

Vehicle cornering light: Cornering lights are usually small lights housed in the headlights assembly or in the fog lamps there generally switch on at low sparks, or during the reverse gear or when the steering is turned in a particular direction sensors activated the cornering light to turn in the direction of the car. Cornering lights highlight the blind spots during bends making it easier for the driver to spot and danger while adaptive lights provided extra brightness in the corners.

Smart lighting system: Smart lighting technology designed for energy efficiency. This may include high efficiency and automated controls, that make adjustments based on conditions such as occupancy or daylight availability. Lighting is the deliberate application of light to achieve some aesthetic or practical effects. It includes task lighting, accent lighting and general automobile lighting and wireless lighting system that is easily control the lights and create the right ambiance for every moment.

Car lighting equipment data	
Head lamps	2
Double filament bulb:	
High beam	45W
Low beam	40W
Front parking and direction indicator lamps	2
Parking	5W
Direction indicator	20W
Direction indicators side mounted reflectors	2W
Bulb	2.5W
Rear parking, direction indicator and stop lamps	2
With reflex reflector bulbs:	
Single filament (direction indicator)	20W
Double filament : Parking	5W
Stop	20W
Rear number plate lamps	2
Bulb	5W
Outer lighting control	Switch on panel by lower switch under steering
Front outer lighting change over control	Wheel
Bulb incorporated in rear view mirror	3W
Switches: Toggle type	On mirror flame
Jam type	On steering wheel side
Pillar lamps, 2 with incorporated switch	Door pillar 3W
Dome light: Lamp with toggle switch on panel	2.5W
Engine compartment light:	
2 Lamps with jam switch actuated by the opening of lid	5W
Indicators - 4 bulbs in instrument cluster, each	2.5W
Direction indicators pilot light	1
Bulb	2.5W
Fuses, 4	8 Amps.

Flasher circuit and flasher unit

Objectives: At the end of this lesson you shall be able to
- **state the need of the side indicator**
- **list out the types of side indicators**
- **explain the flasher wiring circuit**
- **explain the working of the flasher unit**
- **study the wiring circuit of electronic flasher.**

Need of a side indicator in a vehicle

All modern vehicles have been provided with flasher type direction indicators. These direction indicators permit the driver of the vehicle to signal his intentions to make a right or left turn during driving a vehicle on road. These also help to allow free flow of traffic from behind the vehicle and to prevent accidents between two vehicles while turning right or left, on cross-road junctions.

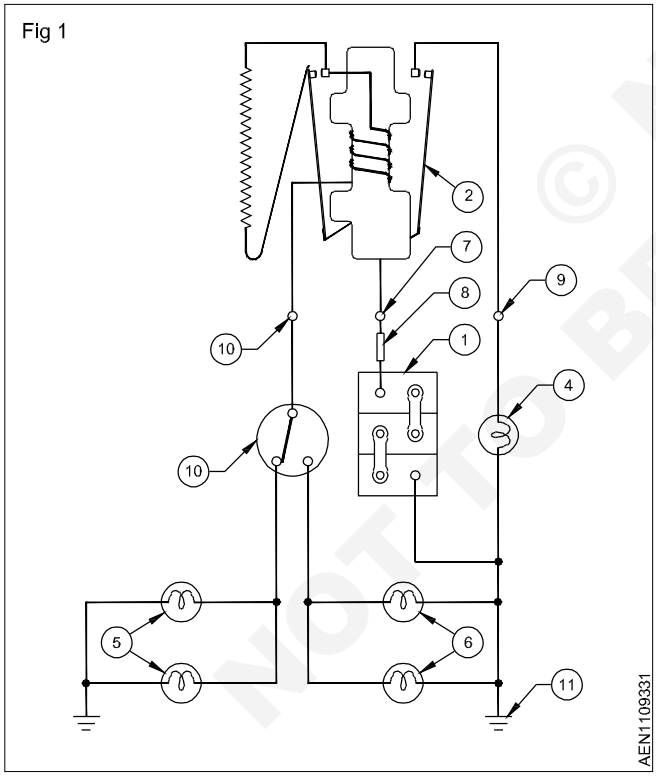
These flashing type of indicators are a standard requirement as per Motor Vehicle Act.

Types

- Mechanical type (Obsolete)
- Electrically operated arm type (Obsolete)
- Flasher type or blinkers

Flasher wiring circuit (Fig 1) (Electrical)

Fig 1



It is used in all the vehicles.

The circuit consists of a battery (1), flasher unit (2), a two way switch (3), an indicator warning lamp (4) and flasher lamps (5) & (6).

The 'B' terminal (7) of the flasher unit (2) is connected to the battery (1) through the fuse (8).

The 'P' terminal (9) of the flasher unit is connected to the pilot lamp (4) on the panel board.

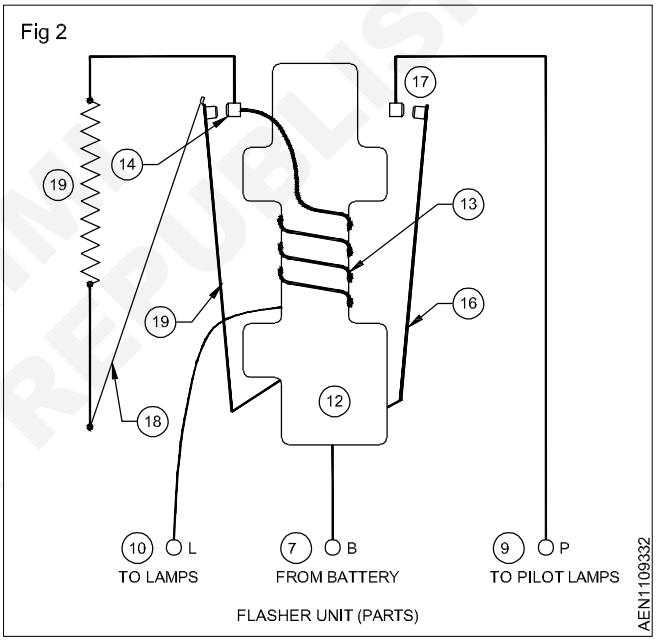
The 'L' terminal (10) of the flasher unit (2) is connected to the two-way switch (3).

The A_1 terminal of the switch is connected to the right side front and rear lamps (6) and A_2 terminal to the left side front and rear lamps (5).

The flasher unit (2), the flasher lamps (5 & 6) and the warning lamps (4) are earthed (11).

Flasher unit (Parts) (Fig 2)

Fig 2



The flasher unit is fitted between the battery and lamps.

It consists of an iron core (12) with windings (13).

One end of the winding (13) is connected to the main contact (14) and the other end to the 'L' terminal (10) of the unit.

There is one main armature (15) with the contacts and another secondary or auxiliary armature (16) with the pilot contacts (17).

The main armature (15) is connected with the actuating wire (18) and ballast resistor (19).

The actuating wire (18) is made of Nichrome, which increases in its length due to the heat and shortens when it is cold.

The indicator warning lamp is connected to the secondary armature's (16) contact.

Working

When the flasher switch (3) is operated to the left or right the current flows through the main armature (15), actuating wire (18), ballast resistor (19) and then to the coil (13) of the iron core (12).

The current from the coil (13) flows to the flasher lamp filaments and to the earth.

The lamps do not illuminate at this stage as the current is limited by the ballast resistor (19). But the filaments are preheated and ready to flash.

When the current is flowing, the actuating wire (18) gets heated up resulting in increasing its length. This causes the lamp contacts (14) to close in the supply circuit of flasher lamps and at the same time short circuiting the actuating wire (18) & ballast resistor (19). Now the full lamp current flows into the coil (13) of the iron core (12) and the lamp contacts are held firmly together in the closed position by the electrol magnetic attraction of the armature (15) to the core. At the same time, the spring-loaded auxiliary armature (16) is also attracted to the iron core (12) and closes the pilot warning lamp circuit.

Now both the contacts (14) and (17) remain in the closed position.

The current flows to the two lamps of the same side (5) through the main points and they begin to flash at the regulation of 70-100 times/min. At the same time current also flows to the indicator warning lamp (4) through the pilot contacts (17) and the pilot lamps are now lit.

When the actuating wire (18) gets cooled down, it becomes short in its length and the points (14) reopen.

When the contacts are made open the actuating wire (18) and the ballast resistor (19) are in circuit.

Now reduced current flows to the coil through the ballast resistor (19). This current is not sufficient to illuminate the lamps (5) & (6).

The circuit breaks and no current flows to the lamps and the light signals are extinguished off.

The reduction of electro magnetism in the iron core (12) allows the auxiliary armature to return to its original position and the pilot warning lights go off at the same time as the indicator lamps.

The above sequence of operations continues to be repeated till the indicator switch is returned to its off position.

Bulbs

Main bulbs - 12 volts - 21 watts

Pilot bulbs - 12 V - 2.2 watts

Colour of indicator lamps

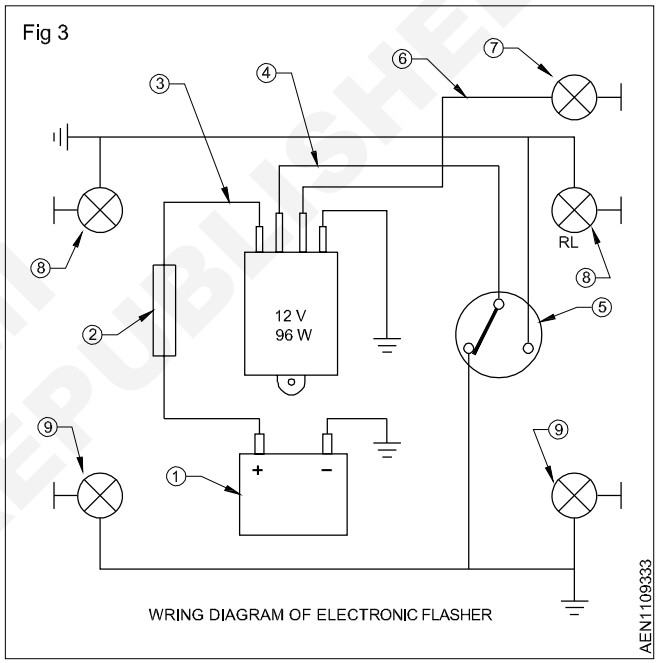
Front	-	White
Rear	-	Red/amber
Pilot lamp	-	Green

Wiring circuit of electronic flasher

Electronic flasher (Fig 3)

Electronic flasher (10) has four terminals B.L.P.E. 'B' connects the battery (+))(1) through fuse (2), 'L' terminal connects to lamps (9) (FR & RR) and (8) (FL & RL) through two way switch (5).

Fig 3



The terminal (P) of electronic flasher connects the pilot lamp (7) and earth terminal (E) is earthed.

When two way switch is moved towards right, the turn signal lamp FR & RR will glow.

When two way is moved toward left, the turn signal lamp FL & RL will glow.

Simultaneously the signal lamp (left or right) will flicker in the dash board.

Horn

Objectives: At the end of this lesson you shall be able to
- **explain the horn circuit**
- **state the types of horn**
- **explain the parts and working of relay type of horn**
- **explain the working of horn switch**
- **state common troubles and remedies in horn.**

Horn circuits (Fig 1)

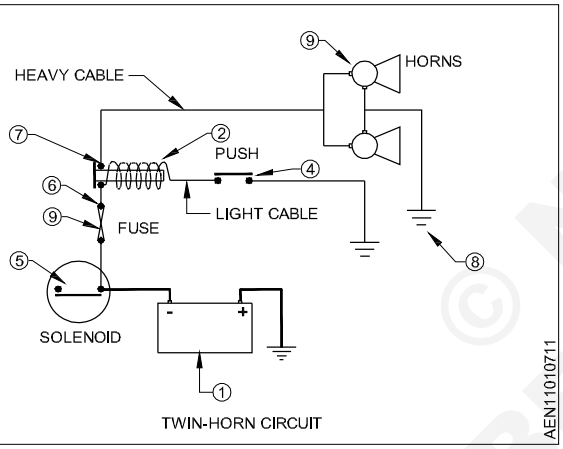
- Battery (1)
- Horn relay (2)
- Fuse (9)
- Horn push-button (4)
- Horn (single or pair) (3)

The circuit is connected in the following ways.

Battery (1) to the solenoid switch input terminal through a cable.

