MECHANIC TRACTOR

NSQF LEVEL - 3

TRADE THEORY

SECTOR: AUTOMOTIVE

(As per revised syllabus July 2022 - 1200 Hrs)

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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

Sector : Automotive

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Post Box No.3142
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INDIA
Email: chennai-nimi@nic.in
Website: www.nimi.gov.in

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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 Media Development Committee members of various stakeholders 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 Tractor - Trade Theory NSQF Level - 3 (Revised 2022)** in **Automotive Sector under Yearly 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 Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

SHRI. ATUL KUMAR TIWARI., I.A.S.,
Director General/ Spl. Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

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 Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of Federal Republic of Germany. The prime objective of this Institute is to develop and provide instructional materials for various trades as per the prescribed syllabi under the Craftsman and Apprenticeship Training Schemes.

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

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

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

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

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

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

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 organisation to bring out this IMP **(Trade Theory)** for the trade of **Mechanic Tractor** under the **Automotive** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

Shri. P.N. Sivakumar Rav	-	Asst. Training Officer, Govt. I.T.I, Chengalpattu.
Shri. A. Muthuvel	-	Junior Training Officer, Govt. I.T.I, Nagapattinam.
Shri. N. Bharath Kumar	-	Junior Training Officer, Govt. I.T.I, Ulundurpet.
Ms. G. Pavithra	-	Junior Training Officer, Govt. I.T.I, Sankarapuram.
Shri. A. Thangavelu	-	Asst. Training Officer (Retd.,), Govt. I.T.I, Chennai..

NIMI - CO-ORDINATORS

Shri. Nirmalya Nath	-	Deputy Director NIMI - Chennai - 32
Shri. S. Gopalakrishnan	-	Assistant Manager, NIMI, Chennai - 32

NIMI records its appreciation of 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 staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in workshop . It consists of a series of practical exercises to be completed by the trainees during the course of the **Mechanic Tractor** 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

This manual is divided into ten modules. The ten modules are given below

Module 1	**Safety Workshop Practice**
Module 2	**Measuring and Marking**
Module 3	**Fastening and Fittings**
Module 4	**Basic Electrical and Electronics**
Module 5	**Manufacturing Hydraulics and Pneumatics Components**
Module 6	**Engine and Engine Components**
Module 7	**Cooling and Lubricating System**
Module 8	**Intake of exhaust and fuel system**
Module 9	**Transmission and Control System**
Module 10	**Agricultural Implements & Charging and Starting 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 Tractor** Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theortical aspects with the skill covered in each exercise to the extent possible. This co-relation 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 indicating about the corresponding practical exercise 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 the purpose of self learning and should be considered as supplementary to class room instruction.

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CONTENTS

LEARNING OUTCOME

On completion of this book you shall be able to

S.No.	Learning Outcome	Ref. Ex.No.
1	Make choices to carry out marking of the components for basic fitting operations in the workshop following safety precautions	1.1.01 - 1.2.09
2	Perform precision measurements on the components in automotive workshop practices.	1.2.10
3	Use different types of fastening and locking devices in a vehicle.	1.3.11 - 1.3.12
4	Use cutting tools in the workshop, following safety precautions while grinding	1.3.13 - 1.3.14
5	Use different types of tools and workshop equipment in the workshop	1.3.15
6	Perform basic fitting operations used in the workshop practices and inspection of dimensions	1.3.16 - 1.3.18
7	Produce sheet metal components using various sheet metal operations	1.3.19
8	Construct electrical circuits and test its parameters by using electrical measuring instruments.	1.4.20
9	Perform basic electrical testing in a vehicle	1.4.21
10	Perform battery Testing and charging operations	1.4.22 - 1.4.23
11	Construct basic electronic circuits and testing	1.4.24
12	Manufacture components with different types of welding processes in the given job	1.5.25
13	Identify the Hydraulic and pneumatic components in a vehicle	1.5.26 - 1.5.30
14	Demonstrate Major Assemblies of different types of Tractor	1.6.31 - 1.6.34
15	Overhaul Diesel Engine of Tractor	1.6.35 - 1.4.49
16	Perform servicing of Cooling and Lubrication system of Tractor in a workshop	1.7.50 - 1.7.56
17	Service Intake and Exhaust System of Tractor in a workshop	1.8.57 - 1.8.61
18	Service Fuel Feed System of Tractor in a workshop	1.8.62 - 1.8.69
19	Overhaul Clutch and Gearbox of Tractor in a workshop	1.9.70 - 1.9.76
20	Overhaul Differential and PTO Unit of Tractor in the workshop	1.9.77 - 1.9.79
21	Overhaul Steering System of Tractor in the workshop	1.9.80 - 1.9.87
22	Carryout Repair of Wheels and Tyres of Tractor in the Workshop	1.9.88 - 1.9.93
23	Overhaul Brake system of Tractor in the workshop	1.9.94 - 1.9.101
24	Overhaul Major Assemblies of Power Tiller and carryout Field Operation	1.10.102 - 1.10.103
25	Overhaul Implements of Tractor	1.10.104 - 1.10.106
26	Overhaul Charging and Starting System of Tractor	1.10.107 - 1.10.109

SYLLABUS FOR MECHANIC TRACTOR

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
Professional Skill 76 Hrs.; Professional Knowledge 12 Hrs.	Make choices to carry out marking of the components for basic fitting operations in the workshop following safety precautions.	1 Familiarization with institute, Job opportunities in the automobile sector, Machinery used in Trade. (07hrs.) 2 Types of work done by the students in the shop floor. (08hrs.) 3 Practical related to Safety and Health, Importance of Maintenance and cleanliness of Workshop. (03hrs.) 4 Interaction with health centre and fire service station to provide demo on First aid and Fire safety, Use of fire extinguishers. (02hrs.) 5 Demonstration on safe handling and Periodic testing of lifting equipment, and Safety disposal of used engine oil. (02hrs.)	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 timetable. 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. Safety disposal of Used engine oil, Electrical safety tips. (04 Hrs.)
		6 Practice using all marking aids, like steel rule with spring calipers, dividers, scriber, punches, Chisel etc. (11 hrs.) 7 Layout a work piece- for line, circle, arcs and circles. (10 hrs.) 8 Practice to measure a wheelbase of a vehicle with measuring tape. (10 hrs.) 9 Practice to measure valve spring tension using spring tension tester Practice to remove wheel lug nuts with use of an air impact wrench Practice on General workshop tools & power tools. (23 hrs.)	**Hand & Power Tools: -** Marking scheme, Marking material- chalk, Prussian blue. Cleaning tools- Scraper, wire brush, Emery paper, Description, care and use of Surface plates, steel rule, measuring tape, try square. Calipers-inside and outside. Dividers, surface gauges, scriber, punches-prick punch, center punch, pin punch, hollow punch, number and letter punch.Chisel-flat, crosscut. Hammer-ball peen, 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, Nippers or pincer pliers, Side cutters, Tin snips, Circlip pliers, external circlips pliers. Air impact wrench, air ratchet, wrenches- Torque wrenches, pipe wrenches, car jet washers Pipe flaring &cutting tool, pullers-Gear and bearing. (08 hrs.)

Professional Skill 56 Hrs.; Professional Knowledge 15 Hrs.	Perform precision measurements on the components in automotive workshop practices.	10 Practice on measuring the various components using precision instruments Vernier Caliper, Micrometer, Dial Bore Gauge, Telescopic Gauge, Feeler Gauge, Pressure Gauge, Dial Test Indicator by given Job. (56hrs)	**Systems of measurement,** Description, care & use of - Micrometers- Outside and depth micrometer, Micrometer adjustments, Vernier calipers, Telescope gauges, Dial bore gauges, Dial indicators, straightedge, feeler gauge, thread pitch gauge, vacuum gauge, tire pressure gauge.(15 hrs.)
Professional Skill14 Hrs.; Professional Knowledge 05 Hrs.	Use different types of fastening and locking devices in a vehicle.	11 Practice on General cleaning, checking and use of nut, bolts, & studs etc. (7 hrs.) 12 Removal of stud/bolt from blind hole. (7 hrs.)	**Fasteners-** Study of different types of screws, nuts, studs & bolts, locking devices, Such as lock nuts, cotter, split pins, keys, circlips, lock rings, lock washers and locating where they are used. Washers & chemical compounds can be used to help secure these fasteners. Function of Gaskets, Selection of materials for gaskets and packing, oil seals. (05Hrs.)
Professional Skill 14 Hrs.; Professional Knowledge 05 Hrs.	Use cutting tools in the workshop, following safety precautions while grinding.	13 Practice on cutting tools like Hacksaw, file, chisel, Sharpening of Chisels, center punch, safety precautions while grinding. (7 hrs.) 14 Practice on Hacksawing and filing to given dimensions. (7 hrs.)	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. (05Hrs.)
Professional Skill 14 Hrs.; Professional Knowledge 05 Hrs.	Use different types of tools and workshop equipment in the workshop.	15 Practice on Marking and Drilling clear and Blind Holes, Sharpening of Twist Drills Safety precautions to be observed while using a drilling machine. (14 hrs.)	Limits, Fits & Tolerances: - Definition of limits, fits & tolerances with examples used in auto components. Drilling machine - Description and study of Bench type Drilling machine, Portable electrical Drilling machine, drill holding devices, Work Holding devices, Drill bits. (05 Hrs.)
Professional Skill 14 Hrs.; Professional Knowledge 05 Hrs.	Perform basic fitting operations used in the workshop practices and inspection of dimensions.	16 Practice on Tapping a Clear and Blind Hole, Selection of tape drill Size, use of Lubrication, Use of stud extractor. (6 hrs.) 17 Cutting Threads on a Bolt/ Stud. (2 hrs.) 18 Adjustment of two - piece Die, reaming a hole/ Bush to suit the given pin/ shaft, scraping a given machined surface. (6 hrs.)	**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. (05 Hrs.)
Professional Skill 7 Hrs.; Professional Knowledge 01 Hrs.	Produce sheet metal components using various sheet metal operations.	19 Brazing of Pipes. (7 hrs.)	Brazing fluxes used on common joints. (1 hrs.)
Professional Skill 14 Hrs.; Professional Knowledge 03 Hrs.	Construct electrical circuits and test its parameters by using electrical measuring instruments.	20 Practice in joining wires using soldering Iron, Construction of simple electrical circuits, measuring of current, voltage and resistance using digital multimeter, practice continuity test for fuses, jumper wires, fusible links, circuit breakers. (14hrs.)	**Basic electricity,** Ground connections, Mulitmeter, Conductors & insulators, Wires, Shielding, Length vs. resistance, Resistor ratings. (03 Hrs.)

Professional Skill 14 Hrs.; Professional Knowledge 03 Hrs.	Perform basic electrical testing in a vehicle.	21 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 Troubles hooting. (14 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. (03Hrs.)
Professional Skill 28 Hrs.; Professional Knowledge 03 Hrs.	Perform battery Testing and charging operations.	22 Cleaning and topping up of a lead acid battery, Testing battery with hydrometer, connecting battery to a charger for battery charging, Inspecting & testing a battery after charging, Measure and Diagnose the cause(s) of excessive Key-off battery drain (parasitic draw) and do corrective action. (16 hrs.) 23 Testing of relay and solenoids and its circuit. (12 hrs.)	Description of Batteries & cells, Lead acid batteries & Stay Maintenance Free (SMF) batteries, Thermisters, Thermo couples, Relays, Solenoids, Charging system circuit (03Hrs.)
Professional Skill 14 Hrs.; Professional Knowledge 05 Hrs.	Construct basic electronic circuits and testing.	24 Identify and test power and signal connectors for continuity, Identify and test different type of Diodes, NPN & PNP Transistors for its functionality, Construct and test simple logic circuits OR, AND & NOT and Logic gates using switches. (14 hrs.)	**Basic electronics:** Description of Semiconductors, Solid state devices-Diodes, Transistors, Thyristors, Uni Junction Transistors (UJT), Metal Oxide Field Effect Transistors (MOSFETs), Logic gates-OR, AND & NOT and Logic gates using switches. (05Hrs.)
Professional Skill 14 Hrs.; Professional Knowledge 3 Hrs.	Manufacture components with different types of welding processes in the given job.	25 Setting of Gas welding flames, practice to make a straight beads and joints Oxy- Acetylene welding (14 hrs.)	**Introduction to welding and Heat Treatment Welding processes** - Oxy - Acetylene welding principles, equipment, welding parameters, edge preparation & fit up and welding techniques. (3 Hrs.)
Professional Skill 56 Hrs.; Professional Knowledge 6 Hrs.	Identify the Hydraulic and pneumatic components in a vehicle.	26 Identification of Hydraulic components used in vehicle. (13 hrs.) 27 Tracing of hydraulic circuit on hydraulic jack, hydraulic power steering, and Brake circuit. (15 hrs.). 28 Identification of different type of Vehicle. (6 hrs.) 29 Demonstration of vehicle specification data; Identification of vehicle information Number (VIN). (11 hrs.) 30 Demonstration of Garage, Service station equipments. Vehicle hoists - Two post and four post hoist, Engine hoists, Jacks, Stands. (11 hrs.)	**Introduction to Hydraulics & Pneumatics: -** Definition of Pascal law, pressure, Force, viscosity. Description, symbols and application in automobile of Gear Pump-Internal & External, single acting, double acting & Double ended cylinder; Directional control valves-2/2, 3/2, 4/2, 4/3 way valve, Pressure relief valve, Non return valve, Flow control valve used in automobile. (03 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. (03 Hrs.)
Professional Skill 56 Hrs.; Professional Knowledge 6 Hrs.	Demonstrate Major Assemblies of different types of Tractor.	31 Demonstration of tractor specification data. (5 hrs.) 32 Identification of different major assemblies of tractor and cleaning of tractors, oil greasing and lubricating all moving parts of tractor. (12 hrs.) 33 Practice on starting and stopping of tractor engine. (12 hrs.)	Tractor Industry in India - leading manufacturers, development in Tractor industry, trends, new product. Study of tractors, Different type of Tractor starting method and stopping. (01 Hrs.)
		34 Dismantling of tractor engine as per procedure & Inspection of components for dimension and wear. (27 hrs.)	**Engine Basics:** Classification of engines, **Principle & working of 2 &4-Stroke diesel engine (Compression ignition Engine (C.I),** Principle of Spark Ignition Engine(SI), differentiate between 2-stroke and 4-stroke, C.I engine and S.I Engine, Direct injection and Indirect injection. Brief on common rail diesel injection engine. **Engine output, compression pressure,** Compression ratio. (05 Hrs.)
Professional Skill 77Hrs.; Professional Knowledge 16 Hrs.	Overhaul Diesel Engine of Tractor.	35 Remove cylinder head from engine. (5 hrs.) 36 Overhauling of cylinder head assembly with use of service manual for clearance and other parameters. (11 hrs.) 37 Practice on removing rocker arm assembly manifolds, fitting of valve guide. (11 hrs.)	**Engine Components -** working principle & construction of cylinder heads, types of combustion chambers. Function of Engine Valves, different types, materials, Type of valve operating mechanism. Importance of Valve seats & inserts, importance of Valve movement, Valve stem, oil seals, Valve-timing diagram and concept of Variable valve timing. (04 Hrs.)
		38 Cylinder block overhaul. (5 hrs.) 39 Measurement of cylinder liner & crankshaft for ovality and taperness. (5 hrs.) 40 Overhauling piston and connecting rod assembly with use of service manual for clearance and other parameters. (10 hrs.) 41 Practice on removing oil sump and oil pump - clean the sump. (5 hrs.)	**Description of Cylinder block, Cylinder block construction,** types of cylinder blocks & cylinder liners. Description & functions of different types of pistons, piston rings and piston pins and materials. Used recommended clearances for the rings and its necessity precautions while fitting rings, common troubles and remedy. (06 Hrs.)
		42 Practice on removing the big end bearing, connecting rod with the piston. (2hrs.) 43 Practice on removing the piston rings, Dismantle the piston and connecting rod. (5hrs.) 44 Check the side clearance of piston rings in the piston groove & lands for wear. (3hrs.) 45 Check piston skirt and crown for damage and scuffing, clean oil holes.	Description & function of connecting rod, importance of big end split obliquely, Materials used for connecting rods big end & main bearings. Shells piston pins and locking methods of piston pins. Recommended clearances for the cylinder liners & rings. Bearing failure & its causes- care & maintenance. Description of crankshaft & Camshafts. Types of their drives. Description of Overhead camshaft, importance of Cam lobes. Crankcase venti-