Solenoid switch (5) input terminal to horn fuse (9).

Fig 1



Ammeter is not connected in the horn circuit.

Horn fuse (9) to the horn relay 'B' (6) terminal.

Horn relay 'S'(6) terminal to the horn push switch (4).

Horn relay 'S' (7) terminal to the horn (3) terminal.

Horn grounded; terminal is earthed (8).

Function

When the horn switch (4) is pressed, the current from the battery (1) flows to the fuse relay (2) and then to the horn(3).

The circuit completes to operate the horn relay (2).

The relay (2) connects the horn (3) direct with the battery to supply more current. The horn (3) produces sound waves.

When the horn button (4) is released the horn circuit is opened.

The relay (2) disconnects the horn from the battery (1) current.

The horn (3) stops producing sound waves.

Need of a horn

The electromagnetic horn is fitted generally in the front end of the vehicle. It produces sound waves due to the vibration set up in the diaphragm to clear or warn the traffic on the road. It is used single or in pairs to produce sound and is operated through the horn switch in the driver's cabin. The horn switch does not operate the horn directly. It operates the horn relay.

Purpose

To produce powerful sound waves so as to indicate and warn the traffic in front of the vehicle.

Types of horn

- Electric horn
  - a Vibrating type
  - b Wind-tone type
- Air horn (Wind horn)
- Bulb horn

Construction (Electric horn) (Fig 2)

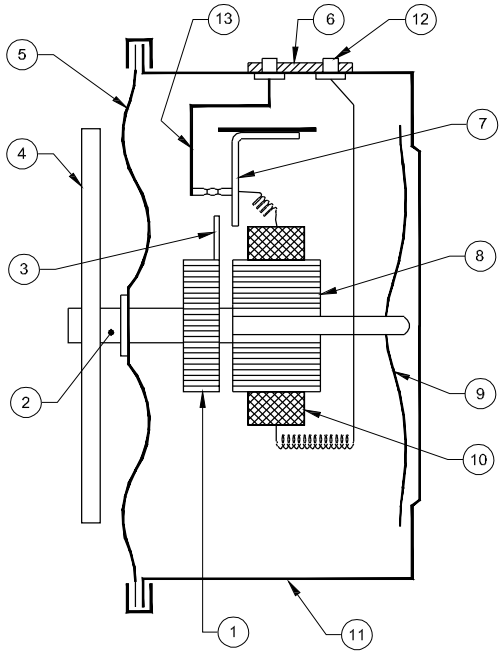
The electric horn consists of a shell or body (11) in which a laminated magnet core (8) is fitted. The winding (10) is wound over the core. One end of the winding (10) is attached to the horn terminal (12) and the other end to the movable contact breaker (7). The movable point connects with the fixed point (13) which is earthed. The armature (1) is attached to a central spindle (2). One end of the spindle (2) is supported by a guide spring (9) and the other end by a diaphragm (5). The armature carries a striker plate(3). The tone disc is at the outer front end of the diaphragm (5) and the diaphragm is clamped to the horn shell.

Operation/working

When the horn switch is pressed the current flows through the contact breaker (7) &(13) and the solenoid circuit is completed; the laminated core (8) is magnetised. The magnet attracts the armature (1). The armature (1) moves towards the magnet core (8). The spindle (2) and diaphragm (5) also move towards the core (8). Thus the striker plate (3) on the moving armature (1) separates the contact point (7) & (8). Immediately the iron core (8) is demagnetised. The armature (1) then returns to its normal position with the diaphragm guide spring (9) in tension. This cycle of operation sets the vibration in the diaphragm (5), about 300 vibrations per second. The tone disc (4) at the end of the

horn gives a frequency of about 2000 vibrations per second. This produces the sound of the horn.

Fig 2



ELECTRIC HORN

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In the vibrating type, the sound is emitted directly from the diaphragm.

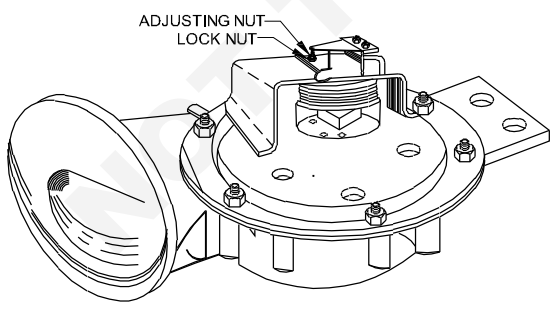
In the wind-tone type, the sound from the diaphragm is made to pass through a wind pipe, which is like a bugle or trumpet.

Electric power wind tone horn (Fig 3)

Principle of operation: These horns operate over the same electrical principle as the high frequency types, but a diaphragm is arranged at the inner end of the trumpet.

This diaphragm is vibrated in the centre of the air column by an electromagnet. This vibration produces sound waves which travel down the length of the trumpet, which decides the note produced by air in motion. The diaphragm is so mounted that its centre is attracted by the electromagnet.

Fig 3



METHOD OF ADJUSTING A WIND TONE HORN

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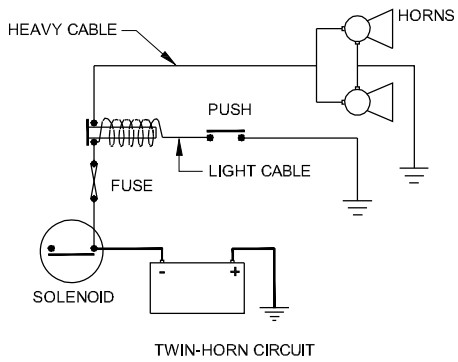
Circuit of these horns & current drawn by them (Fig 4): These air horns draw a heavy current intermittently than that of high frequency horns. Two such horns are connected in series with a relay and current from the battery is supplied through this relay and through a fuse of 50 amps. Each horn carries a current of 13 amps in a 12 volt system, but the adjusting amperage for these horns is from 6 amps to 8 amps.

Fig 4



TWIN-HORN CIRCUIT

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Special construction: The trumpet is coiled for occupying less space in its mounting. The heavy currents are being carried by heavier and short cables and the relay current (being small) is carried by lighter cables. The relay contacts are protected by a pellet type resistance.

Air horns (Compressed air operated type)

A number of vehicles incorporate an electrically driven air pump or compressor which forces air through two or more plastic trumpets in sequence. The length of trumpets differ and so provide different notes. These are also operated via relays.

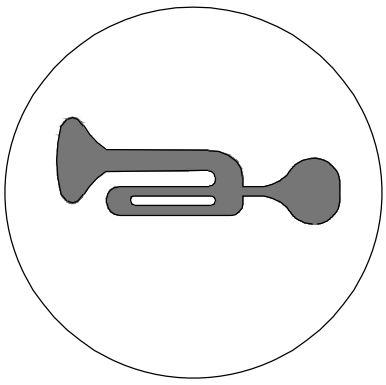
Bulb horn (Fig 5)

Application

These bulb horns are fitted to motor vehicles such as trucks (closed), lorries, auto-rickshaws in addition to electric horns.

These are generally used by drivers when electric horns fail to function due to short circuit or lack of current supply from the battery. These are also compulsory as per M.V.Act and Rules.

Fig 5



BULB HORN

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Construction

In the bulb horn a reed (metallic)is fitted on a metal base and the unit mounted on the windpipe near the bigger end of the horn tube. The windpipe is coiled for space consideration. The wind pipe is bigger in diameter at one end (called mouth) and is less in diameter at the small end. A hollow rubber bulb is fitted at the small end. It is simple

in construction, can be mounted near driver cabin easily and its maintenance is less. The reed can be replaced when it goes out of order.

Operation

When the rubber bulb is pressed a number of times, the air in the wind pipes pass through the reed, making it to vibrate and produce the sound. This sound is transmitted through the bigger dia. of the horn tube in a high tone to the outside atmosphere.

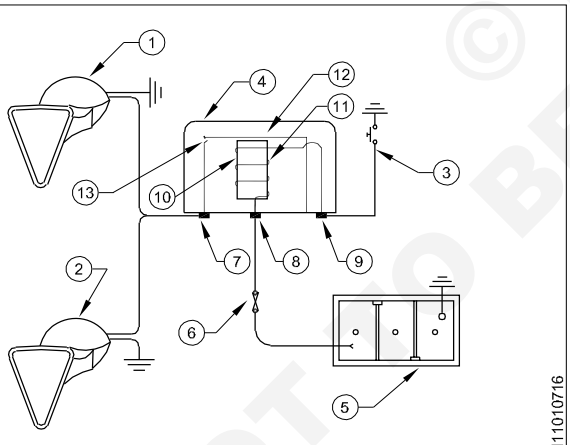
Horn circuit connection: The horn used in a vehicle must give good quality sound and penetration.

The relay type of horn

When more powerful horns are employed - as in the larger cars - the current needed to operate the horn can be appreciable and would cause severe pitting of the horn's contacts, due to sparking action. To obviate this it is now usual to employ a relay unit. Thus, the horn switch would require a current of 3 or 4A, but when operated would energize a solenoid which in turn would cause a pair of contacts to close so as to switch in the larger current of some 8 to 12A at 12 volts.

Horn relay and its description (Fig 6): The horn relay (4) consists of a base with three terminals (7,8 & 9) marked as H,B and S. Inside the horn relay an iron core (10) is wound with a coil (11). One end of the coil (11) is attached to the 'B' terminal (8) and the other end is connected to the armature (12) which carries the contact breaker point (13). The fixed point of the contact breaker point is connected to the 'H' terminal (7).

Fig 6



HORN CIRCUIT CONNECTION

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In relay the 'H' terminal (7) is connected to the horns (1 & 2), the 'B' terminal (8) is connected to the battery (5) via the fuse (6) and the 'S' terminal (9) to the horn button (3).

Operation/working

When the horn button switch (3) is pressed, the current from the battery (5) flows through the coil (11) and to the horn switch (3), thus completing the circuit. Now the iron core (10) becomes an electromagnet. The armature (12) is attracted by the iron core (10). The movement of the armature (12) closes the contact breaker points (13) together. Maximum current starts flowing to the horns (1 & 2) via 'H' terminal (7) and the horns starts produce sound waves.

When the horn button switch (3) is released, the current to the horn button (1) is cut off and the circuit breaks. The iron core (10) is demagnetised and the armature (12) is pulled back by the spring tension. The point (13) gets opened and the current to horns (1&2) is cut off and the horn stops working.

Location of horn switch (Fig 7): The horn switch is fitted normally at the centre of the steering wheel hub. In some vehicles the horn switch is fitted on the dashboard.

Purpose

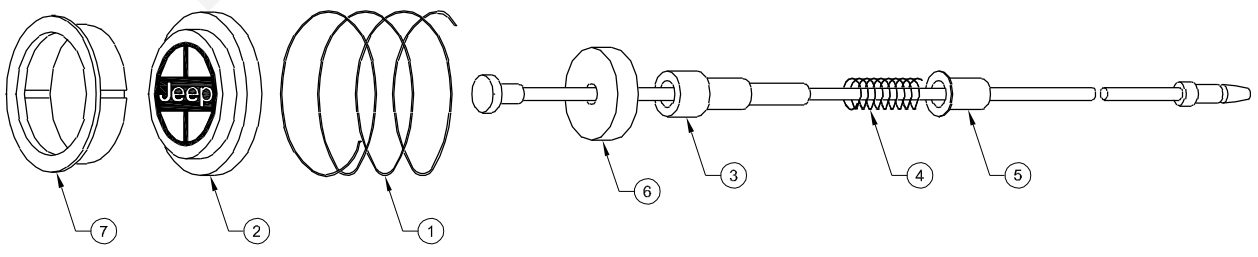
The horn switch is part of the horn circuit and is used to operate the horn relay.

The horn switch is operated by a button or ring or lever. The horn switch does not connect the horns directly to the battery. It consists of a spring loaded button (2), horn cable (3) with spring (4) and cup (5). The cable runs through the inner steering column and the end is attached to the horn button and the other end to the 'S' terminal of the horn relay. The horn button (2) is kept disengaged from the steering wheel hub's grounded plate (6) by the spring (1). The horn button is retained in the steering wheel hub by the retainer (7).

When the horn button (2) is pressed, the button touches the grounded plate (6) thus completing the electrical circuit. When the circuit is completed, the relay comes into action and supplies maximum current to the horns.