		Measure -the piston ring close gap in the cylinder, clearance between the piston and the liner, clearance between crank pin and the connecting rod big end bearing. (2hrs.) 46 Check connecting rod for bend and twist. (3hrs.) 47 Setting of Connecting rod big end & main bearing. (2hrs.) 48 Assembling crank shaft, main bearings, connecting rods and piston assembly in the engine, fitting cylinder head. (5hrs.) 49 Setting valve timing. (3hrs.)	lation (PCV). Camshaft, Crank-shaft balancing, Firing order of the engine. Description and function of the fly wheel and vibration damper. Timing mark. (06 Hrs.)
Professional Skill 56 Hrs.; Professional Knowledge 6 Hrs.	Perform servicing of Cooling and Lubrication system of Tractor in a workshop.	50 Checking cooling system for overheating under-cooling. (6 hrs.) 51 Dismantling, cleaning, assembling & testing of water pumps, reverse flushing the system. (11 hrs.) 52 Checking of thermostat valve, pressure cap. (6 hrs.) 53 Adjusting the fan belt tension. (5 hrs.) 54 Identification of lubrication oil flow circuit in an engine. (6 hrs.) 55 Overhauling oil pump, servicing of oil cooler & centrifugal oil filter. (11 hrs.) 56 Testing oil pressure. (11 hrs.)	**Cooling systems:-**Purpose, types, Heat transfer method, effect of boiling point & pressure, coolant properties, preparation and recommended change of interval, use of anti-freezer. **Cooling system components,** water pump, function of thermostat, pressure cap, Recovery system & Thermo-switch. Function & types of Radiator. (03 Hrs.) **Lubrication system: -** purposes & characteristics of oil, type of lubricants, grade as per SAE, & their application, oil additives, type of lubrication system. Lubrication system components- different type of Oil pump, Oil filters & oil cooler. Probable reasons for low / high oil pressure, high oil consumption and their remedies. (03 Hrs.)
Professional Skill 28 Hrs.; Professional Knowledge 04 Hrs.	Service Intake and Exhaust System of Tractor in a workshop.	57 Servicing of air cleaner (Oil bath) Checking & changing an air filter. (5 hrs.) 58 Dismantling & assembling of turbo charger, check for axial clearance as per service manual. (6 hrs.) 59 Checking of Exhaust Gas Recirculation. (5 hrs.) 60 Check Exhaust system for rubber mounting for damage, deterioration and out of position; for leakage, loose connection, dent and damage; Practice on Exhaust manifold removal and installation. (6 hrs.) 61 Practice on Catalytic converter removal and installation. (6 hrs.)	**Intake & exhaust systems -** Description of Diesel induction & Exhaust systems. Description & function of air compressor, Super charger, Intercoolers, turbo charger, variable turbo charger mechanism. **Intake system components-** Description and function of Air cleaners, Different type air cleaner, Description **of** Intake manifolds and material. **Exhaust system components-** Description and function of Exhaust manifold, Exhaust pipe, Mufflers- Reactive, absorptive, Combination, Electronic mufflers, Catalytic converters, Backpressure, Diesel particulate filter, Exhaust Gas Recirculation (EGR). (04Hrs.)

Professional Skill 56 Hrs.; Professional Knowledge 7 Hrs.	Service Fuel Feed System of Tractor in a workshop.	62 Practice in engine tune up in a vehicle -testing vacuum and compression of engine, (6 hrs.) 63 Tracing of different parts of fuel system. (5 hrs.) 64 Repairing fuel leaks in pipe line and unions, Servicing and testing of fuel feed pump. Servicing of fuel filters. Servicing of fuel Injection Pump. (8 hrs.) 65 Servicing of pressure pump of (C.R.D.I.). (7 hrs.) 66 Regulator's and Elect/Electronic injectors, checking operation of C.R.D.I. system. Overhauling & testing of injectors. (8 hrs.) 67 Setting injection timing. Bleeding fuel lines for Air locks. (8 hrs.) 68 Testing cylinder compression, checking idle speed, Obtaining & interpreting scan tool data. (7 hrs.) 69 Fault finding & remedy, care & maintenance. (7 hrs.)	Diesel fuel characteristics, concept of Quiet diesel technology & Clean diesel technology, Fuel feed system used in Tractor's description and layout. Diesel fuel system components, Description and function of Diesel fuel injection system, types of fuel injection pumps, type of drive, injectors-types and function. Governor and their types. Distributor-type injection pump, Glow plugs, Cummins & Detroit Diesel injection. Diesel electronic control- Diesel electronic control systems (DEC), Common rail diesel injection System. Method of bleeding fuel supply system. (7 hrs.)
Professional Skill 28 Hrs.; Professional Knowledge 05 Hrs.	Overhaul Clutch and Gearbox of Tractor in a workshop.	70 Dismantle clutch assembly. (4 hrs.) 71 Inspect the parts of clutch. (2 hrs.) 72 Relining of clutch plate & assemble. (3 hrs.) 73 Coupling the clutch with flywheel & join the engine with gear box. (5 hrs.) 74 Adjust clutch pedal free play. Dismantle gear box of a tractor & inspect the parts. (5 hrs.) 75 Assemble the gear box. (5 hrs.) 76 Overhauling Transfer case and auxiliary gear box. (4 hrs.)	**Clutch:-**types, construction and function. Components of clutch -driver & driven plates, torsion spring, cushion springs, operating fingers, clutch shaft, Slave cylinder & oil seal. Clutch release bearing & linkages. **Manual transmissions-** Function, description, types and their application. Gearbox layout. Components of tractor gear box. Principle of epicyclical gear box. Necessity of torque convertor, need of 4 x 4 wheel drive / Front wheel drive, Low & high gear ratio, universal joint and propeller shaft. (05 Hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 07 Hrs.	Overhaul Differential and PTO Unit of Tractor in the workshop.	77 Overhauling of differential. (6 hrs.) 78 Servicing of reduction gear, rear axle wheel hub. (11 hrs.) 79 Servicing of PTO (Power Take Off). Measure rpm of PTO shaft & speed of belt pulley. (11 hrs.)	**Final Drive & Drive Shafts** Differential carriers double reduction gearing, differential lock, crown wheel and pinion adjustments, function and types of power take off (PTO) mechanism. Types of front & rear axles. Common trouble and their remedies, care and maintenance. (05 Hrs.)
Professional Skill 56 Hrs.; Professional Knowledge 9 Hrs.	Overhaul Steering System of Tractor in the workshop.	80 Checking, Layout of Mechanical steering system. Checking/ Inspection of Steering linkage and necessary repair. (6 hrs.) 81 Remove steering wheel. Overhauling of steering gear box of tractor. (5 hrs.)	**Steering Systems-** Function and types of steering system. Description, construction and function of mechanical steering system steering wheel, steering gear box, tie-rod, arms link, ball and socket joints etc. their movement and adjustment. Description and mechanism of foot steerage pedal as incorporated in tractors.

		82 Remove front axle and spindle hub and steering linkage. (6 hrs.) 83 Reassembling steering assembly and Test for correct function. (6 hrs.) 84 Checking, inspect layout of different parts of Hydraulic steering system. (11 hrs.) 85 Practice on visual Inspection of chassis frame for crack, bent and twists. (6 hrs.) 86 Overhauling and Inspection of shackle, front & rear suspension. (10 hrs.) 87 Lubricating a suspension system. (5 hrs.)	Description, working and principle of hydraulic steering system. Different parts such as pump, distributor valves, pipe line and hoses etc Development of mechanical framing. Use of Power tiller, Tractor & Bulldozer, Chassis frame of tractor. (9 hrs.)
Professional Skill 28 Hrs.; Professional Knowledge 05 Hrs.	Carryout Repair of Wheels and Tyres of Tractor in the Workshop.	88 Remove wheels from tractor. (4 hrs.) 89 Dismantle wheel for checking rims, tyres for wear and tubes for leaks. (6 hrs.) 90 Repairing, de-rusting, painting. (5 hrs.) 91 Fitting of tyres and tubes on rim & inflate to correct pressure. (5 hrs.) 92 Balancing of Tractor wheels. Practice of tyre rotation. Fitting wheels on tractors. Tightening of wheel in correct sequence. (5 hrs.) 93 Checking & adjusting tire pressure by use of air or by Nitrogen. (4 hrs.)	**Wheels & Tyres-** Description, construction and function of Wheel. Rim sizes. Types & sizes of tyres. Solid, pneumatic & Radial. Ply rating. Tyre materials, Hysteresis & designations, Tyre information, Tyre tread designs, Tyre ratings for temperature & traction. Importance of in-Flatting tyres to correct pressure. Repair and maintenance of tyres and tubes. Storage of tyres. Descriptions Tire wear Patterns and causes Nitrogen vs atmospheric air in tyres. (05Hrs.)
Professional Skill 28 Hrs.; Professional Knowledge 9 Hrs.	Overhaul Brake system of Tractor in the workshop.	94 Overhauling brakes including cleaning and inspection of all components, relining shoes, setting and actuating shoe clearance. (6 hrs.) 95 Inspection spring of both shoe and lever. (5 hrs.) 96 Inspecting and setting parking brakes. (5 hrs.) 97 Inspecting and setting hydraulic main brake including replacement of washer and oil seals. (4 hrs.) 98 Overhauling serve mechanism (as applicable) inspecting piston and valves. (2 hrs.) 99 Bleeding and adjustment of brakes. (2 hrs.) 100 Fault tracing and remedy. (2 hrs.) 101 Skimming of brake drum and disc plate. (2 hrs.)	**Braking Systems -** Braking fundamentals Principles of braking, Drum & disc brakes, Lever/mechanical advantage, Hydraulic pressure & force, Brake fade. **Braking systems -** Brake type used on tractor -principles, Air brakes, **Braking system components-** Park brake system, Brake pedal, Brake lines, Brake fluid, Bleeding, Master cylinder, Divided systems, Tandem master cylinder, Power booster or brake unit, Hydraulic brake booster, Applying brakes, Brake force, Brake light switch Drum brakes & components - Drum brake system, Drum brake operation, Brake linings & shoes, Backing plate, Wheel cylinders Disc brakes & components-Disc brake system, Disc brake operation, Disc brake rotors, Disc brake pads, Disc brake calipers, Proportioning valves, Proportioning valve operation, Brake friction materials. (9hrs.)

Professional Skill 21 Hrs.; Professional Knowledge 04 Hrs.	Overhaul Major Assemblies of Power Tiller and carryout Field Operation.	102 Overhauling power tiller transmission system includes main clutches, steering clutch/brakes mechanism-gear box and wheel hub testing for field operation without implements and with implements. (13 hrs.) 103 Driving practice with trolley/trailer. (8 hrs.)	Description, working principle & use of power tiller (two wheel tractor) power unit. Method of power transmission to wheel from engine. Main clutch assembling working procedure steering Clutch/ brakes mechanism method of power transmission to implement (Rotation), irrigation pump, thresher. Hitching of M.B. Plough, trailer disc harrow. (04 Hrs.)
Professional Skill 15 Hrs.; Professional Knowledge 07 Hrs.	Overhaul Implements of Tractor.	104 Checking implements such as ploughs, harrows, cultivators, seed drills, tractor trailer, & P.T.O. units etc. for serviceability before use. (5 hrs.) 105 Lubricate them as required. Hitching practice (single & three points). (5 hrs.) 106 Exercise in driving a tractor with different implements. (5 hrs.)	**Tractor equipment:-** Description, function of harrows, cultivators, seed drills & tractor trailer. Hitching of equipment. Danger in overloading & incorrect field operation. Average life of Agriculture implements. Description and function of tractor accessories such as Draw bar, top link & Belly Pulley. Setting of draw bar to correct height. Use of Hydraulic lift. Maintenance of tractor accessories.(07Hrs.)
Professional Skill 28 Hrs.; Professional Knowledge 05 Hrs.	Overhaul Charging and Starting System of Tractor.	107 Practice on removing alternator from vehicle dismantling, cleaning checking for defects, assembling and testing for motoring action of alternator & fitting to vehicles. (11 hrs.) 108 Practice on removing starter motor vehicle and overhauling the starter motor, testing of starter motor. (11 hrs.) 109 Servicing storage batteries, tracing lighting circuit fault rectification. (6 hrs.)	**Tractor Electrical Maintenance:** Lighting arrangement in tractors (As applicable). Description of charging circuit. Operation of alternator, regulator unit ignition warning lamp troubles and remedy in charging system. Fault finding in electrical system. Description of starter motor circuit, common troubles and remedy in starter circuit. Description of lighting circuit. Charging & discharging of lead acid battery.(05Hrs.)

Organization of ITI's and scope of the Mechanic Tractor

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 OMR answer sheet pattern and multiple choice type questions. After passing, National trade certificates (NTC), will be issued by DGT which is authorized and recognized internationally.

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 Tractor

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

Scope of the Mechanic Tractor training: Mechanic Tractor 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 an instructor in ITIs

Job Opportunities

- Mechanic Tractor 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 avoid polluting the environment.

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

Always attend the institute well dressed and good physical appearance.

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

Prepare well before writing a test/examination.

Avoid any malpractice during the test/examination.

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

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

Time-table

Practical and theory class hours are schedulated in advance and working hours is generally 8 hrs included lunch hours. There are two shifts are provided fro training in the I.T.I generally 1st shift working hours 7.30am to 4.00pm and 2nd shift working hrs 9.00am to 5.30pm

Course Content in the syllabus

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

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

Facilities in I.T.I

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

Occupational health and safety

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

Safety

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

Occupational health and safety

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

Need of occupational health and safety

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

Occupational (Industrial) Hygiene

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

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

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

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

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

Occupational Hazards

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

Types of occupational health hazards

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

1 Physical Hazards

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

2 Chemical Hazards

- Inflammable
- Explosive
- Toxic
- Corrosive
- Radioactive

3 Biological Hazards

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

4 Physiological

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

5 Psychological

- Wrong attitude
- Smoking
- Alcoholism
- Unskilled
- Poor discipline
  - 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 the work, by training the people and engaging skilled and competent workers, maintaining plant and equipment, and checking, inspecting and keeping records- all of this contributes to the safety in the workplace.

The employer will be responsible for the equipment provided, 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 and use the experience of your training, and your general attitude to safety work.

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

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

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

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

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

- prohibition signs
- mandatory signs
- warning signs
- information signs

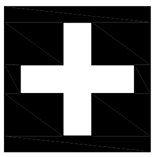
Prohibition signs

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

Mandatory signs

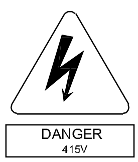
Shape Circular.
Colour White symbol on blue background.
Meaning Shows what must be done.
Example Wear hand protection.

Warning signs



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

Information signs



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

Prohibition signs (Fig 2)

Fig 2

Mandatory signs (Fig 3)

Fig 3

MANDATORY 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?

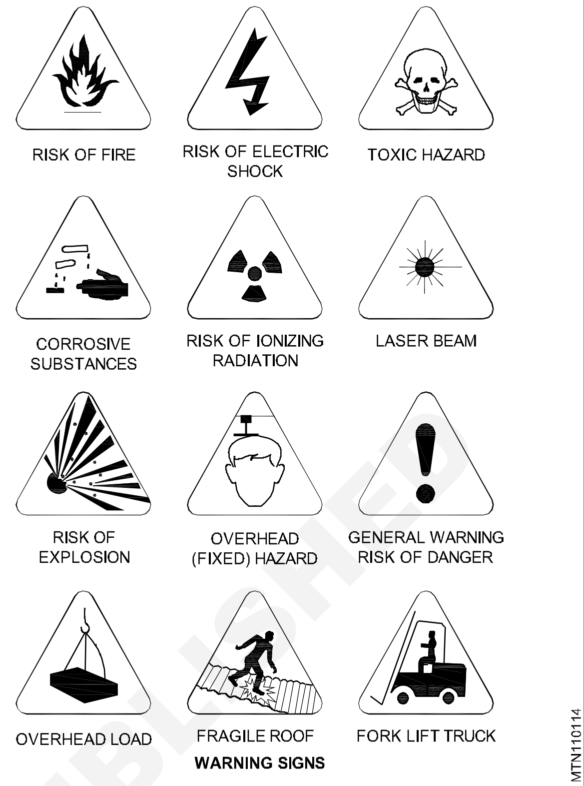
Are the plant, machinery and tools that you use really safe? Do you know how to use them safely and keep them in a safe condition?

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?

Warning signs (Fig 4)

Fig 4



WARNING SIGNS

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

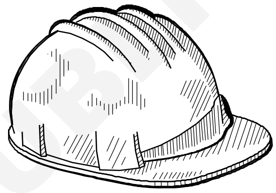


Fig 2

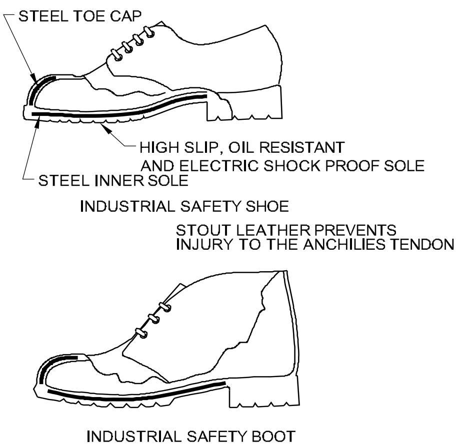
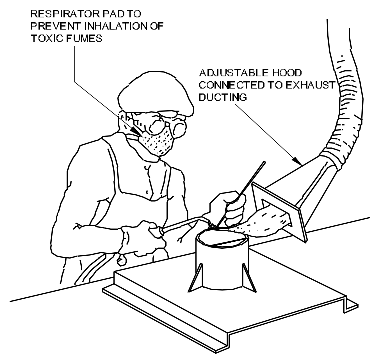


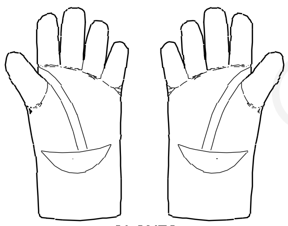
Fig 3



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

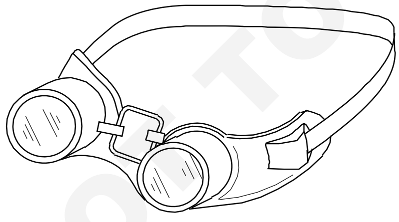
Types of protection	Hazards	PPE to be used
Head protection (Fig 1)	1. Falling objects 2. Striking against objects 3. Spatter	Helmets
Foot protection (Fig 2)	1. Hot spatter 2. Falling objects 3. Working wet area	Leather leg guards Safety shoes Gum boots
Nose (Fig 3)	1. Dust particles 2. Fumes/ gases/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

Fig 4



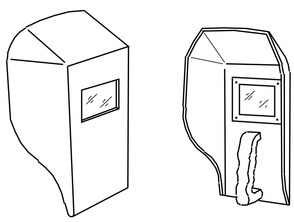
GLOVES

Fig 5



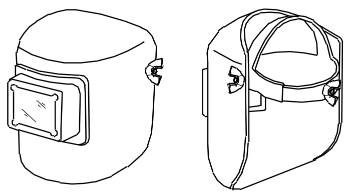
GOGGLES

Fig 6



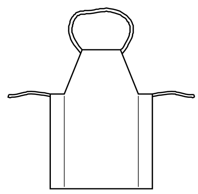
HAND SCREEN

Fig 7



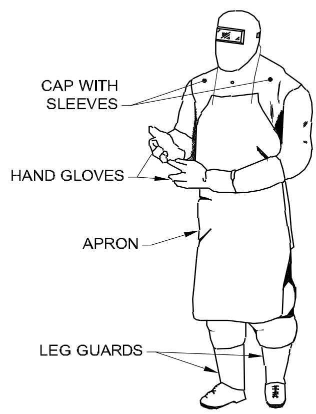
WELDING HELMET

Fig 8



APRON

Fig 9



LEG GUARDS

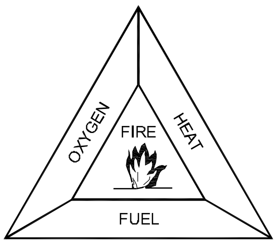
Safety practice - fire extinguishers

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 corneres 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.

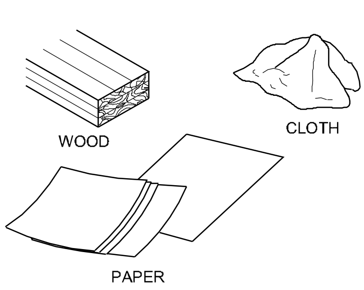
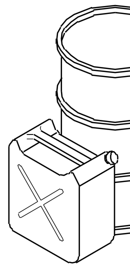
Fuel	Extinguishing
Fig 2 	Most effective ie. cooling with water. Jets of water should be sprayed on the base of the fire and then gradually upwards.

Fig 3

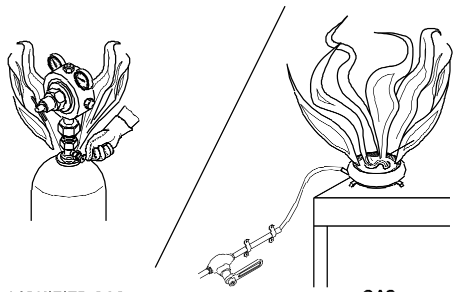


Should be smothered. The aim is to cover the entire surface of the burning liquid. This has the effect of cutting off the supply of oxygen to the fire.

Water should never be used on burning liquids.

Foam, dry powder or CO_2 may be used on this type of fire.

Fig 4



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

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.

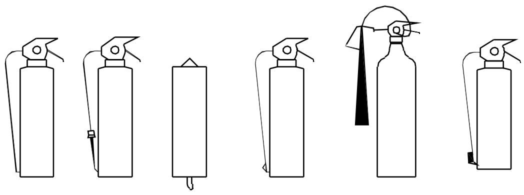
Types of fire extinguishers

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.**

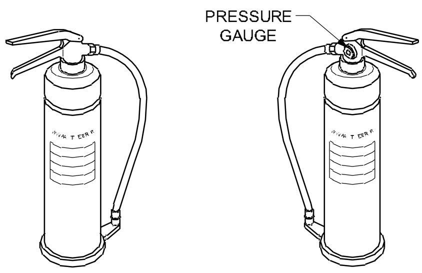
Many types of fire extinguishers are available with different extinguishing 'agents' to deal with different classes of fires. (Fig 1)

Fig 1



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

Fig 2



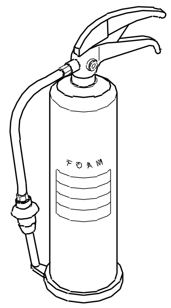
– Gas cartridge type

– 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



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Most suitable for

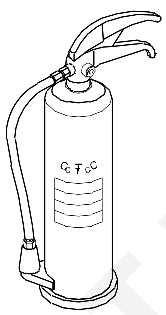
– flammable liquid fires

– 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



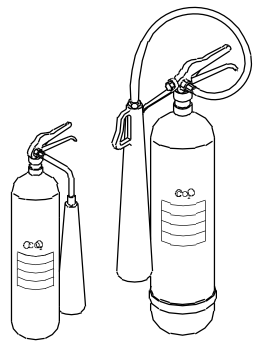
MTN110144

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



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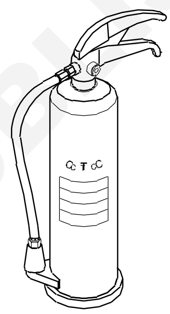
Halon extinguishers (Fig 6)**:** These extinguishers may be filled with carbon-tetrachloride and Bromochlorodifluoro methene (BCF). They may be either gas cartridge or stored pressure type.

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

Fig 6



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

The general procedure in the event of a fire

– Raise an alarm.

– Turn off all machinery and power (gas and electricity).

– Close the doors and windows, but do not lock or bolt them. This will limit the oxygen 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 hishead.

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 unburnt gases such as carbon-monoxide, nitrogen oxide and other gases which are harmful to human health. Hence a systematic and scientifically designed methods are adopted for safedisposal 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 fule 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.

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 serve pain, burning of skin at the point of contact, and even death. So it is need safe and free from electrical hazards.

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

Safety tips

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

2 Do not overload outlets.

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

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

5 Minimize the use of extension cards.

6 Do not cover power cord with rugs or mats.

7 Do not run electrical cord theough pedestrian aisles.

8 Disconnect the power before

9 Donot ignore warning signs.

10 Replace the defective cords immediately.

11 Cover or guard any exposed electrical components of wire.

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

13 Don’t pull cord from a distance.

Authorization moving of road testing vehicles

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

Ministry of road transport & highways

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

Responsibility of regional transport office

Issue of license

- Testing and issue of learning license

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

Revenue collection for the government

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

Environmentel upgradation

- CNG/LPG conversion
- PUC testing
- Road safety measures

Registration of vehicle

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

Road safety precautions

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

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

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

Drive slowly on narrow winding road.

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

Do not overtake on bends

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

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

Always park the vehicle at specified places.

Always give the signal when turning.