When the horn button is released, the spring (1) pushes the button (2) back to its position. The horn circuit breaks and stops the working of the horn.

Fig 7



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Sl.No	Defects/Faults	Causes	Remedies
1	Horn does not produce any sound.	1 Broken circuit wire connections	Rectify.
		2 Defective horn points (burnt or broken off)	Replace.
		3 Defective switch	Rectify or replace.
		4 Incorrectly adjusted relay	Readjust.
		5 Battery charge is low or dead.	Charge the battery.
		6 Fuse blown off	Provide new fuse of correct ampere age.
		7 Open field coil winding	Rectify.
2	Horn sounds continuously (when button switch is in the off position).	1 Short circuit of switch wire	Rectify.
		2 Relay points stuck up	Rectify.
3	Horn produces low improper sound (unsatisfactory tone).	1 Voltage at horn terminal is too low or too high	Check & adjust generator output voltage.
		2 Voltage drop in the circuit excessive	Rectify fault.
		3 Low battery voltage	Recharge.
		4 Loose cover & bracket screws	Tighten.
		5 Cracked diaphragm	Replace.
		6 Incorrectly adjusted horn points	Readjust.
		7 Tone disc damaged	Replace.
		8 Poor electrical connections	Rectify.

Wiper circuit and wind screen wiper

Objectives: At the end of this lesson you shall be able to
- **explain the need of wiper unit in vehicle**
- **describe the wiper wiring circuit and operation**
- **state the types of wiper**
- **explain care & maintenance**
- **attend defects, cause and remedies.**

Need of a wiper unit

During the rainy season when the vehicle is driven on the road the rain water falls on the wind shield glass of the vehicle. Due to this it becomes very difficult for the driver to see the road and traffic clearly. The water layer on the wind shield glass is wiped off by an accessory called wind shield wiper.

Description (Wiring circuit) (Fig 1)

The wiper circuit consists of a battery, fuse, wiper switch and a wiper unit.

The circuit consists of the following.

The battery (1) is connected to the wiper switch (2).

The wiper switch (2) to the wiper fuse (3).

The wiper fuse (3) to the wiper electric motor terminal (4).

Motor terminals (4) to the armature brush (5) and field coil (6).

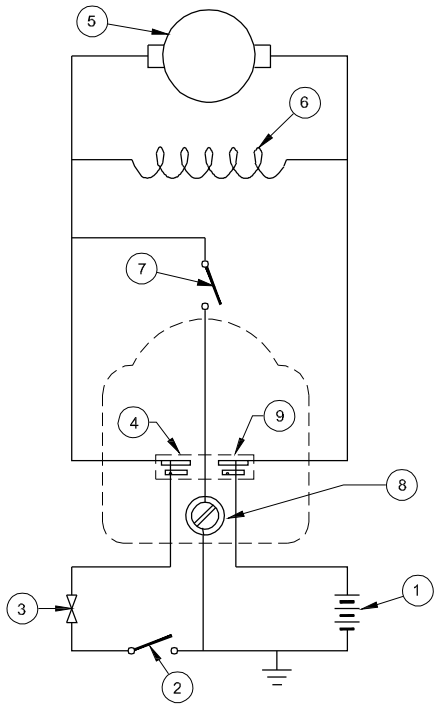
The other terminal of the wiper motor (9) is grounded.

The limit switch's (7) one end is connected to the wire from the terminal (4) and the other end to the earth screw (8).

Operation

When the wiper switch (2) is switched 'ON' the current from the battery (1) flows to the wiper motor terminal (4) via the fuse (3).

Fig 1



WIND SHIELD WIPER MOTOR WIRING DIAGRAM

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The current flows to the motor field (6) and armature (5) through the brushes. The motor rotates like a starter motor.

When the wiper switch (2) is switched 'OFF' the current from the battery is cut off; so the motor stops rotation.

Windscreen wiper unit

The wiper unit is fitted at the top or bottom of the wind shield glass frame/pillar.

Types: The following types of wiper units are used in vehicles;

- Hand operated
- Vacuum operated
- Compressed air operated
- Hydraulically operated
- Electrically operated.

Short description of the types

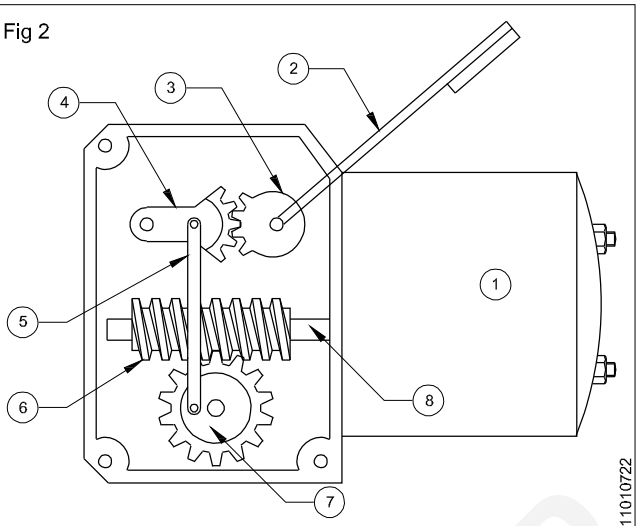
A Hand-operated wiper unit: These are no longer used in vehicles and have been replaced by electrically operated wiper units.

B Vacuum operated wiper: The wiper units work under the engine vacuum for their function. In certain vehicles (old models like jeep, land rover) a double AC pump (petrol) was used for operation of these wipers. The vacuum required for their operation is developed by the AC pump diaphragm having valves in its body.

C Compressed air operated wipers (Fig 2): The vehicles fitted with air compressors use this kind of wipers. These are used in heavy motor vehicles (diesel trucks & heavy haulage vehicles)

D Hydraulically operated wipers: These are not popularly used in vehicles nowadays.

Fig 2



COMPRESSED AIR OPERATED WIPES

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E Electrically operated wipers: These are widely used in all motor vehicles nowadays. Their construction and operation are described briefly in this lesson.

Explanation

The motor is of a self-switching, two-pole design, having a permanent magnet field system provided by high-energy magnets, together with a gearbox housing a two-stage reduction gear. The power from the motor is transmitted by a three-start worm gear provided on the extension of the armature shaft through a low stage reduction gear system. The drive to the blades is transmitted via a shaft and rotary link assembly. It is incorporated with a special limit switch which ensures application of regenerative braking to the armature on completion of the wiper cycle during which the control switch is turned to OFF position. It thus ensures consistent parking of the wiper arms and blades in the correct position.

Electrical connections are made to the motor via a non-reversible in-line plug and socket assembly. This type of connection ensures the maintenance of correct motor polarity during the course of motor connecting to the vehicle wiring. The working of the wiper unit is explained below.

Working

When the wiper switch is operated, the current passes to the electric motor and the motor shaft (8) rotates. A worm (6) is fixed on which the motor shaft drives the gear (7).

The gear wheel operates the cranking link (5).

The cranking link (5) operates the sector (4).

The sector (4) operates the pinion (3) with the arm shaft.

The arm shaft oscillates the arm (2) and moves the blade to and fro on the glass.

When the wiper switch (7) is put off the motor stops working.

The arm (2) returns to the edge of the wind shield glass and stops due to limit switch action.

The blade is provided for 50 to 100 oscillations per minute depending on the speed of the wiper motor and the drive arrangement of the blades.

The wind shield wiper motor consumes a current of 2.7 amps to 3.4 amps at 12 volts under normal operating conditions.

A 5-amps fuse is provided in the motor circuit.

Care and maintenance

Keep the wiper unit secure on its mounting.

Keep the electrical connection tight.

Never operate the wiper on dry glass.

Do not attempt to turn the arms on the spindle.

Fit the arms to the driving drums at the correct angle.

Replace the perished or worn wiper blade immediately.

A drop or two of machine oil should be applied to the outside cranking link and hinge pin joints.

Power window

Objectives: At the end of this lesson you shall be able to
- **explain the purpose of power window**
- **explain the operation of power window**
- **state safety for power window.**

Power windows are usually inoperable when the car is not running. This is primarily a security feature. It would be a simple thing to allow electric power windows to be operable when the ignition is turned off, however it would also make the car much easier to steal. As a compromise, some systems offer the compromise of leaving power applied to the windows until a passenger door is opened at which time the window power is removed.

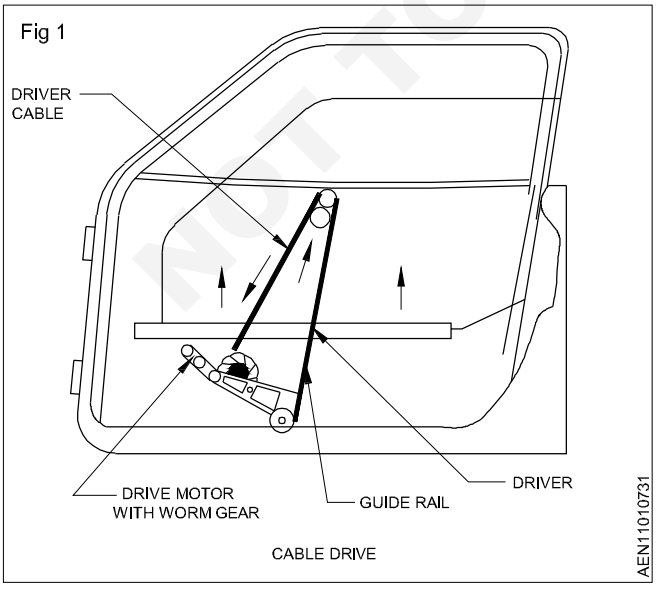
Electric power windows operation

Comfort and convenience systems

This allows electric opening and closing of the windows and where fitted, sliding sunroof via a rocker switch (pushbutton switch).

To power the windows up and down, a cable drive system is normally used (Fig 1). The drive motor actuates a cable via a worm gear mechanism, which will open or close the window depending on the direction of motor rotation. The self - locking effect of the worm gear mechanism prevents the window from opening in response to application of force.

Fig 1



Electrically - operated windows

In this system a DC permanent magnet motor is normally used to operate each window, and a three position rocker switch changes the polarity of providing up and down motion of the window. Four main window switches one for each window are installed on the drivers panel, and an isolation switch is also added to disconnect the supply to the rear windows. Two relays control the current to each motor and are powered by a common feed.

A gearbox forms the drive between the motor and the window glass and amplifies the torque sufficiently to undertake upward motion of the window, which is more difficult than the downward motion.

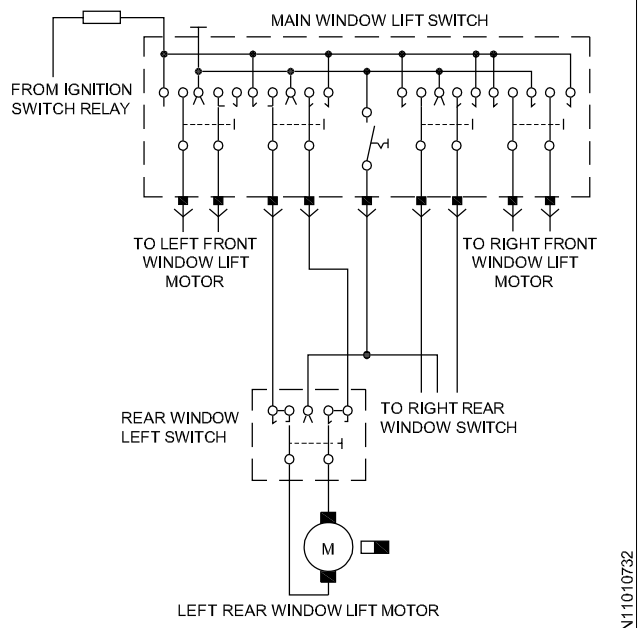
To limit the current during overloading one or more thermal cut out switches are installed in the circuit, sometimes in the motor. The cut out is opened if the operating switch is held closed when the window has reached its limit of movement or in case where free movement of the glass is arrested by ice. A main overload switch, if used, is generally of a requiring resetting after encountering an overload situation.

Fig 2 shows the circuit for electric operation of a rear passenger window, but the balance of the circuit has not been shown for simplicity. The motor in this layout is powered directly through the ignition switch. The ganged switch supplies the current with suitable polarity to rotate in the required direction during the operation of the window.