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

Reversing the vehicle

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

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

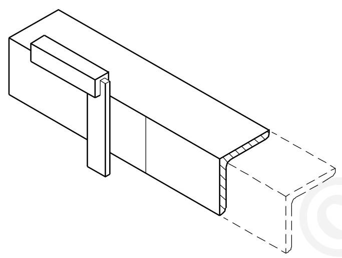
Chalk mixed with methylated spirit

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



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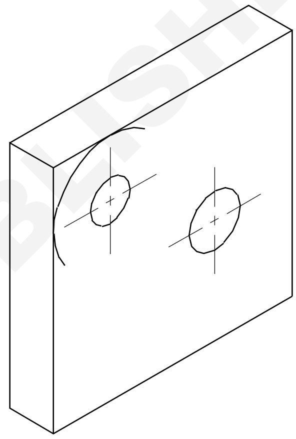
Cellulose Lacquer

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

Prussian Blue

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

Fig 2



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Cleaning tools

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

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

The General Cleaning Tools are

1) Wire brushes

2) Emery sheets.

Wire Brushes

Wire brushes are generally used for cleaning the work surfaces.

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

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

Applications

1 Wire brushes can be used for cleaning uneven Surfaces

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

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

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

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

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

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

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

Safety precautions

Steel wire brushes should be used carefully on soft metals.

It should not make any scratches on the finished surface.

EMERY Sheet (Fig 2**)**

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

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

Description

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

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

> **Safety Precautions**
>
> **After cleaning with emery paper, component should be rinsed properly.**

Fig 2

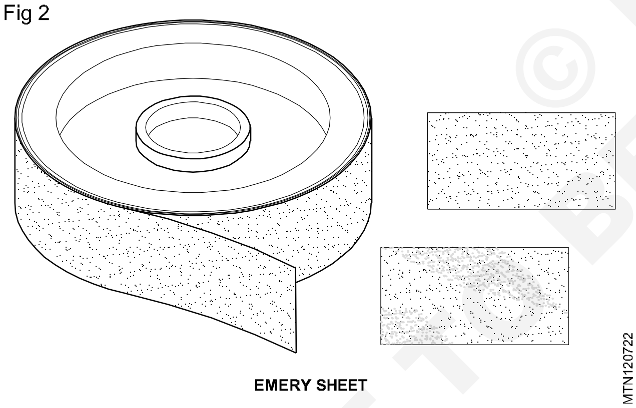
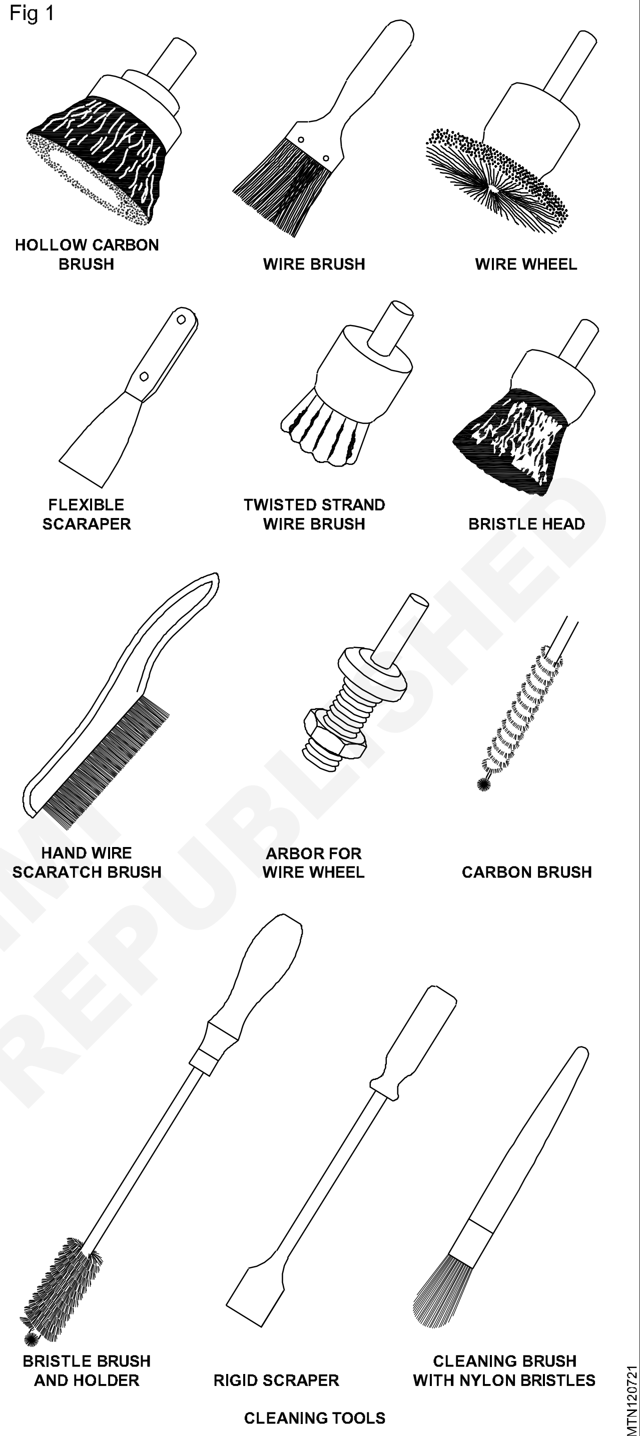


Fig 1



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 liner.

Type of scrapers

1 Flat scraper

2 Special scraper

Flat scraper

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

Use

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

Special Scraper

Special scraper is available for scraping and finishing curved surfaces.

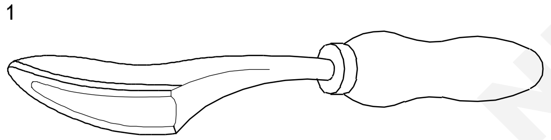
They are

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

Half round scraper

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

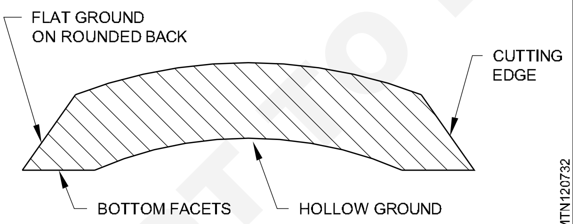
Fig 1



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)

Fig 2



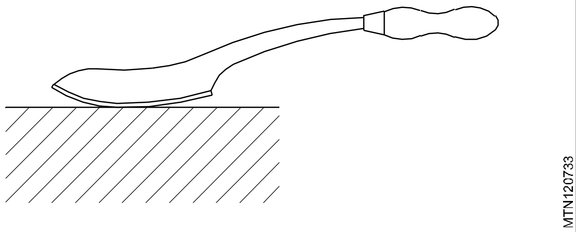
The cutting angle is between 45^0 and 65^0.

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.

Fig 3

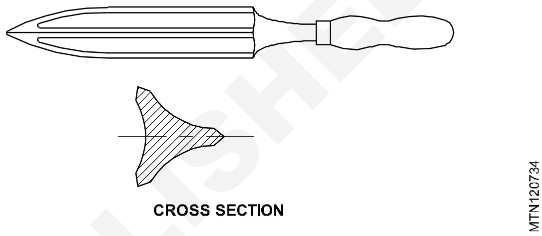


The cross-section of this is triangular. This has more number of cutting edges and the hollow portion between the cutting edges helps in re-sharpening easily.

Bull nose scraper (Fig 5)

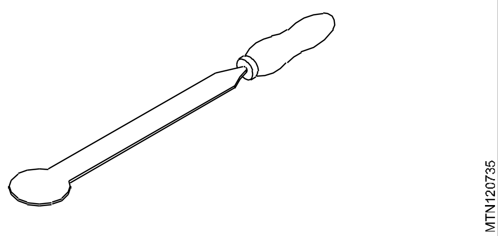
This scraper has the cutting edge shaped into a flat circular disc. The cutting edge forms about two thirds of the circle.

Fig 4



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

Fig 5



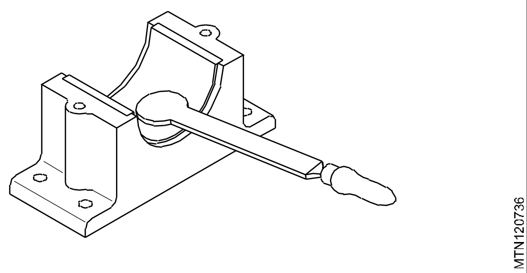
scraper. This dual action helps to prevent ridges on the scraped surfaces.

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 not in use.

Fig 6



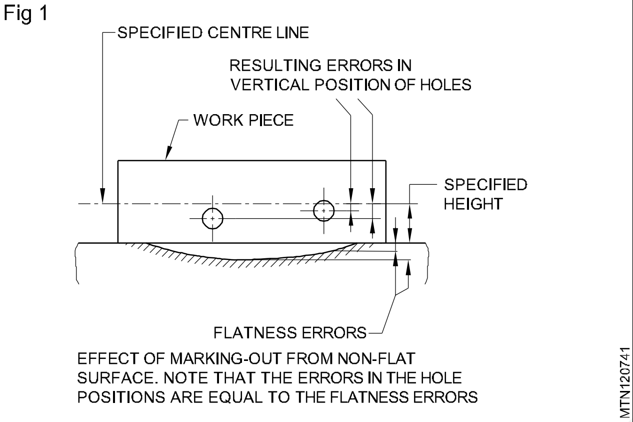
Surface plates

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of surface plates**
- **state the application of different grades of surface plates**
- **specify surface plates and state the uses of marking of 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.

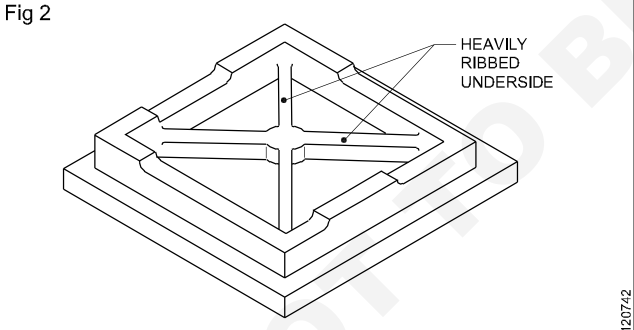
Fig 1



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

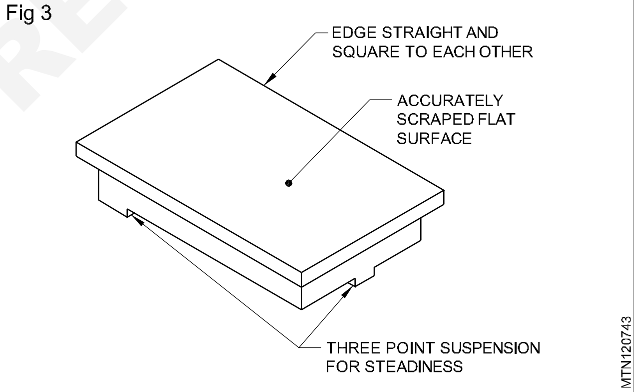
Cast iron surface plates are designated by their length, breadth, grade and the Indian Standard number.

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 wheeltrack**
- **state measuring tape, its types and uses.**

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

Wheel/Track : The wheeltrack of a vehicle equals the centre 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. Metal Tape (Fig 2)
2. Plastic Tape (Fig 3)
3. Fibre glass
4. Ribbon cloth

Fig 1

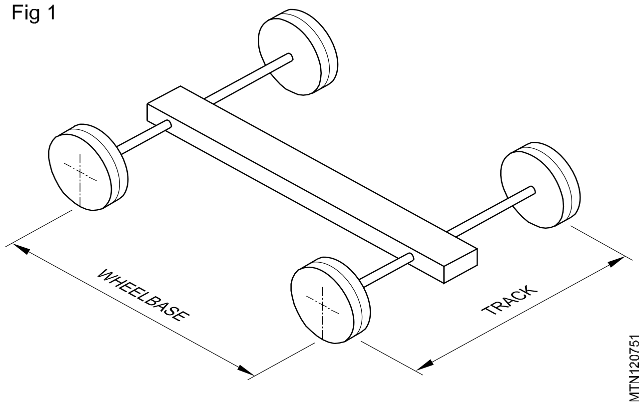


Fig 2

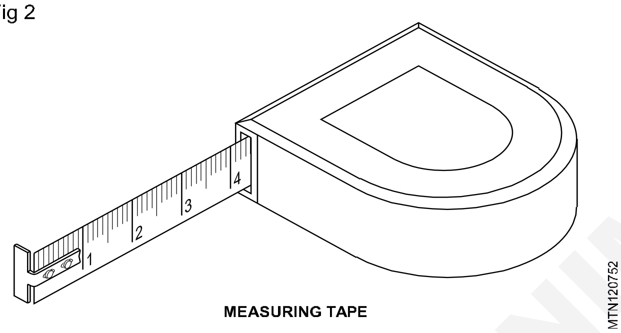
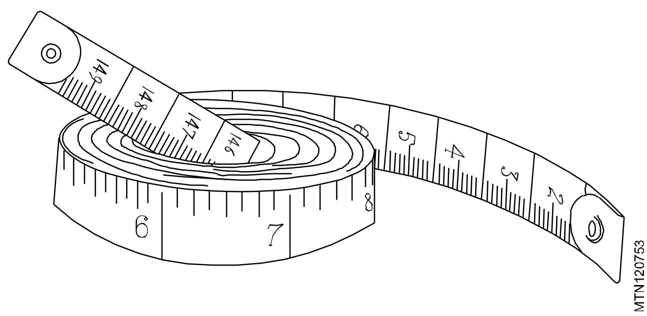


Fig 3



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.