Safety

Power windows have come under some scrutiny after several fatal accidents in which children's necks have become trapped, leading to suffocation. Some designs place the switch in a location on a hand rest where it can be accidentally triggered by a child climbing to place his or her head out of the window. To prevent this many vehicles feature a driver controlled lockout switch, preventing rear-seat passengers (usually smaller children) from accidentally triggering the switches. This also prevents children from using them as toys and pets riding with their heads out windows from activating the power window switch.

Fig 2



Central door locking

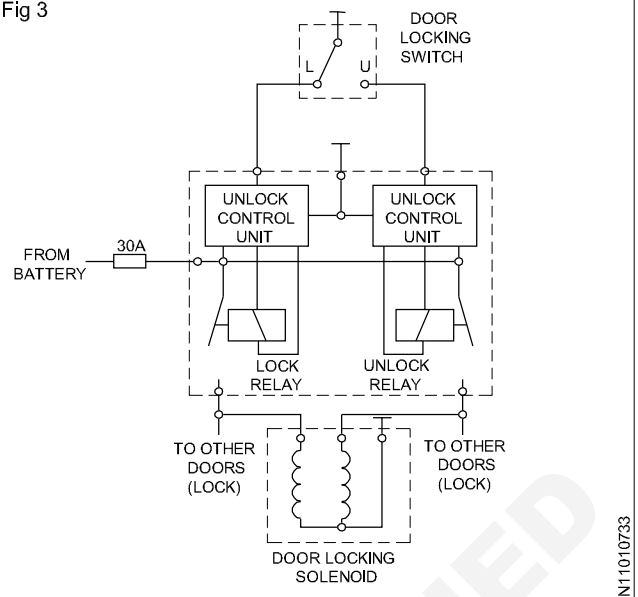
A door locking system normally locks all doors, including the tailgate or boot simultaneously when the driver's door lock is activated. When the key is turned or the driver's door lock button is operated the electrical system actuates all the locking activators installed adjacent to the door locks. Unlocking the door takes place in the similar way except the locking actuators work in the opposite direction. Both for convenience and safety reasons, a mechanical latches system is fitted which unlocks each door manually from inside the car. Various types of control are incorporated to provide the locking / unlocking pulse for operation of the actuators. In some designs two relays are used, one for locking and the other for unlocking the doors. A transistorised switching circuit controls these relays. The circuit timed by the charge - discharge action of capacitor to provide a current pulse length sufficient to actuate the locks. (Fig 3)

Now a day's almost all door actuators use small motors which, via suitable gear reduction, operate a linear rod in either direction to lock or unlock the doors. A simple motor reverse circuit is presented in Fig 4 & 5, where the driver's door switch operates the locks on four doors. More sophisticated systems are now becoming popular for consideration of safety as well as improved comfort.

Key less entry system

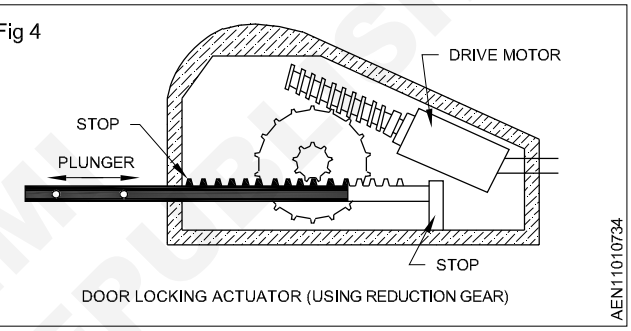
A keyless entry system is an electronic locks that controls access to a building or vehicle without using a traditional mechanical key. The term keyless entry system originally meant a lock controlled by a keypad located at or near the driver's door, which required entering a predetermined numeric code. Such systems now have hidden touch - activated keypad and are still available on certain modern cars.

Fig 3



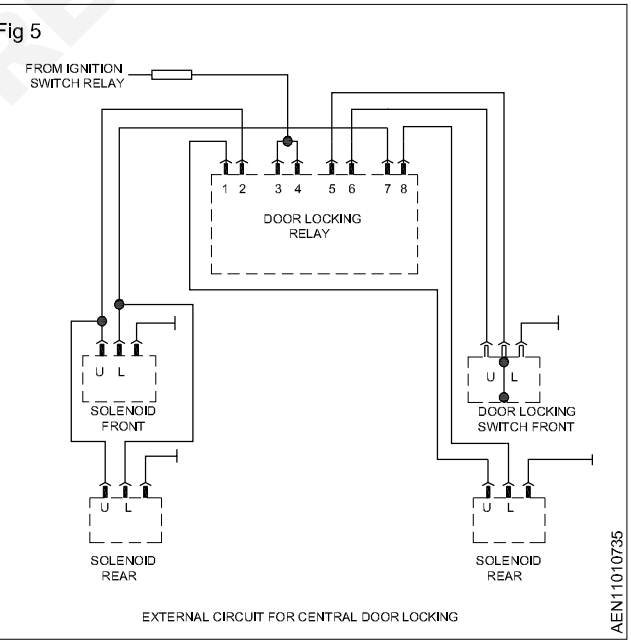
CENTRAL DOOR LOCKING CIRCUIT (TRANSISTORIZED CONTROL)

Fig 4



DOOR LOCKING ACTUATOR (USING REDUCTION GEAR)

Fig 5



EXTERNAL CIRCUIT FOR CENTRAL DOOR LOCKING

Remote control locking refers to a lock that uses an electronic remote control as a key which is activated by a handhold device.

Keyless entry system performs the functions of standard car key without physical contact. When within a few yards of the car, pressing a button on the remote car lock or unlock the doors, and may perform other functions. A remote keyless entry system which unlocks the doors.

Car anti theft system: Though most of the car models are with immobiliser, still the number of cars stolen are on raise. Gear locks considered one of the base defence a car thief would be in a very rare circumstance puts up time to break gear lock in the car.

Ignition cut off: A key operated or hidden manual switch that interrupts the power supply from the battery to the ignition system. This manual switch can be taken out by the driver once the car is locked.

Introduction: What is a hybrid? A hybrid vehicle combines any two power (energy) sources. Possible combinations include diesel/electric, gasoline/fly wheel, and fuel cell (FC)/battery. Typically, one energy source is storage, and the other is conversion of a fuel to energy. The combination of two power sources may support two separate propulsion systems. Thus to be a True hybrid, the vehicle must have at least two modes of propulsion.

For example, a truck that uses a diesel to drive a generator, which in turn drives several electrical motors for all-wheel drive, is not a hybrid . But if the truck has electrical energy storage to provide a second mode, which is electrical assists, then it is a hybrid Vehicle.

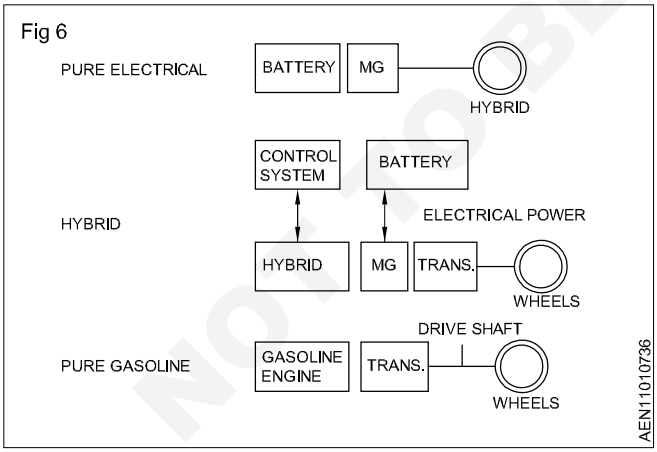
These two power sources may be paired in series, meaning that the gas engine charges the batteries of an electric motor that powers the car, or in parallel, with both mechanisms driving the car directly.

Hybrid electric vehicle (HEV)

Consistent with the definition of hybrid above, the hybrid electric vehicle combines a gasoline engine with an electric motor. An alternate arrangement is a diesel engine and an electric motor.

Fig 6 shows the components of a hybrid Vehicle that combines a pure gasoline with a pure EV.

Fig 6



As shown in Fig 6, a HEV is formed by merging components from a pure electrical vehicle and a pure gasoline vehicle. The Electric Vehicle (EV) has an M/G which allows regenerative braking for an EV; the M/G installed in the HEV enables regenerative braking. For the HEV, the M/G is tucked directly behind the engine. In Honda hybrids, the M/G is connected directly to the engine. The transmission appears next in line. This arrangement has two torque producers; the M/G in motor mode, M-mode, and the gasoline engine. The battery and M/G are connected electrically.

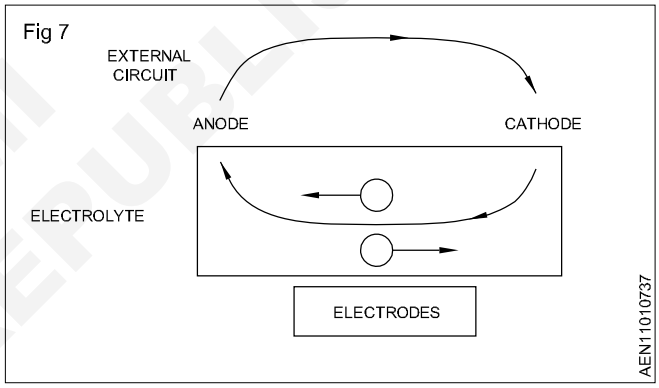
HEVs are a combination of electrical and mechanical components. Three main sources of electricity for hybrids are batteries, FCs, and capacitors. Each device has a low cell voltage, and, hence, requires many cells in series to obtain the voltage demanded by an HEV. Difference in the source of Energy can be explained as:

- The FC provides high energy but low power.
- The battery supplies both modest power and energy.
- The capacitor supplies very large power but low energy.

The components of an electrochemical cell include anode, cathode, and electrolyte (shown in Fig 7). The current flow both internal and external to the cell is used to describe the current loop.

Fig 7 shows An electrode, a circuit for a cell which is converting chemical energy to electrical energy. The motion of negative charges is clockwise and forms a closed loop through external wires and load and the electrolyte in the cell.

Fig 7



A critical issue for both battery life and safety is the precision control of the Charge/Discharge cycle. Overcharging can be traced as a cause of fire and failure.

Applications impose two boundaries or limitations on batteries. The first limit, which is dictated by battery life, is the minimum allowed State of Charge. As a result, not all the installed battery energy can be used. The battery feeds energy to other electrical equipment, which is usually the inverter. This equipment can use a broad range of input voltage, but cannot accept a low voltage. The second limit is the minimum voltage allowed from the battery.

Hydrogen is used in cars two ways: a source of combustible heat or a source of electrons for an electric motor. Hydrogen fuel cells create electricity.

Internal combustion vehicle

Hydrogen internal combustion engine cars are different from hydrogen fuel cell cars. The hydrogen internal combustion car is a slightly modified version of the traditional gasoline internal combustion engine car. These hydrogen engines burn fuel in the same manner that gasoline engines do; the main difference is the exhaust product. Gasoline combustion results in carbon dioxide

and water vapour, while the only exhaust product of hydrogen combustion is water vapour.

A hydrogen vehicle is a vehicle that uses hydrogen as its onboard fuel for motive power. Hydrogen vehicles include hydrogen-fuelled space rockets, as well as automobiles and other transportation vehicles. The power plants of such vehicles convert the chemical energy of hydrogen to mechanical energy either by burning hydrogen in an internal combustion engine, or, more commonly, by reacting hydrogen with oxygen in a fuel cell to run electric motors. Widespread use of hydrogen for fuelling transportation is a key element of a proposed hydrogen economy.

As of 2016, there are three models of hydrogen cars publicly available in select markets: the Toyota Mirai, the Hyundai Nexo, and the Honda Clarity. Several other companies are working to develop hydrogen cars. As of 2014, 95% of hydrogen is made from natural gas. It can be produced by thermo chemical or pyrolytic means using renewable feed stocks, but that is an expensive process. Renewable electricity can however be used to power the conversion of water into hydrogen: Integrated wind-to-hydrogen (power-to-gas) plants, using electrolysis of water, are exploring technologies to deliver costs low enough, and quantities great enough, to compete with hydrogen production using natural gas. The drawbacks of hydrogen use are high carbon emissions intensity when produced from natural gas, capital cost burden, low energy content per unit volume at ambient conditions, production and compression of hydrogen, and the investment required in filling stations to dispense hydrogen.