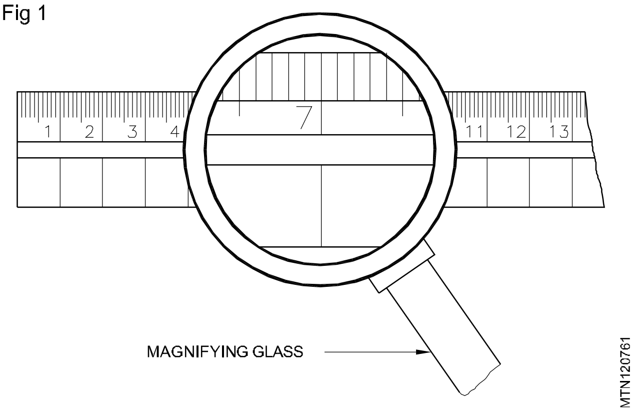
METRE (m)	=	1000 mm
CENTIMETRE(cm)	=	10 mm
MILLIMETRE (mm)	=	1000 mm
MICROMETRE (m)	=	0.001 mm

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

Fig 1



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

However in a regular Steel rule & in vernier caliper the main scale readings of metric in the bottom and imperial in inches in the top 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 satin-chrome finished to reduce glare, and to prevent rusting.

Sizes of steel rules (Fig.1)

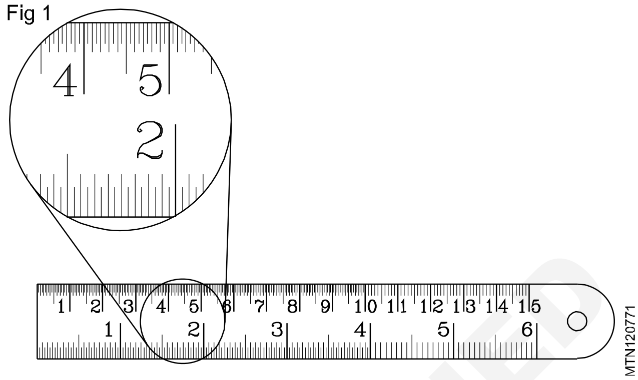
Steel rules are available in different length, the common sized being 150mm, 300 mm and 600 mm.

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

The reading accuracy of the steel rule is 0.5 mm.

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

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.

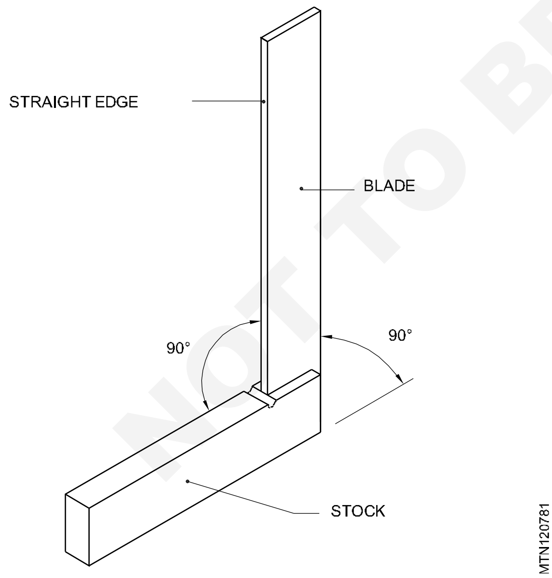
These lines serve as guides for positioning components while setting and marking.

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.

Fig 1

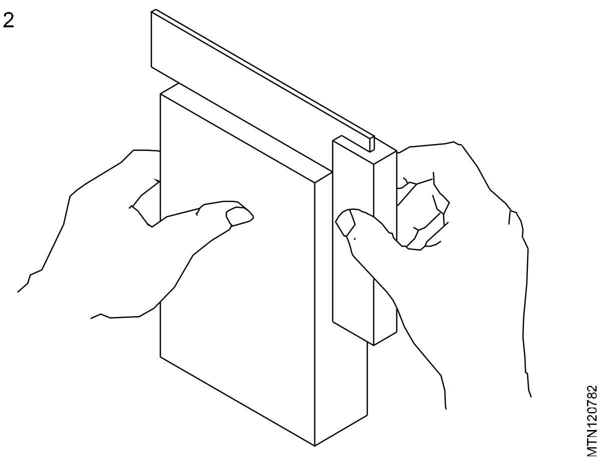


The accuracy of measurement by a try square is about 0.002 mm per 10 mm length, which is accurate enough for most workshop purposes. The try square has a blade with parallel surfaces. The blade is fixed to the stock at 90^0.

Uses

The try squareness is used (Figs 2 & 3)

Fig 2



- check flatness of surfaces (Fig. 3)
- mark lines at 90^0 to the edges of workpieces (Fig. 4)
- set workpieces at right angles on work, holding devices. (Fig. 5)

Try squares are made of hardened steel.

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

Use of a try square and steel rule.

Fig 3

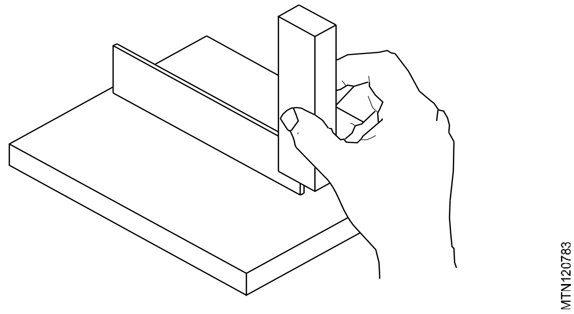


Fig 4

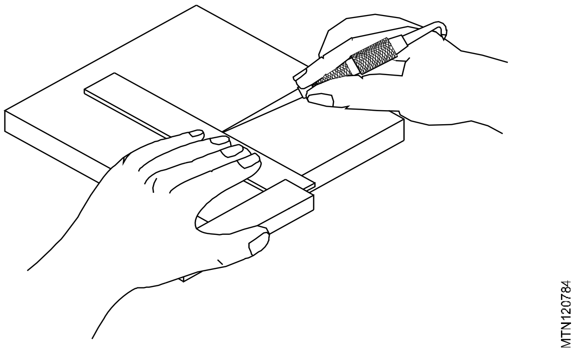


Fig 5

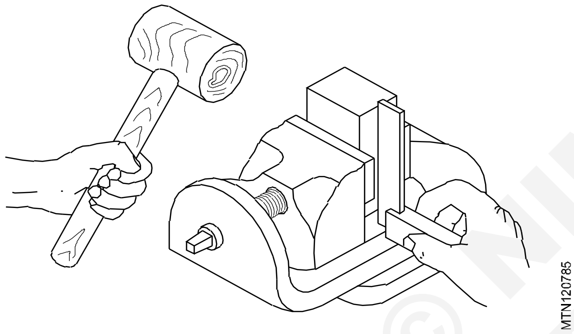
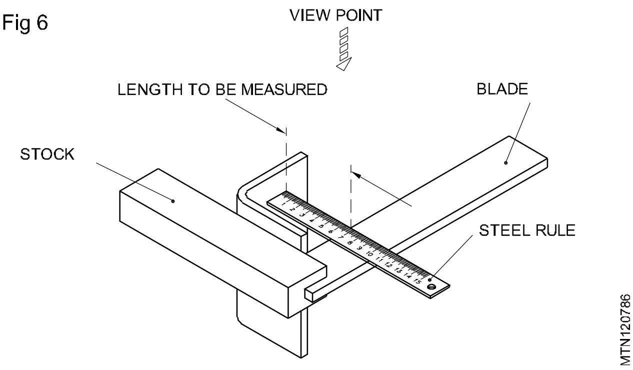


Fig 6 shows the method of using a try square and a steel rule for accurate measurements.

Fig 6



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

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

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

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

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

Types of calipers

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

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

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

Types of joint

The commonly used calipers are:

- firm joint calipers
- spring joint calipers.

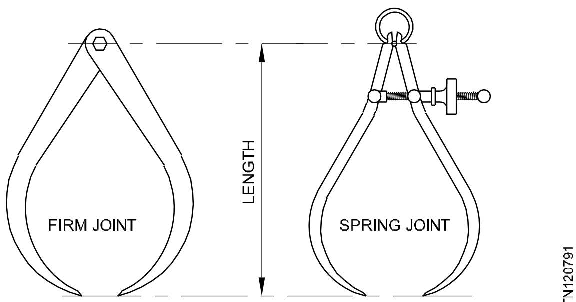
Firm Joint calipers (Fig. 1)

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

Spring joint calipers (Fig. 2)

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

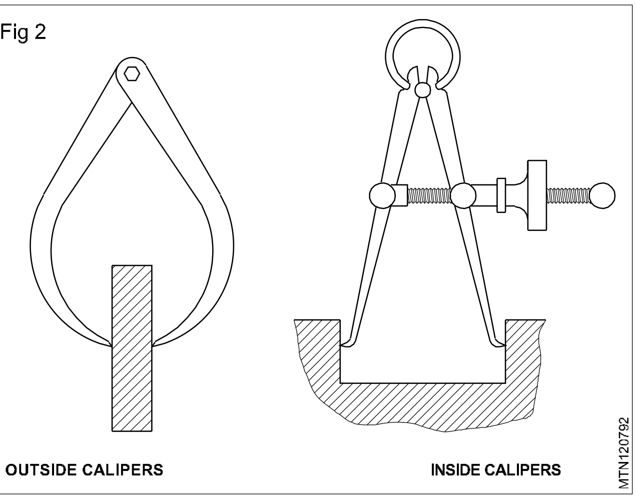
Fig 1



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.

Fig 2



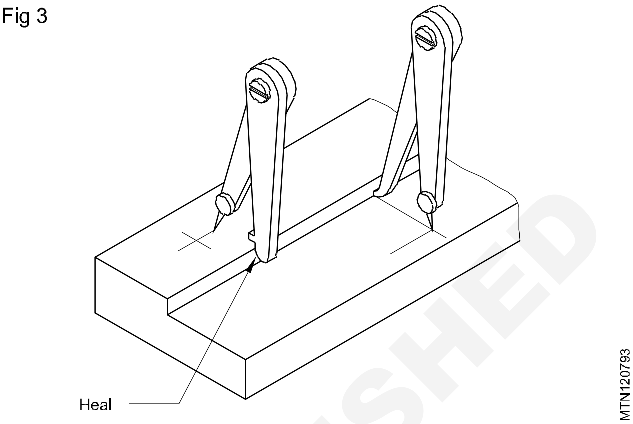
Types of legs: Outside and inside calipers are differentiated by the shape of the legs.

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

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

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

Fig 3

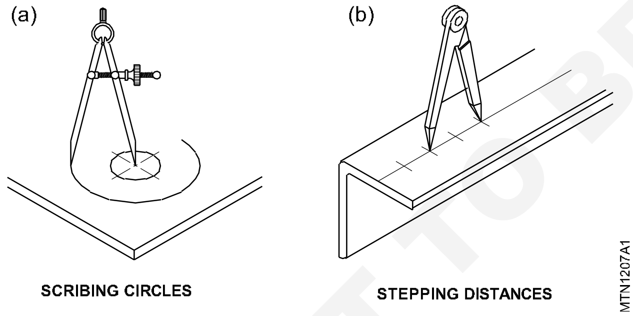


Dividers

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

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

Fig 1



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

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)

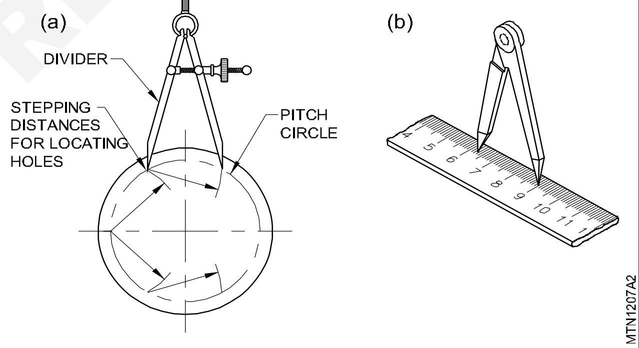
For the correct location and seating of the divider legs, prick punch marks of 30° are used. (Fig 3b)

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

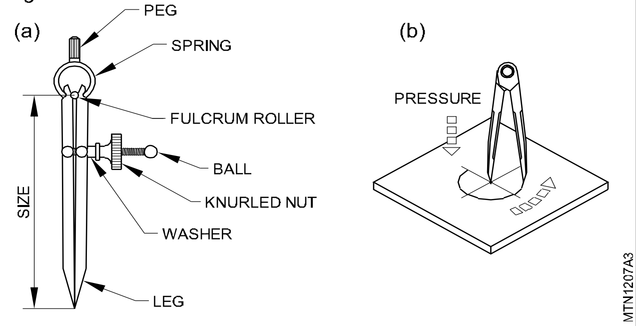
Fig 2



than sharpening by grinding. Sharpening by grinding will make the points soft.

> **Do not sharpen the divider points on grinding wheels.**

Fig 3



Surface Gauges

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

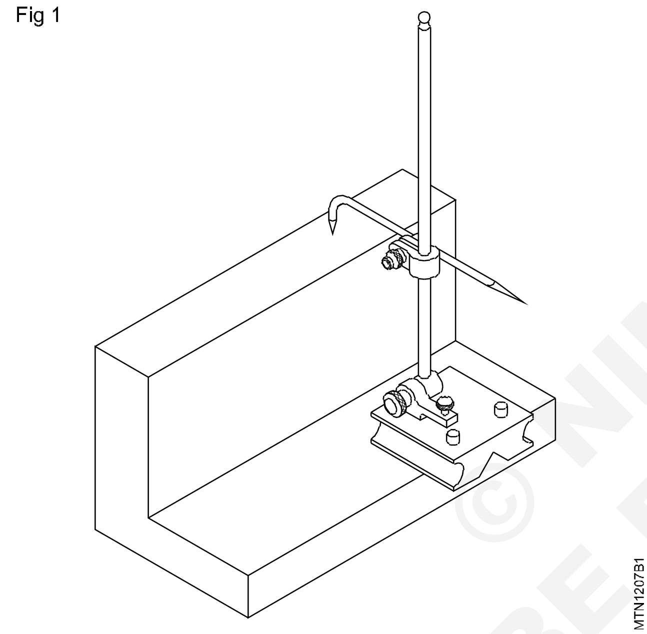
The surface gauge is one of the most common marking tools used for.

scribing lines parallel to a datum surface

Types of surface gauges

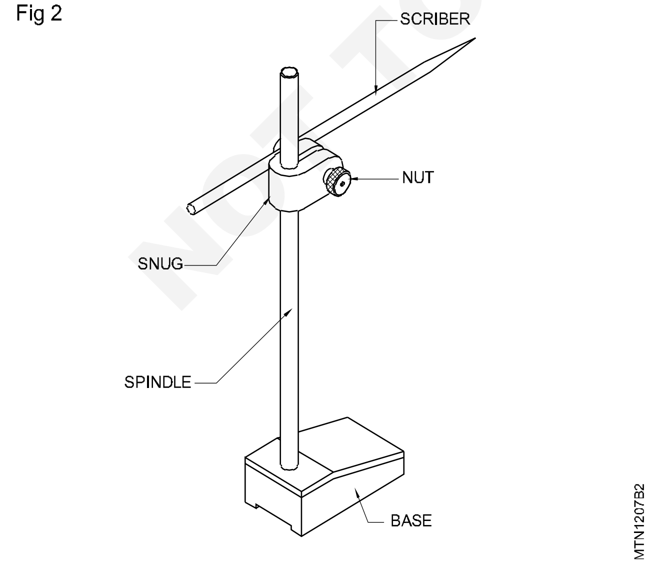
- Surface gauges/scribing blocks are of two types.
- Fixed (Fig.2)
- Universal (Fig.1)

Fig 1



Surface gauge-fixed type (Fig.2)

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.