Hydrogen

Hydrogen does not exist in convenient reservoirs or deposits as do fossil fuels or helium and is produced from feed stocks such as natural gas and biomass or electrolyzed from water. A suggested benefit of large-scale deployment of hydrogen vehicles is that it could lead to decreased emissions of greenhouse gasses and ozone precursors. However, as of 2014, 95% of hydrogen is made from methane. It can be produced by thermo chemical or pyrolytic means using renewable feed stocks, but that is an expensive process. Renewable electricity can however be used to power the conversion of water into hydrogen: Integrated wind-to-hydrogen (power to gas) plants, using electrolysis of water, are exploring technologies to deliver costs low enough, and quantities great enough, to compete with traditional energy sources.

Hydrogen fuel-cell vehicles would generate only three-fifths the carbon dioxide as a comparable vehicle running on gasoline blended to 10 percent ethanol. While methods of hydrogen production that do not use fossil fuel would be more sustainable, currently renewable energy represents only a small percentage of energy generated, and power produced from renewable sources can be used in electric vehicles and for non-vehicle applications.

The challenges facing the use of hydrogen in vehicles include chiefly its storage on board the vehicle. While the well-to-wheel efficiency for hydrogen from the least efficient manner of producing it (electrolysis) is less than 25 percent, it still exceeds that of vehicles based on internal combustion engines.

Electrical and electronic architecture

Instead of simply being modes of conveyance as in the past, today cars are also expected to entertain and inform passengers in a safe and protected environment. Further, they are supposed to ease the complexity of driving by providing different forms of assistance to the driver. To support these increasing demands, automotive - specific buses and gateways. Moreover, emerging functionally like car - to - car and car to infrastructure communication, as well as infotainment and driver assistance systems have increased the number of vehicle components with communication interfaces to the outside world. Such complex E/E and connected automotive architectures are increasingly vulnerable to malicious attacks and recent this topic considering security side - by - side with safety is crucial for the overall reliability of an automotive E/E architecture, since s vulnerable electronic component might undermine the passenger's safety to the extent as a faulty one. However, in the highly competitive automotive domain, the cost of security features often pose an obstacle to their adoption.

Immobilizer system

Objectives: At the end of this lesson you shall be able to
- **description of immobilizer system**
- **state immobilizer circuit.**

Engine immobilizer

The engine immobilizer is a theft protection system that prevents someone from starting the engine with an incorrectly coded key.

Do not shield the car keys with metal objects. This may prevent the receiver from recognizing that key as a valid one.

Engine immobilizer system description

The engine immobilizer system is designed to prevent reduces motor vehicle theft.

This system uses a transponder key ECI that stores the key codes of authorized ignition keys. If an attempt is made to start the engine using an unauthorized key, the ECU sends a signal to the ECM to prohibit fuel delivery and ignition, effectively disabling the engine.

When the ECU detects that the unlock warning switch is ON, the ECU provides current to the transponder key coil and produces a faint electric wave. A transponder chip in the key grip receives the faint electric wave. Upon receiving the faint electric wave, the transponder chip outputs a key ID code signal. The transponder key amplifier amplifies it, and then the signal is transmitted to ECU. The ECU matches the key's ID code with the vehicle's this signal, the transponder key amplifier amplifies it, and then the signal is transmitted to the ECU. The ECU matches the key's ID code with the vehicle's ID code, which was previously registered in the ECU and then communicates the results to the ECM using the SFI communication.

After the identification results show that the key's ID code matches the vehicle's ID code and the ECU has confirmed their match:1) the immobilizer system is cancelled and the engine starting controls (fuel injection control and ignition control) enter standby mode; and 2) the ECU transmits a security indicator signal that communicates "indicator OFF" to the multiplex network body EXU. Then, the multiplex network body ECU turns OFF the security indicator lamp.

Immobilizer circuit (Fig 1)

Car alarms: There are several alarm systems that will serve to deter or discourage vehicle thefts and alert others of forced entry into the car. You need sure that these noise speakers should be installed in such a way as not to be easily accessible on glance, else will be forts disabled by them.

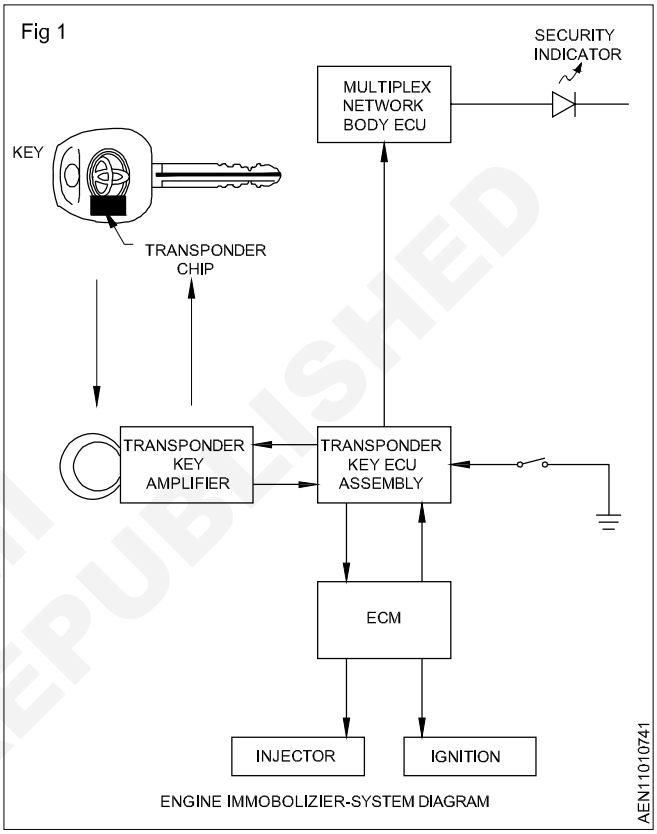
Steering lock: A long metal bar with a lock that fits on the steering wheel and is designed to prevent the steering wheel from turning, steering wheel locks are effective.

ICAT: ICAT means Intelligent Computerised Anti - Theft system under this system the car starts only when car starts only when the sensor in the vehicle accepts the chip in the key. Even sensors creates alarms buzz, when someone tries to insert the fake key in a car.

GPS tracker: A GPS facility, which can help tracking a stolen car. In fact, it can also alert a misuse of your car by any service station.

Tyre lock: Tyre lock device is very difficult to lock and unlock the car wheel, but its cost is very lower than other anti theft system device.

Fig 1



ENGINE IMMOBOLIZIER-SYSTEM DIAGRAM

Audio system

Objectives: At the end of this lesson you shall be able to
- **describe head unit**
- **describe the amplifier**
- **describe the speaker.**

Head unit (Fig 1): A car audio system uses separate electronic components - a radio tuner, DVD player, preamp, amplifier - connected by various cables. The head unit performs two main functions are controlling the overall system volume and the various audio and video sources in a vehicle.

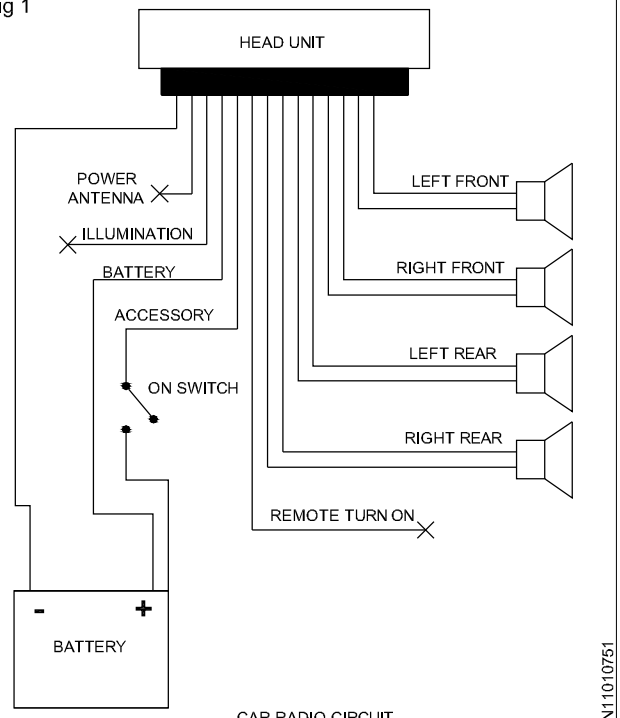
Head units can also be used to control media players like the iPod or navigate the content of a USB flash drive that's connected to the stereo system. Head units with Blue tooth audio can also play music that's streamed wirelessly from a compatible mobile phone.

In addition to controlling the system's volume, head units usually include basic tone controls such as bass and treble to tailor the sound to the listener's taste. Many audio systems also include signal processing that automatically adjusts the volume, depending on the ambient noise in a moving vehicle. Some audio systems also have a separate subwoofer and subwoofer level controls.

The amplifier (Fig 2): A car stereo system has to have an amplifier to increase the power of an audio signal so its strong enough to move the speakers and create sound. Amplification is a two stage processes handled by a preamp and a power amplifier.

The preamp is usually housed inside the head unit and takes data from a radio, CD player or other audio source and prepares it for the power amplifier. This process includes slightly boosting the audio signal, which makes it compatible with the input of the power amplifier and ensures that its resistant to noise that can radiate from other electronics in a vehicle.

Fig 1



CAR RADIO CIRCUIT

The power amplifier then takes the preamp's low -level single and significantly boosts it so it can move the speakers and create sound.

Many head units have a small, built - in low power amplifier that can "drive" smaller speakers. This allows the audio system to be reduced to just a head unit and a few speakers. But better sound requires more power. So higher - end systems have separate power amplifiers that are mounted away from the head unit due to their size and the heat they generate.

The speakers (Fig 2): Speakers take an amplified electrical signal and convert it into mechanical energy that moves the speaker cone back and forth to create sound. Sound is essentially vibrations in the air that we hear, and a speaker cone creates these vibrations. The human ear hears these vibrations in a frequency range from about 20 hertz (very low bass) to 20,000 Hz (very high notes).

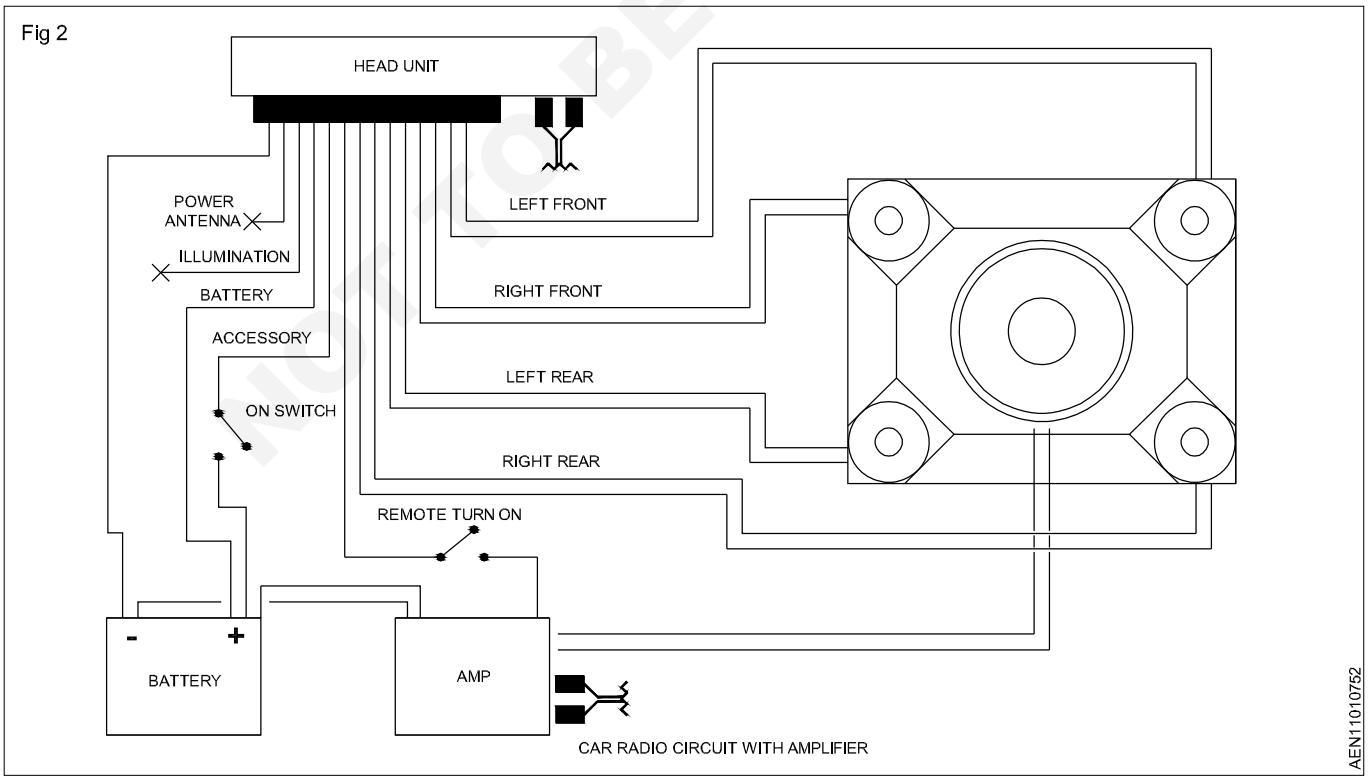
The most basic automotive speakers are designed to be "full range" to cover the entire frequency range. But by trying to cover the entire frequency spectrum, bass response is generally nonexistent and higher frequencies are dull. You can get more accurate sound reproduction by using an assortment of speakers dedicated to reproducing a smaller range of sound.