Universal surface gauge (Figs 3&4)

Fig 3

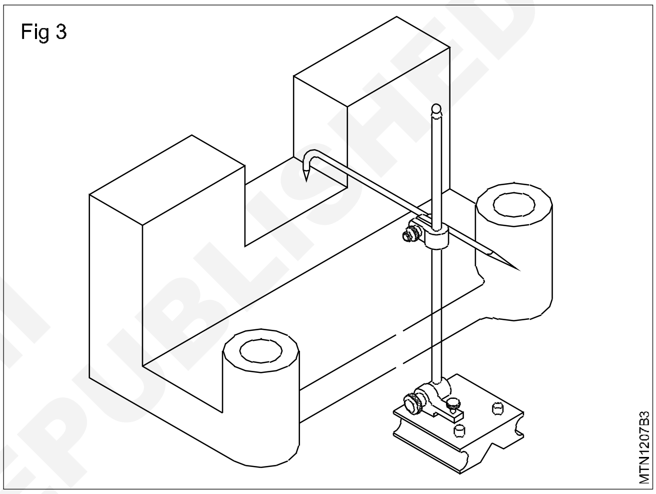
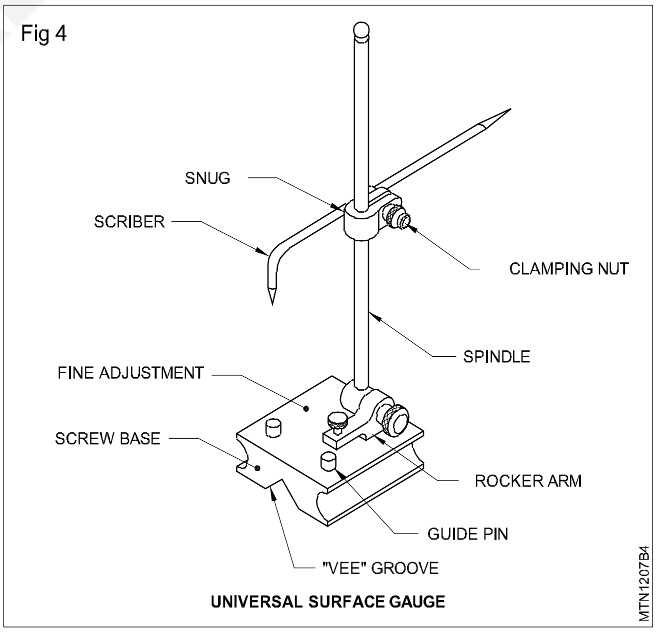


Fig 4



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.

Scriber

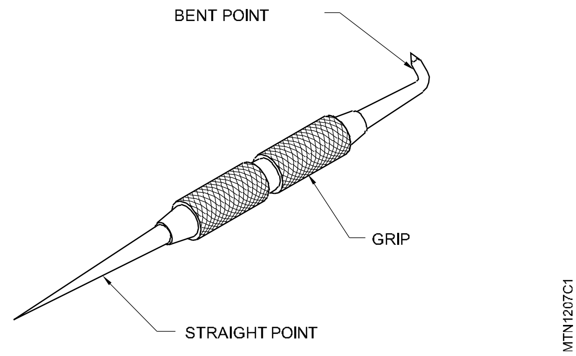
Objectives: At the end of this lesson you shall be able to
- **state the features of scribers**
- **state the uses of scribers.**

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.

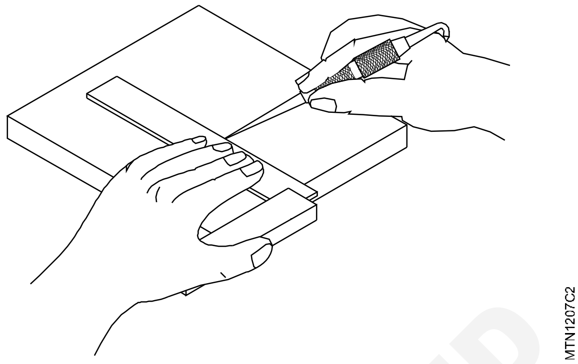
Scribes are available in different shapes and sizes. The one most commonly used is the plain scriber (Fig.1).

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)

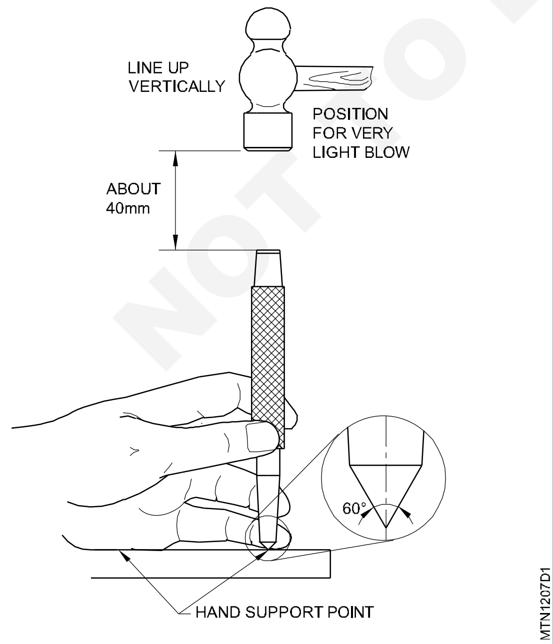
Hand tools

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)

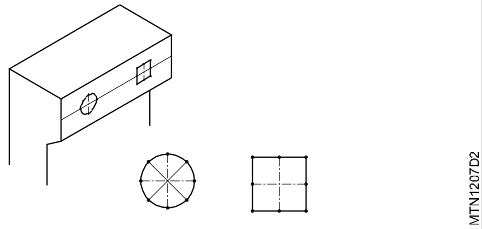
Prick punches

Fig 1



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

Fig 2



This makes it easier to see accurate marking out lines.

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

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

Centre punches

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

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

Fig 3

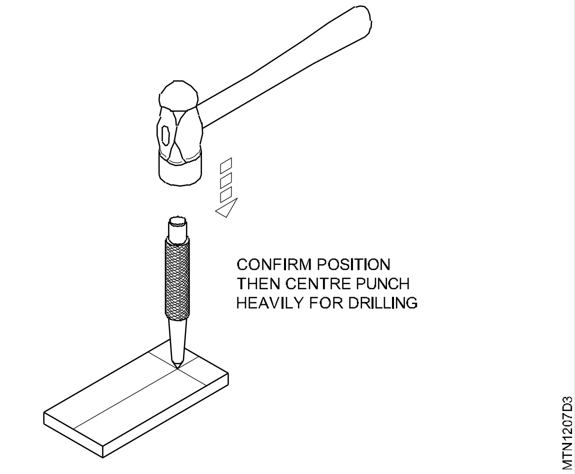
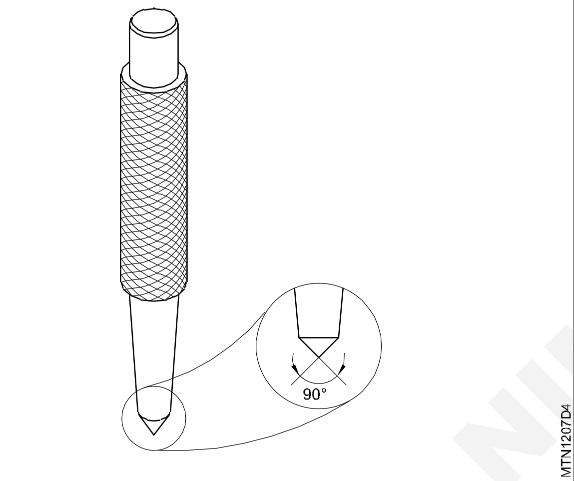


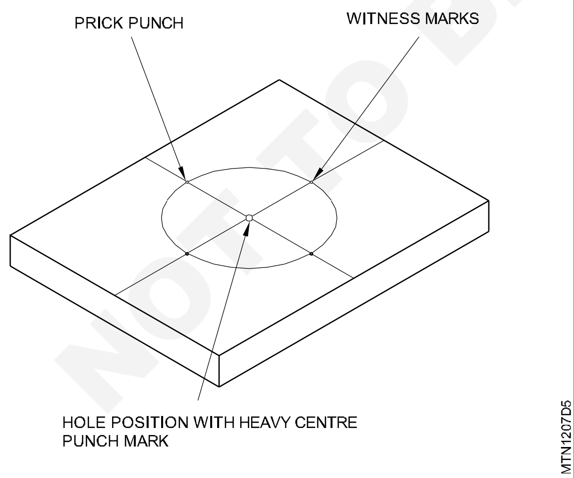
Fig 4



Centre punches are used

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

Fig 5



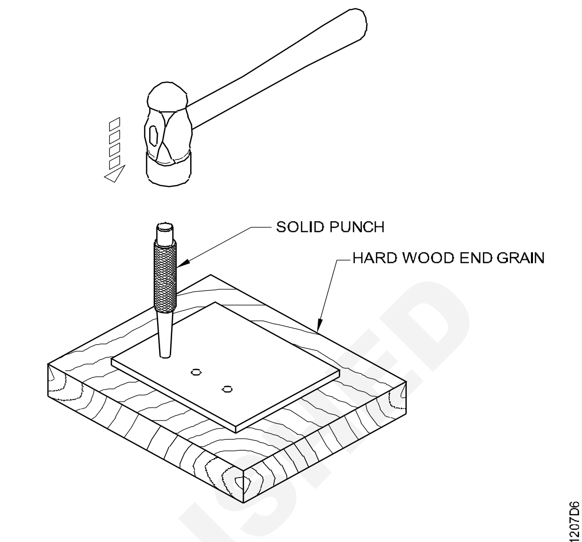
Solid punch (Fig 6)

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

Letter and number punches

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

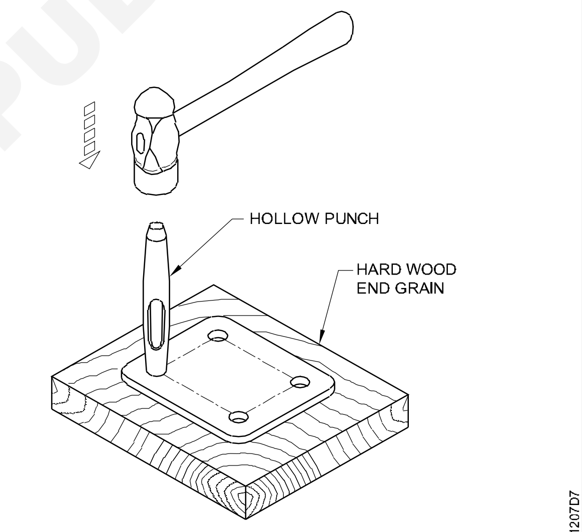
Fig 6



PUNCHING HOLES FOR RIVETS WITH A SOLID PUNCH

Hollow punch (Fig 7)

Fig 7



USING A HOLLOW PUNCH

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.

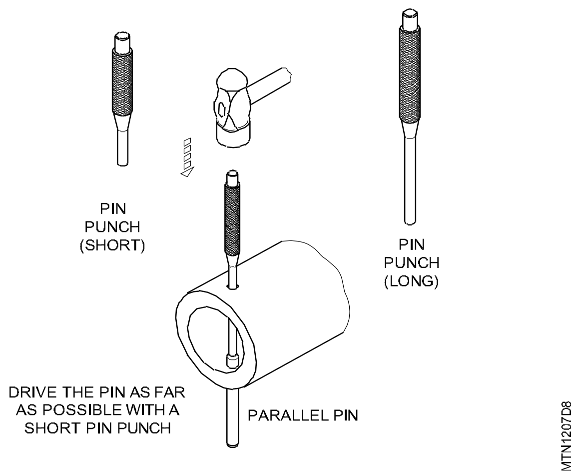
While using solid or hollow punches, the materials is rigidly supported with a block of wood (with the end of grain up) or lead. This will also avoid any damage to the tip of the punch while punching.