Woofers and subwoofers are large speakers designed to reproduce only low frequency bass sounds. The aptly named midrange drivers handle the middle range frequencies. Some systems take it one step further and use a specialized Midas driver to handle the troublesome frequencies between low bass and midrange. Tweeters are the smallest of the specialized drivers and reproduce the upper treble frequencies.

Car videos: A car video system uses separate electronic components LCD monitor is connected with DV players, speakers and rear view camera.

In many car sound systems, two speakers of different sizes are combined on one frame to create a two way speaker. For example a coaxial speaker mounts a small tweeter directly above and on the same axis as a small woofer. That creates a full -range speaker from two separate drivers.

Fig 2



CAR RADIO CIRCUIT WITH AMPLIFIER

Air bag and seat belt

Objectives: At the end of this lesson you shall be able to
- **state need of air bag and seat belt**
- **state functions of seat belt**
- **state the types of seat belt restraints**
- **describe the passive seat belt restraints**
- **state safety points for driver & passengers**
- **describe the air bag system**
- **describe air bag system warning light**
- **describe the multi stage air bag deployment**
- **describe seat belt pre-tension.**

Need of air bag and seat belt: Vehicle safety is one of the most important considerations of the average vehicle buyer today. In simple terms, safety sells vehicles! Therefore, vehicle manufacturers have spent a large amount of money engineering improved safety systems. Passive restraints at the present time include the drivers air bag, passenger side air bag, side - impact air bags, air bag curtains, and seat belt pre-tension. The seat belt and air bag systems are intended to work together to protect the driver and passengers.

Functions of seat belts: An air bag equipped vehicle, conventional seat belts perform these functions:

1 Hold the occupants in proper position when air bags inflate.

2 Reduce the risk of injury in a less severe collision in which the air bags do not deploy.

3 Reduce the risk of occupant ejection from the vehicle and thus reduce the possibility of injury.

State types of seat belt restraints: All vehicles manufactured and sold vehicles must have passive restraints.

Passive restraints may be air bags or automatic seat belts. Most vehicles with air bags also have active restraints. These are

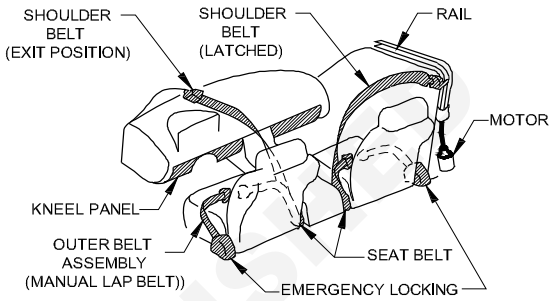
1 Passive restraints 2 Active restraints

Passive restraints: Operate automatically with no action required by the driver. Active restraints require action by the driver or passengers before the restraints provide any protection.

Passive seat belt restraints: A passive seat belt system uses electric motors to automatically move the shoulder belts across the driver and front seat passenger. The upper ends of the belts are attached to a carrier mounted in a track just above the top of the door frame. The other end of each shoulder belt is secured by an inertia lock retractor that is mounted in the centre console. When a front door is opened, the outer end of the shoulder belts move forward in the door tracks to allow easy entry and exit from the vehicle (Fig 1).

When the door is closed and the ignition switch turned on, the shoulder belts move rearward in the door tracks to secure the front seat occupants. The active lap belt must be buckled by the driver or passenger and must be worn with the shoulder belt.

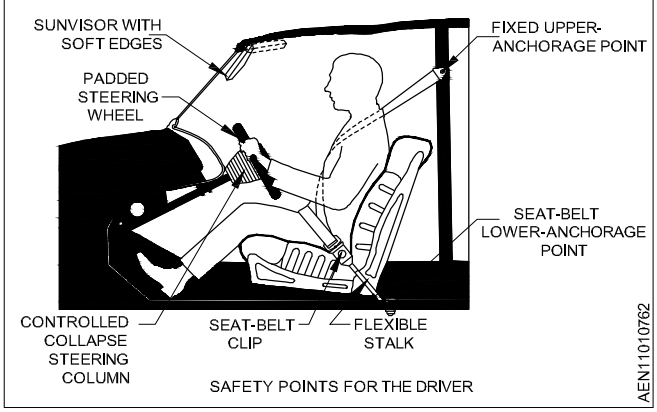
Fig 1



A APSSIVE SEAT BELT RESTRAINT SYSTEM

Safety points for driver and passenger (Fig 2): Some of the better modern front seats embody an adjustable lumber support in the backrest. Where the seat must hinge forward to give access to the rear compartment, a catch is usually fitted on recent models to secure it in a collision. Fascias and parcel shelves are now well padded to minimize injury, and some inside mirrors are designed to break from their mountings on impact, instead of shattering.

Fig 2



SAFETY POINTS FOR THE DRIVER

Comfort: The seat belt anchorage, which incorporates the retaining clip, should be so located that the belt can be put on and taken off quickly, using only one hand. The belt must fit comfortably and must not slip off or cut into the wearer. A settled, restful position reduces strain and fatigue a considerable safety factor.

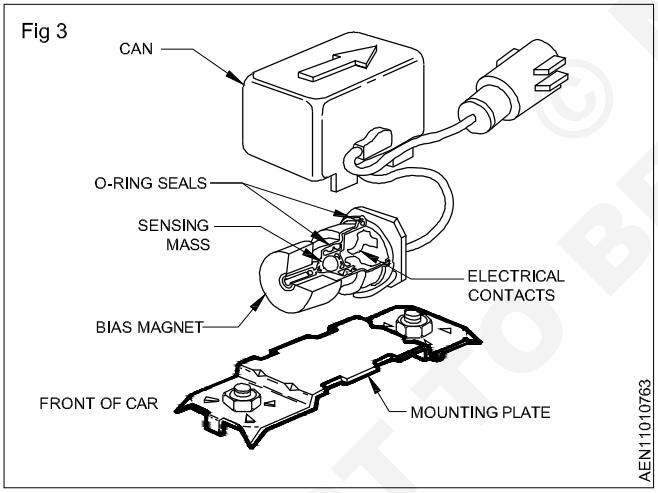
Air bag system components: Understanding air bag system components is essential to comprehend the complete system operation. A knowledge of air bag system operation is absolutely necessary to maintain, diagnose and service air bag systems quickly and accurately.

Sensors

Some air bag system sensors contain a set of normally open, gold plated contacts and a gold plated ball that acts as a sensing mass (Fig 2). This ball is mounted in a stainless steel - lined cylinder. A magnet holds the ball about 1/8 in away from the contacts. When the vehicle is involved in a collision of sufficient force, the ball moves away from the magnet and closes the switch contacts.

These contacts remain closed for 3 milliseconds before the magnet pulls the ball away from the contacts. The sensor is completely sealed in epoxy to prevent contaminants and moisture from entering the sensor. Sensors must be mounted with the forward marking on the sensor facing toward the front of the vehicle. To operate properly, sensors must be mounted in their original mounting position and sensor brackets must not be distorted.

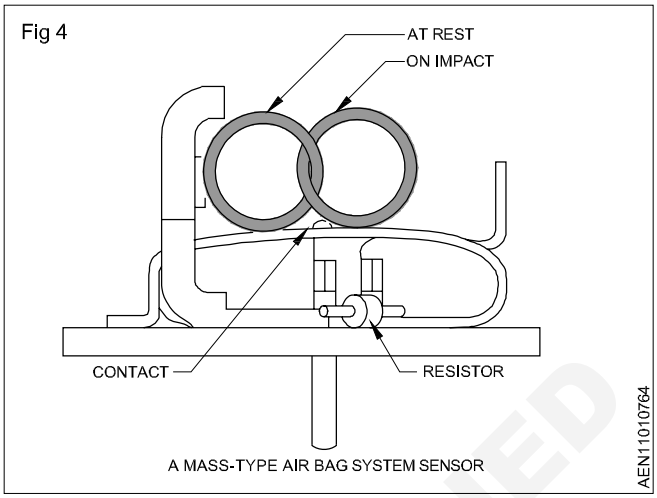
Some air bag sensors contain a roller on a ramp. This roller is held against a stop by small, retractable springs on each side of the roller. If the vehicle is involved in a collision of sufficient force, the roller moves up the ramp and strikes a spring contact completing the electrical circuit between the contact and the ramp. (Fig 3)

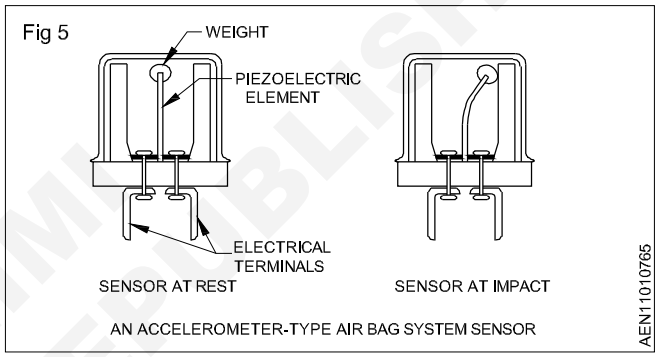


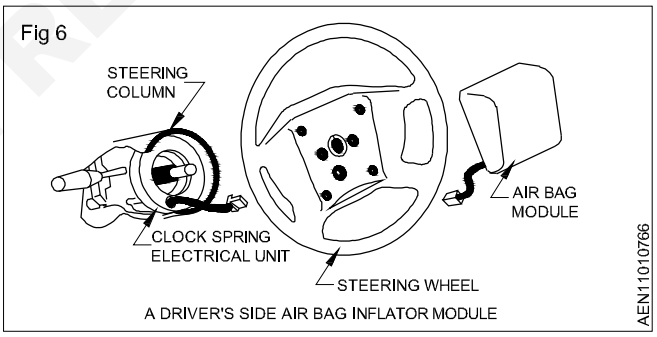
Some air bag sensors contain an accelerometer that contains a piezoelectric element (Figs 4 & 5). If the vehicle is involved in a collision, this element is distorted. The voltage signal from the sensor to the air bag system module depends on the force of the collision and the amount of element distortion.

Inflator module

The inflator module contains the air bag, air bag container and base plate, inflator, and trim cover. The retainer and base plate are made from stainless steel and are riveted to the inflator module. The air bag is made from porous nylon and some air bags have a neoprene coating. The purpose of the inflator module is to inflate the air bag in a few milliseconds when the vehicle is involved in a collision. A typical driver's side air bag has a volume of 2.3 cubic feet. The driver's side air bag inflator module is usually retained with four bolts in the top of the steering wheel. (Fig 6)







Air bag system warning light

The air bag system warning light is mounted in the instrument panel. The air bag system warning light should come on when the ignition switch is turned on. If the ignition switch is left in the on position without starting the engine or when the engine is started, the air bag system warning light should flash a few times and then go out. This light action indicates the air bag system is satisfactory. If the air bag system warning light is on with the engine running, there is an electrical defect in the air bag system and the air bag system may not be operational in a collision.