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 8

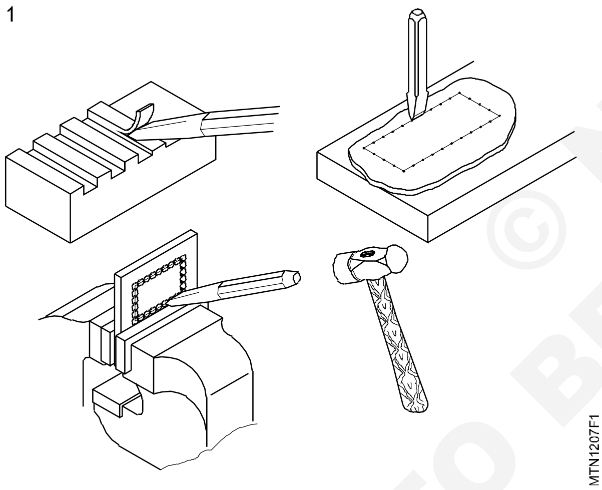


Chisel

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

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

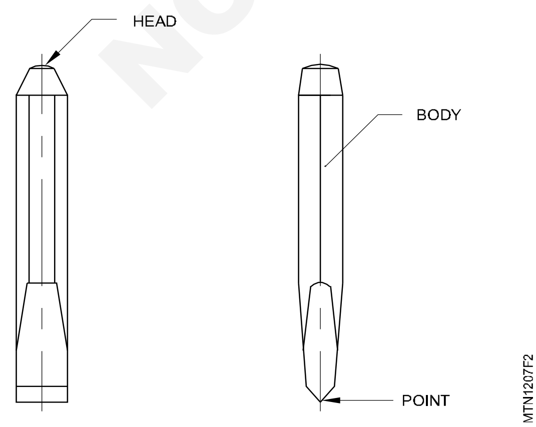
Fig 1



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

Parts of a chisel (Fig.2)

Fig 2



A chisel has the following parts.

Head

Body

Point or cutting edge

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

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

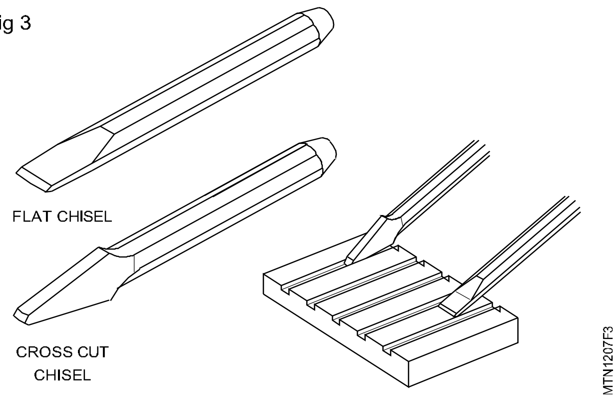
Flat chisels (Fig.3)

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.

Fig 3

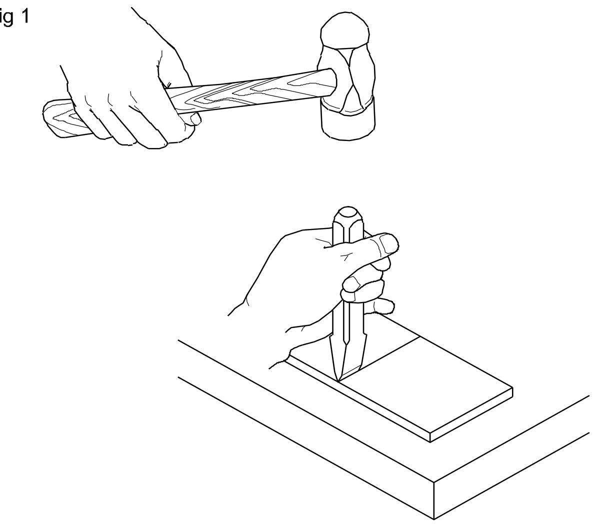


Hammers

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

Fig 1



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

Major parts of a hammer (Fig.2)

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

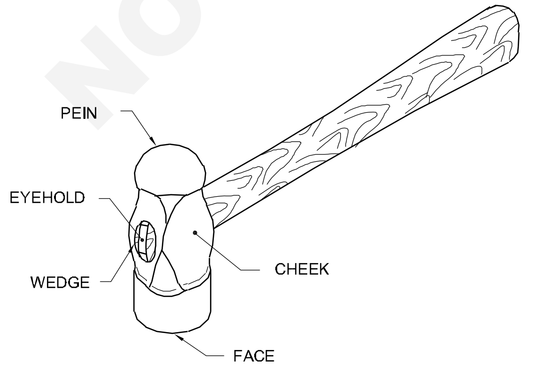
The head is made of drop-forged carbon steel, while the wooden handle must be capable of absorbing shock.

The parts of a hammer head are the

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

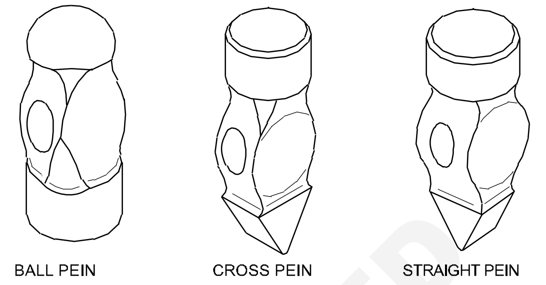
The face is the striking portion. Slight convexity is given to it avoid digging of the edge.

Fig 2



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

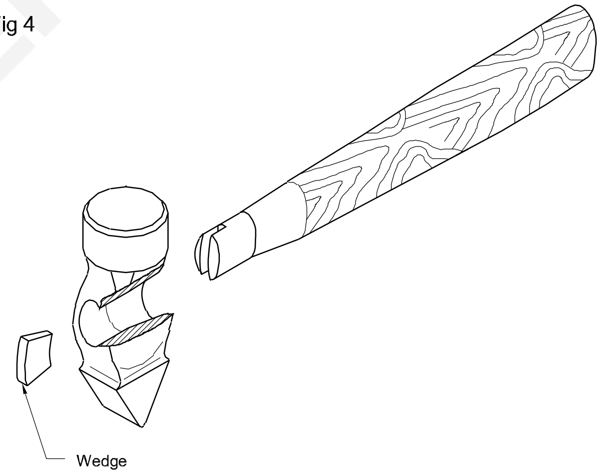
The face and the pein are hardened.

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



Specification

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

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

Before using a hammer

make sure the handle is properly fitted

select a hammer with the correct weight suitable for the job

check the head and handle for any cracks ensure the face of the hammer is free from oil or grease.

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

Fig 5

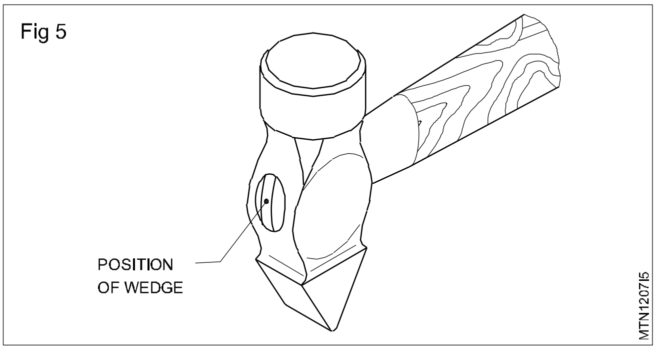
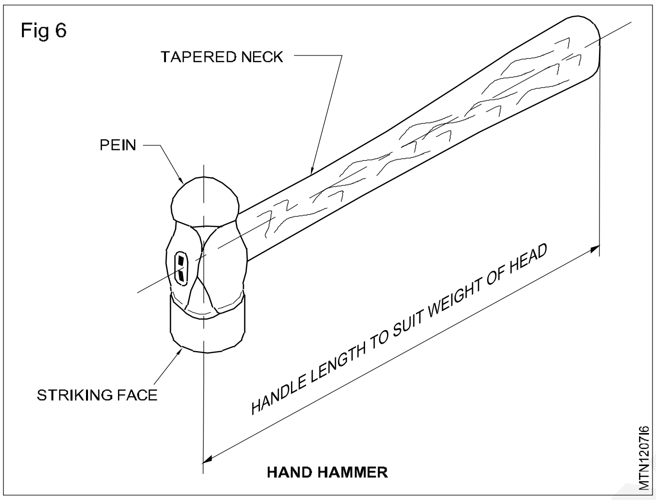
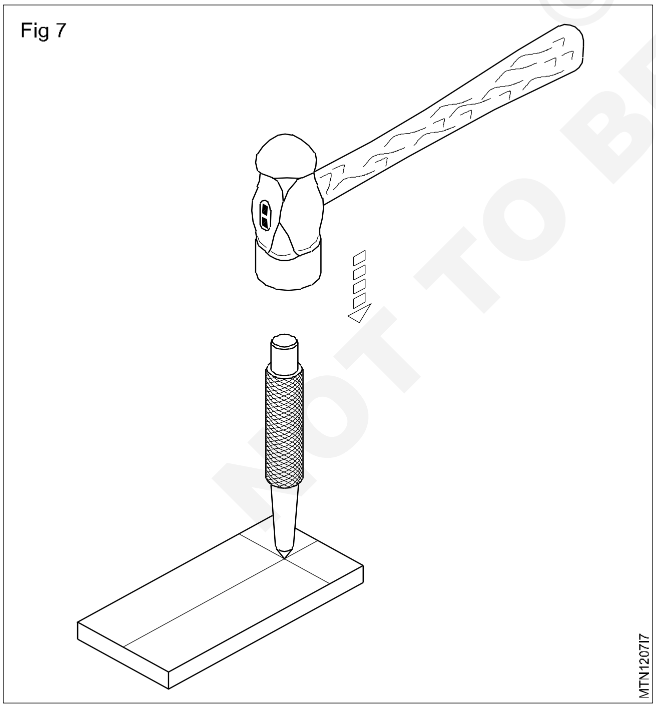


Fig 6



The face of the hammer is used for general work, such as striking chisels and punches and levelling 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)

Fig 8

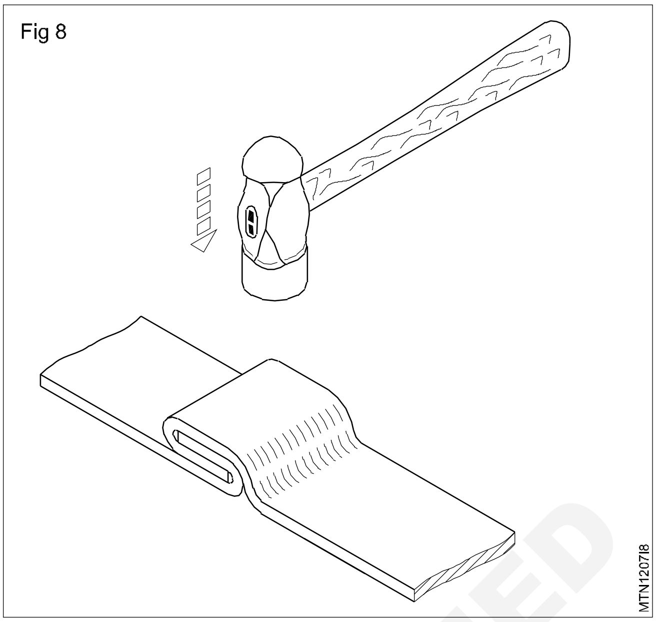
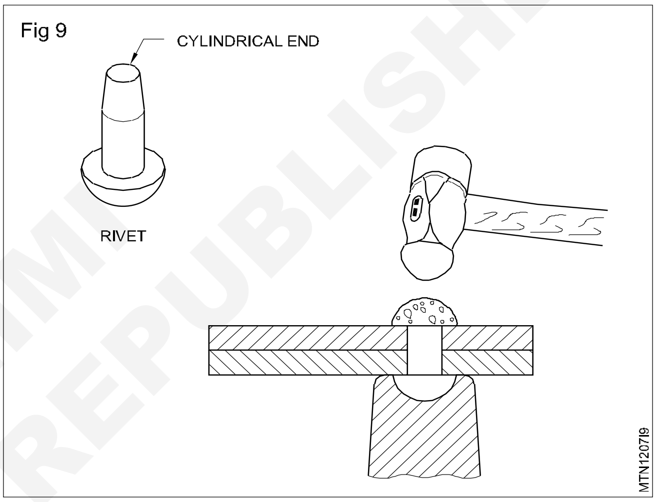


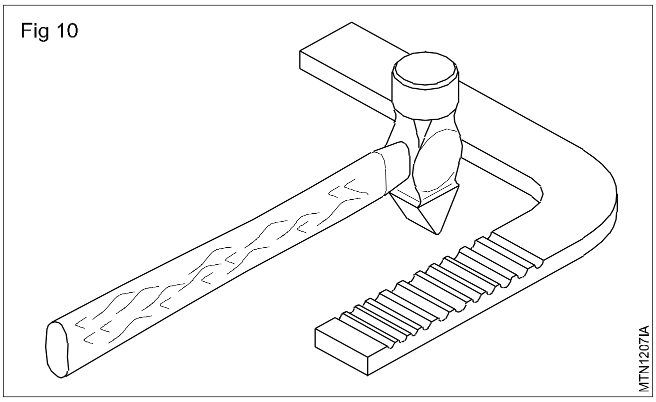
Fig 9



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

Cross pein hammer (Fig 10)

Fig 10



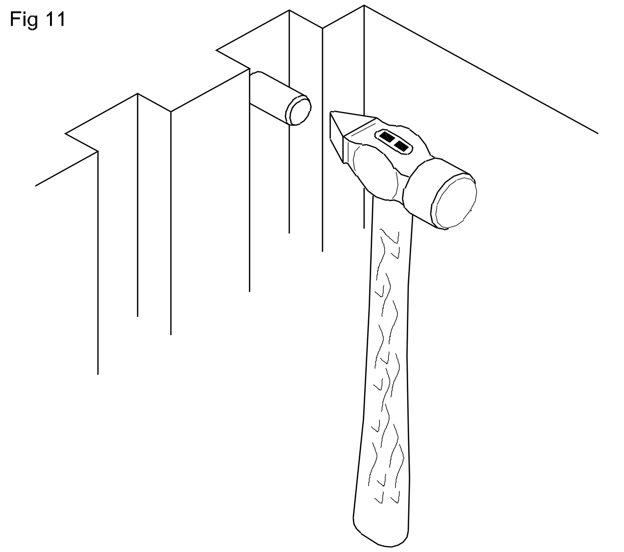
A cross pein head is used to spread metal in one direction in the line of striking.