Side impact air bags (Fig 7): Some vehicles are now equipped with side impact air bags that protect the driver or passengers during a side collision. The side impact air bag systems are separate from the driver's side and passengers side air bag systems. Side impact air bag

systems have their own sensors and ASDM. (Adaptive Security Device Manager). Separate ASDMs are usually installed for each side impact air bag. The ASDMs for the side impact air bags may be under the front seats or behind the B-pillar panels.

Left and right side ASDMs for side impact air bags are not interchangeable.

Some vehicles have a side impact air bag that deploys out of the door panelling. In other systems, the side air bags are mounted in the side of the seat back near the top. Some vehicles have a side air bag curtain that deploys out of the headliner just above the doors. This type of air bag protects the front and rear seat occupants from head injury.

Smart air bag systems

Some air bag systems have a switch in the passenger's side of the front seat. This switch informs the ASDM if anyone is sitting in the front passenger seat or not. If no one is sitting in this seat, the passenger's side air bag does not deploy if the vehicle is involved in a collision. Some smart air bag systems can detect from the passengers weight. If a child below a certain weight is occupying this seat, the air bag does not deploy. In some air bag systems, the weight of the person in the passenger's side air bag deploys.

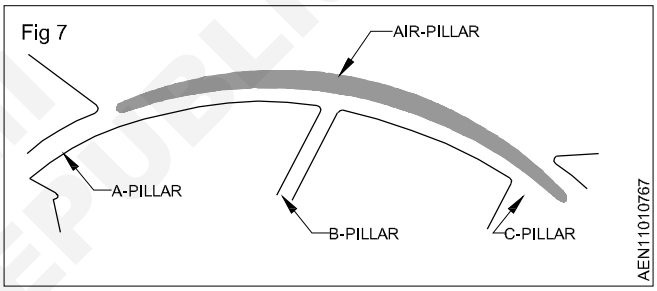
On some smart air bag systems, if a rearward facing child's seat is place in the front passenger's seat, the passenger's side air bag does not deploy.

If a child in a rearward facing child's seat is placed in the front passengers seat and the air bag deploys, the deployed air bag may force the seat and the child against the vertical part of the front seat causing the child to suffocate.

Some vehicles have a small knee air bag that deploys out of the dash in front of the drivers knees. This air bag protects the driver from knee injury and also keeps the driver from sliding under the seat belt during an accident. This action maintains the driver in a better position to be protected by the driver's side air bag.

Seat belt pre tensioners: Some vehicles have seat belt pre tensioners on the seat belts. The pre tensioners contain materials similar to a single stage air bag inflator module. The pre tensioners may be mounted on the buckle side of the seat belt (Fig 7). If the front air bags are deployed, the ASDM also fires the pre tensioners. A thin cable sis connected between the buckle and a small piston in the pre tensioner. When a pre tensioner is fired, the piston moves up the cylinder and the cable pulls the buckle tight. This action holds the occupant tightly against the seat and helps to prevent injury.

Fig 7



Global Positioning Satellites (GPS)

Objectives: At the end of this lesson you shall be able to
- **state the uses of global positioning satellites (GPS)**
- **describe working of GPS**
- **describe the uses of crash sensors**
- **describe on integrated communications system**
- **describe the uses of proximity sensor**
- **describe the uses of reflective displays**
- **describe triangulation / trilateration**
- **describe telematics**
- **describe networking & multiplexing.**

Global Positioning Satellites (GPS)

A system known as a Global Positioning System, or GPS can be used to determine the exact location of a vehicle on the earth's surface.

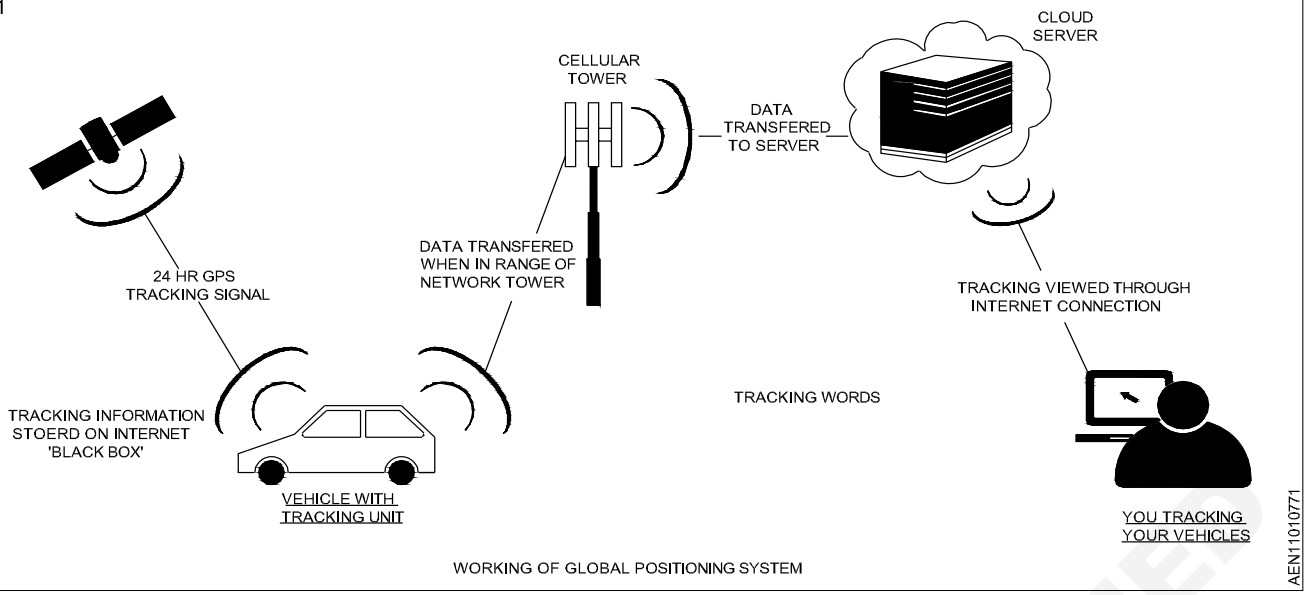
Thousands of satellites, service a variety of purposes, are continually in orbit high above the earth. The use of satellite technology in vehicle systems provides an ever increasing array of options for vehicle manufacturers. It is an area of automotive technology that increases the flexibility and power of many onboard systems.

Satellite technology is used in: Navigation, vehicle tracking, vehicle theft recovery, communication and internet access.

Mountains, tunnels, large buildings and other objects can interfere with satellite communication and make it unreliable. Most vehicle tracking systems can work very accurately without satellites once their initial position has been determined. On board sensors can be used to keep track of the exact vehicle location.

Working of global positioning system (Fig 1): The basis of the GPS is a constellation of satellites that are continuously orbiting the earth. These satellites, which are equipped with atomic clocks, transmit radio signals that contain their exact location, time and other information. The radio signals for the satellites, which are monitored and corrected by control stations, are picked up by the GPS receiver.

Fig 1



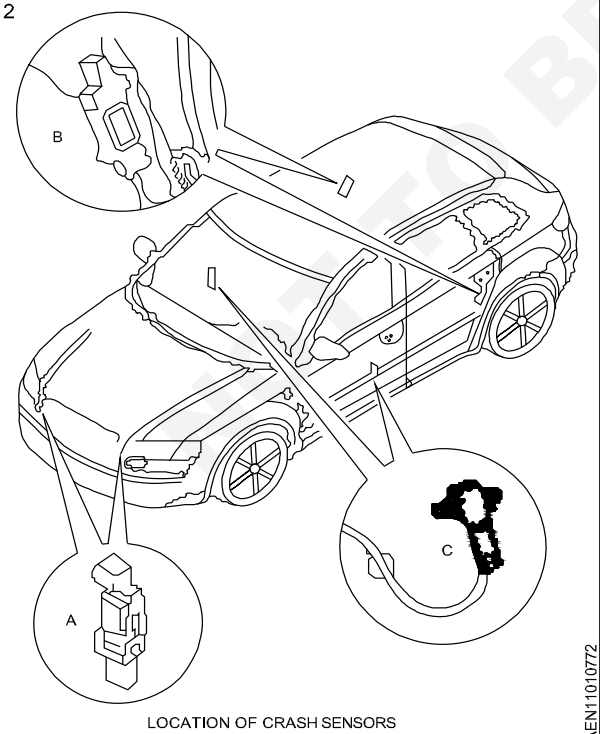
WORKING OF GLOBAL POSITIONING SYSTEM

A GPS receiver needs only three satellites to plot a rough, 2D position, which will not be very accurate. Ideally, four or more satellites are needed to plot a 3D position, which is much more accurate.

Crash sensor (Fig 2): Sensors are located behind the front bumper, headlights, dash and doorsill or 'B' pillar. Some manufacturers also place sensors with the electronic control unit.

Crash sensors can be fitted in various positions throughout the vehicle. Their location depends upon the direction of deceleration they are designed to detect. Some manufacturers place the sensors within the electronic control unit. Others are located behind the front pumper, headlights and dash.

Fig 2



LOCATION OF CRASH SENSORS

Side impact sensors are located in the doorsills or "B" pillar. They will inform the SRS control unit of side impact and whether to deploy the left or right side air bags.

When the sensors indicate that a predetermined deceleration rate has been exceeded and it is from the appropriate direction, the SRS control unit deploys the relevant air bags.

If the collision is from the front, the driver and passenger air bags will deploy. If the collision is from the side, the sensor determines whether the seat mounted air bag, or curtain air bags for one side of the vehicle will deploy.

With more refined designs, the passenger air bag deploys only if there is an occupant in the seat. Deployment can also depend on the weight of the occupant and whether the passenger air bag switch, if fitted, is turned on.

To prevent incorrect and unnecessary deployment, systems include a safing sensor mounted within the SRS control unit. The SRS control unit will only pass current through the squib if both the safing sensor and a crash sensor indicate simultaneously that a predetermined deceleration rate has been exceeded.

The SRS warning light is illuminated, and stays on, if a fault is detected in the system.

Capacitors within the SRS (Supplemental Restraint System) control unit are used to store electricity and act as a backup power supply. If a vehicle has its battery destroyed or disconnected in an accident, the capacitors supply the electricity required to keep the SRS system operational.

Some seat mounted side impact air bags also operate without electricity. When the side of a vehicle is crushed inwards, a detonator mounted on the lower outside edge of the seat is detonated. Pyrotechnic tubes connect the detonator to the air bags, which in turn ignite the squib. Many vehicles use two stage side impact bags. This provides protection to the upper chest over a more extended time.

Integrated communications (Fig 3): Modern vehicles

integrate audio, video and communication systems into a network.

Modern vehicles integrate audio, video and communication systems into a network. This allows for a high quality, compact and ergonomic system, which combines entertainment features with simple operation.

Controls are centralized with hardware, such as CD stackers, and DVD players located remotely.

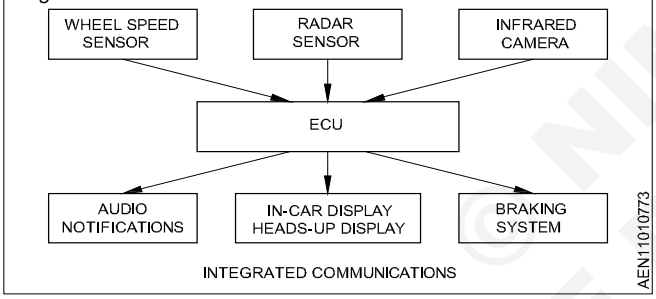
Communication between components uses a combination of hard wiring and data buses.

With data being used, audio messages can be broadcast over the audio system that relate to other vehicle systems. For example, a voice message can say "the park brake is on" or "left rear tire is under inflated".

The system allows for features such as the interruption or replacement of audio entertainment when there is an incoming phone call, or simply muting the audio to allows for safer driving.

The music played on a system usually comes from one of several sources. Magnetically on a cassette tape, optically on a CD or DVD, by radio frequency from radio stations or satellites, or from other portable devices.

Fig 3



INTEGRATED COMMUNICATIONS

The information is decoded or processed by the control unit and outputted to drive speakers located throughout the vehicle.

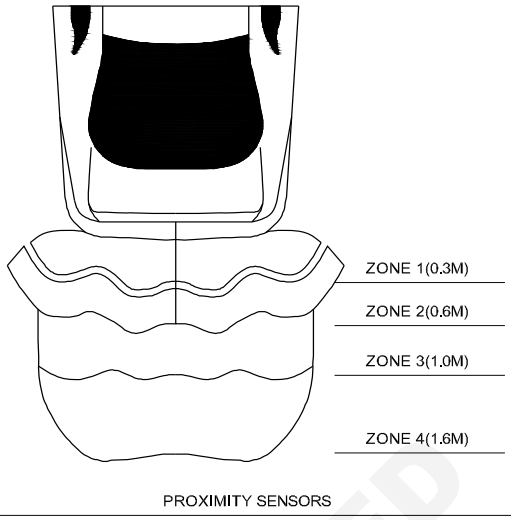
Another function provided by the body control unit is that of speed dependent volume. The control unit has an input from the vehicle speed sensor, which allows it to gradually increase audio system volume proportionally with road speed. As speed and therefore engine and road noise increases, the audio volume will increase. As speed decreases the audio volume will decrease.

Viewing screens for onboard TV, DVD and games can be located in the dash, however, if the screen is viewable by the driver it must disable when the vehicle is in motion. Other mounting points are from the roof or integrated into the rear of seat headrests. Control units can be hard wired, or wireless using an infrared remote control.

Proximity sensors (Figs 4 & 5): Proximity sensors are mounted in the front or rear bumpers. The control unit determines the distance between the sensor and an obstacle by measuring the time taken for sound waves to leave and return to the sensor.

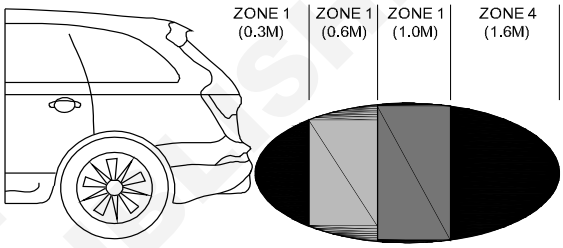
To allow for safer parking, proximity sensors can be mounted in the front or rear bumpers.

Fig 4



PROXIMITY SENSORS

Fig 5



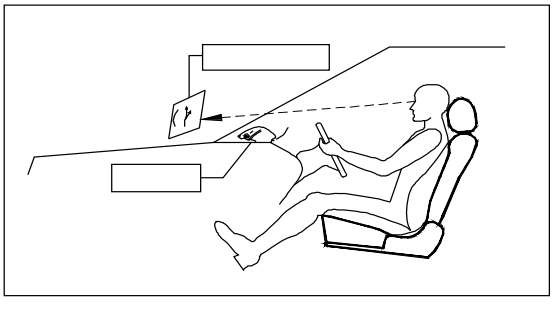
PROXIMITY SENSORS

These colour matched sensors emit ultrasonic sound waves that the human ear cannot detect. These piezo sensors are used to transmit and receive coded sound waves. The control unit determines the distance between the sensor and an obstacle by measuring the time taken for the sound wave to leave and return to the sensor. Normally 4 sensors are used to allow for full coverage across the width of the vehicle.

Proximity to obstacles can be indicated by separate audible and visual alarms, or by integrating warning sounds with the vehicles audio system. If a trailer is attached to a coupling, the rear sensors are disabled automatically when the harness plug is inserted. Front sensors can be disabled manually in start or stop and go traffic.

Reflective displays (Fig 6): Reflective displays use a mirror embedded in the dash so the instruments appear further away than they are actually.

Fig 6



REFLECTIVE DISPLAYS

This way the drivers focal point changes less when looking from the road to the instruments and back.

Conventional instrument panels require the driver to change the line of sight and their visual focal length to read information on the instrument cluster. This means the driver is looking away from the road for a significant distance when travelling at speed.

Reflective displays are mounted within the dash panel. They use a mirror embedded in the dash, forward of the driver, to reflect an image of the instrument cluster. The actual instruments are hidden in the dash and it is a reflected view of them that the driver sees.

This has the effect of the instruments appearing to be located further away than they actually are. The benefit of this system is that the drivers focal point changes less when looking from the road to the instruments and back.

Triangulation / trilateration

Trilateration or triangulation is the system whereby a vehicles location is determined by forming a triangle with a group of four or more satellites.

The Global Positioning System or GPS uses a group of at least 24 satellites orbiting approximately 12 600 miles or 20 200 kilometers above the earth. The vehicle is equipped with a receiving antenna and computer system. The GPS receiver on the vehicle has to locate four or more of these satellites, determine the distance to each, and use this information to establish its own location. This operation is based on a mathematical principle called "trilateration".

"Trilateration" in three dimensional space is quite complex. For ease of understanding, the term that is generally used in the automotive industry to describe how the GPS positioning system operates, is "Triangulation". "Triangulation" is the process of finding the position of an unknown point based on forming a triangle with two known points.

For simplicity, the dimensions used to determine these points are commonly known as latitude, longitude and elevation.

If a group of three satellites are taken to form a triangle, 12 600 miles or 20 200 kilometers above the earth, the shape and size of this triangle will never change.

Equally any fixed point on the surface of the earth will triangulate with the satellites. The numbers of fixed points are infinite.

What the GPS does to work, is form many triangles with triangulate with the satellites. The numbers of fixed points are infinite.

What the GPS does to work, is form many triangles with different pairs of satellites.

Each satellite has an atomic clock onboard and regularly transmits a unique radio frequency signal simultaneously with all other global positioning satellites. The RF signals travel out across space in all directions.

The speed at which RF signal travels in space is approximately 186,000 miles or 300,000 kilometers per second, the speed of light in a vacuum.

Each of these transmitted signals will reach the GPS antenna of the vehicle. The time taken for the RF signal to travel from each satellite and arrive at the vehicle is dependent on the distance each satellite is from the vehicle. The greater the distance the longer the time taken.

The vehicle's onboard GPs system needs to know three things to determine the location of the vehicle.

The time it takes for the signal to travel from the satellites to the vehicle.

The location of each satellite, and accurate time.

Given these facts, enough information is available to form a three dimensional figure of a pyramid with a triangle base.

The base of the pyramid is formed by the location of the satellites and the apex of the pyramid is the location of the vehicle on the earth, a point derived from triangulation of the known points of the base.

The GPS equipment knows that all of the apexes (the position of the GPS) of each triangle must be in the same literal position.

Telematics: Automotive telematics is a satellite based system that combines two way communication and information technology within the vehicle.

Using this system allows for: vehicle tracking, monitoring of onboard systems, messaging, travel information, entertainment, security, safety and fleet management systems which monitoring of onboard systems, messaging, travel information, entertainment, security, safety and fleet management systems which monitor information such as location, distance travelled, speed, stops and fuel usage.

A vehicle manufacturer may offer telematics as a service to its customers. The benefits of this can include: the location & immobilization of a stolen or lost vehicle, notification to emergency services after SRS deployment, engine shut down and door unlocking in the event of a severe accident, roadside assistance and remote diagnosis.

Car becomes a connected mode on the network

Network & multiplexing: A multiplex network reduces the number of wires in the wiring harness and greater vehicle content flexibility.

Even the most basic vehicles include many electronically controlled systems. If each electronic system had its own ECU, harness and sensors, the weight of the added components would negate any efficiency it provided. A vehicles multiple electronic systems could require over 1 mile or 1.6 kilometers of insulated wiring, consisting of around 1000 individual wires and many terminals.

One solution to the problem is the use of a system that integrates sensors into a common wiring harness by combining all the individual systems, where possible, into a multiplexed serial communications network, so they can share the information. An added advantage of such a

system is that if there is less wire and connections there is less chance of dirty connections causing faults.

This system is referred to as a controlled Area Network BUS or BUS and it uses two thin wires to connect, or multiplex, all the control units and their sensors to each other. The output devices are referred to as nodes.

The advantage of a multiplex network is that it enables a decreased number of dedicated wires for each function, and therefore a reduction the number of wires in the wiring harness, reduced system cost and weight, improved reliability, serviceability and installation.

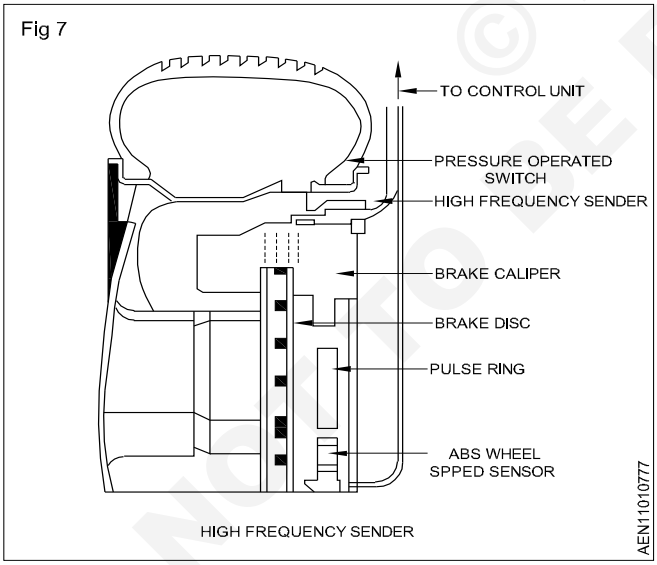
In addition, common sensor data such as vehicle speed engine temperature etc. are available on the network, so data can be shared, thus reducing the number of sensors. Also, networking allows greater vehicle content flexibility because functions can be added or modified through software changes.

Other control units can be added to the system by simply connecting them to the network.

A diagnostic tool can be connected to the CANBUS to extract operation information to assist in diagnosis and fault.

Tyre pressure warning: Poorly inflated tyre causes loss if control and increase fuel consumption. Fig 7 shows the layout and circuit of the tyre pressure warning system. The main idea is to give the driver warning of reduced pressure. There are three basic components used in the system. A pressure operated switch is mounted in the wheel rim, the contacts of which close when pressure falls.

Fig 7



This is recognized by a high frequency pulse transmits an appropriate pulse to the electronic evaluator. When the pressure drops below the set valve, the switch contacts close. This causes the high frequency pulse to interrupt its stream of pulses to the evaluation circuit so that the warning lamp lights up. The system measures the tyre pressure with an accuracy of ± 5kPa. The design of the switch is such that changes in the temperature of the air in the tyre do not cause false readings. If a tyre pressure warning system is used in conjunction with wheels fitted with limp home tyres.

Controller area network (CAN bus): CAN bus is a robust vehicle bus standard designed to allow micro controllers and devices to communicate with each other's applications without a host computer. It is a message based protocol, designed originally for multiplex electrical weiring with in automobiles to save on copper, but can also be used in many other contexts for each device the data in a frame is transmitted sequentially but in such a way that more than one device transmits at the same time the highest priority device is able to continue while the other back off. Frames are received by all devices, including by the transmitting device.

(Local interconnect network): LIN is a serial network protocol used for communication between components in vehicles the need for a cheap serial network arose as the technologies and the facilities implemented in the car grew, while the CAN bus was too expensive to implement for every component in the car LIN may be used also over the vehicle battery power line with a special LIN over DC power line (DC. LIN) transceiver.

CAN in automation has been appointed by the ISO technical management board as the registration authority for the LIN supplier ID standardized in ISO 17987 series

LIN advantages

- Easy to use
- Components available
- Cheaper than CAN and other communication buses
- Harness reduction
- More reliable vehicles
- Extension easy to network implements
- No protocol license fee required.
- It is used within subsystems that are not erotised to vehicle performance or safety.

MOST Network (Media oriented systems transport): It is a high speed multimedia network technology optimized by the automotive industry. It can be used for applications inside or outside the car.

Most is a serial communication system for transmitting audio, video and control data via fibre-optic cables this multi functional high performance multimedia network technology based on synchronous data communication requires professional software tools and hardware interfaces.

Flex ray: Flex ray is an automotive network communication protocol developed by the flex ray consortium to govern on-band automotive computing it is designed to be faster and more reliable than CAN and TTP but it is also more expensive flex ray is used is particular for data communication technology in very safety-critical use areas in the automobile.

Impotence of electrical and electronic vehicle architecture: It helps to improve vehicle performance, safety and reliability and at the same time reduces vehicle weight thus resulting in lower system costs, it also helps to develop an automotive system architecture requires a series of steps, all influencing each other. Continental can offer the realization of every steps with complete traceability while fulfilling automotive standards.