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

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

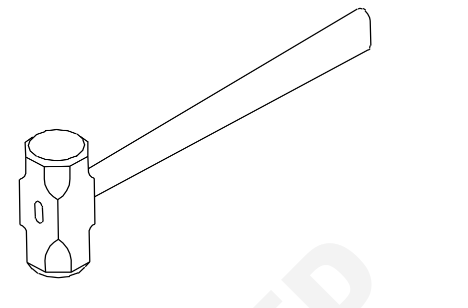
This hammer has a blunt wedge-shaped pein in line with the axis of the handle.

Fig 11



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

Fig 12



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.**

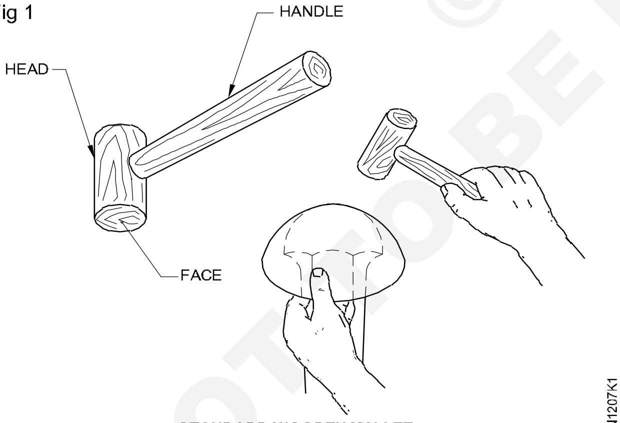
Mallets

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.

Fig 1

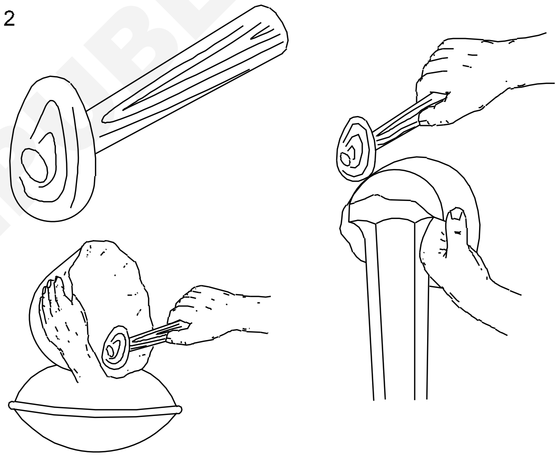


STANDARD WOODEN MALLET

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

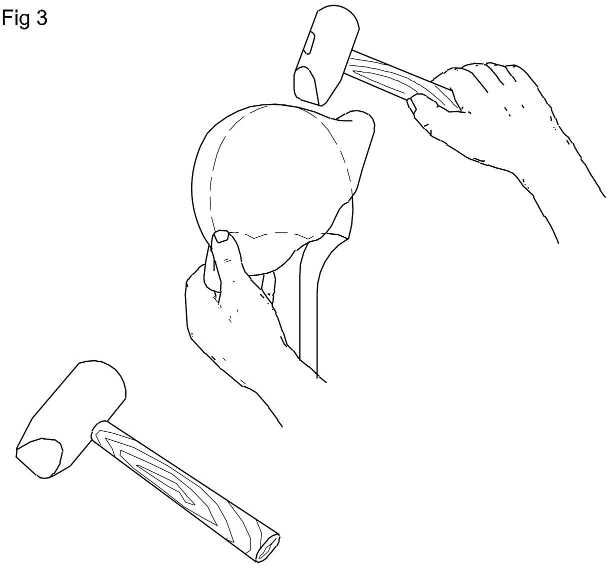
An end-faked mallet (Fig.3) is used for stretching, hammering etc.

Fig 2



SHAPING THE HEMISPHERICAL BOWL BY RAISING BOSSING MALLET

Fig 3



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.**

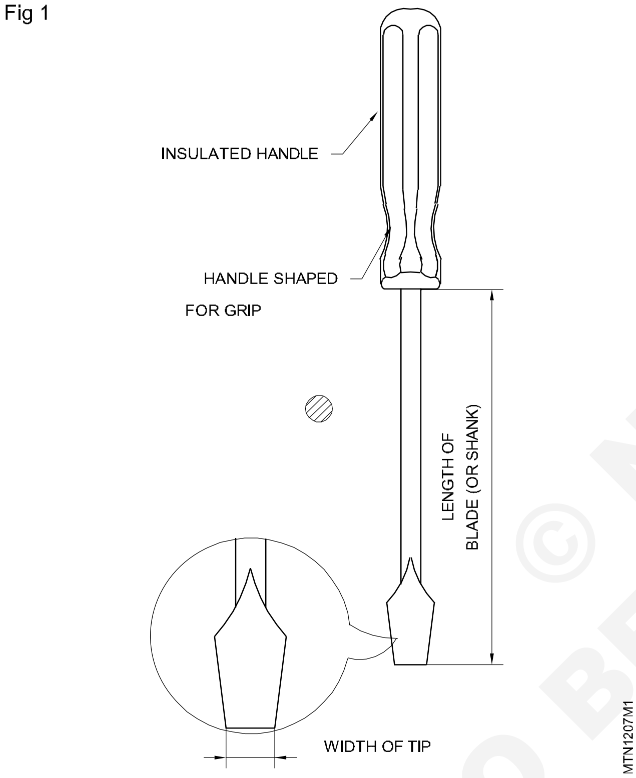
Screwdrivers are used to tighten or loosen screws which are fixed in the machine element.

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)

Fig 1



Screwdrivers must have:

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

Standard Screwdrivers

Standard screwdrivers are classified as:

- heavy duty screwdrivers
- light duty screwdrivers
- stumpy screwdrivers

Heavy duty screwdrivers (Fig 2 & 3)

Fig 2

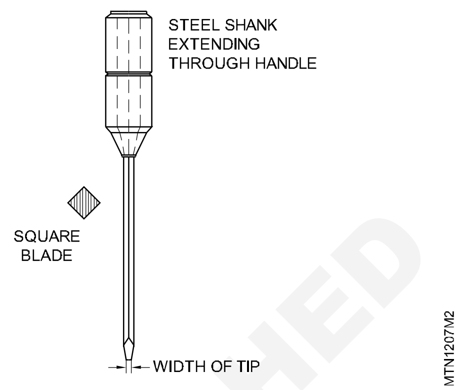
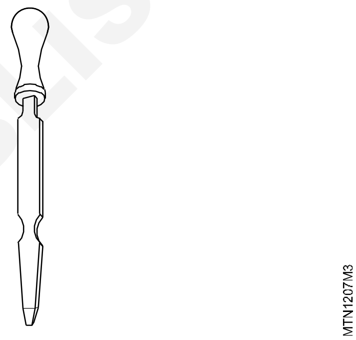


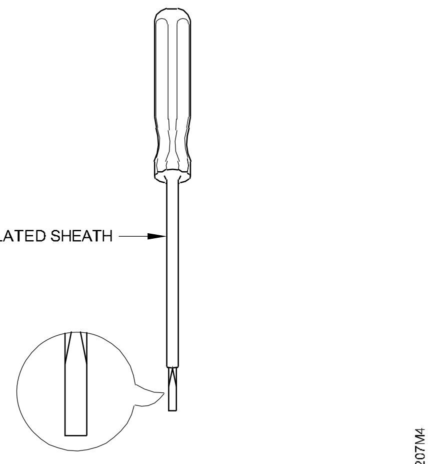
Fig 3



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

Light duty screwdrivers (Fig 4)

Fig 4

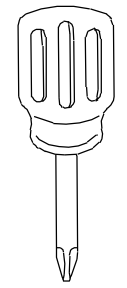


LIGHT DUTY SCREW DRIVER

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

Stumpy screwdrivers (Fig 5)

Fig 5



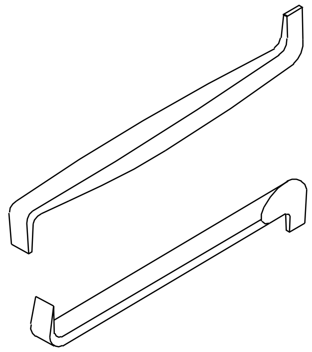
STUMPY SCREW DRIVER

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

Special screwdrivers and their uses

Offset screwdriver (Fig 6)

Fig 6



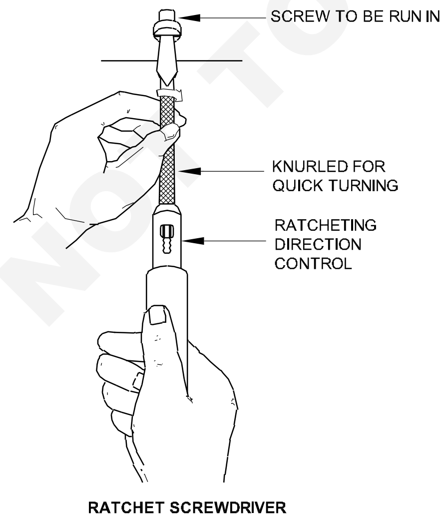
Offset screwdrivers are used on screws which are placed in blind spaces.

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

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

Ratchet screwdriver (Fig 7)

Fig 7



RATCHET SCREWDRIVER

The following are the features of ratchet screwdrivers.

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

They are used for tuning screws in confined spaces.

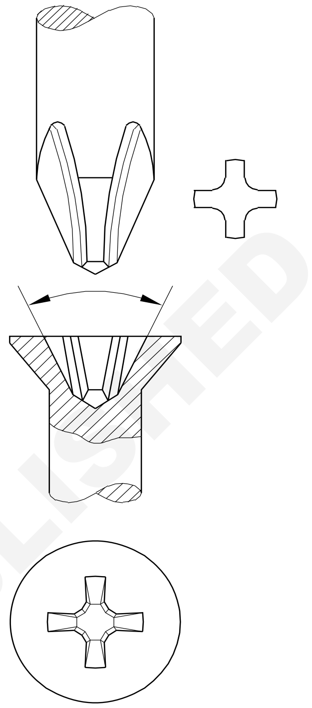
They can be operated without changing the hand grip.

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

They are used in mass production.

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

Fig 8



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

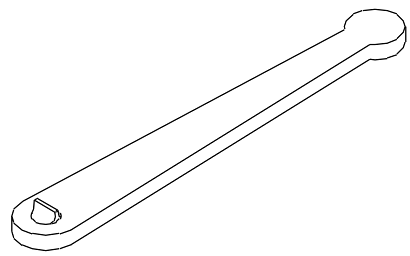
The end of the four flats is tapered to an angle of 53°

The extreme end is ground to 110°.

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

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

Fig 9



Specification

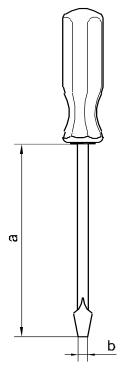
Screwdrivers are specified (Fig.10) according to the

- 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.

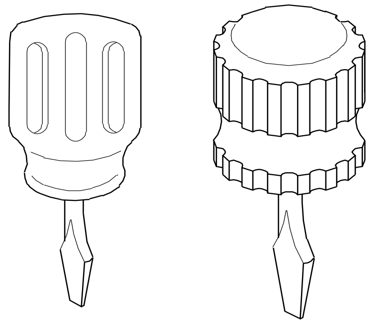
Fig 10



Screwdrivers for special uses

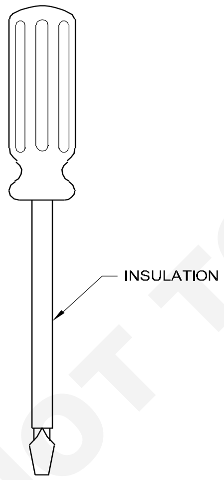
Small sturdy screwdrivers (Fig.11) are available for use where there is limited space.

Fig 11



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

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 13

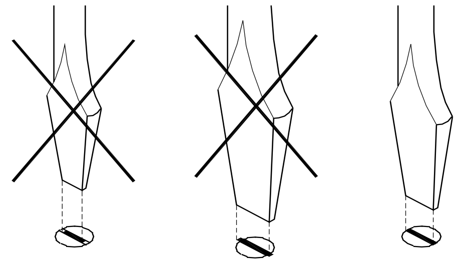


Fig 14

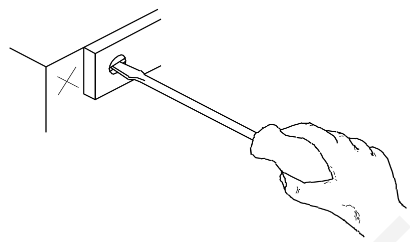
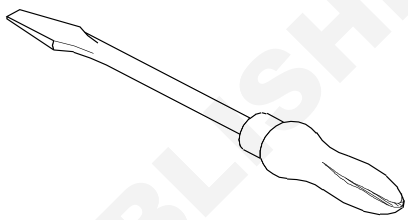


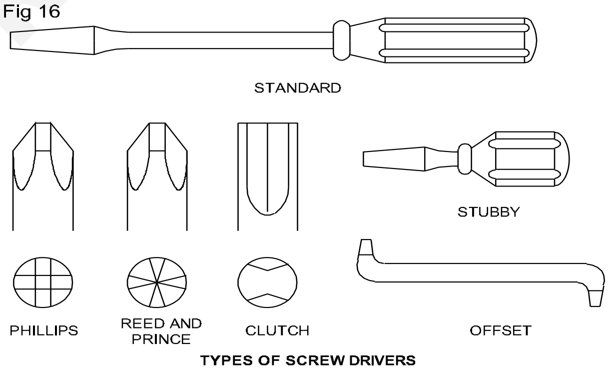
Fig 15



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

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

Fig 16



Specification of a screwdriver: Screwdrivers are specified according to the

- length of the blade
- width of the tip

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

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

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

Safety: 1 Always use correct type and size screw drivers.

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

Allen keys

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

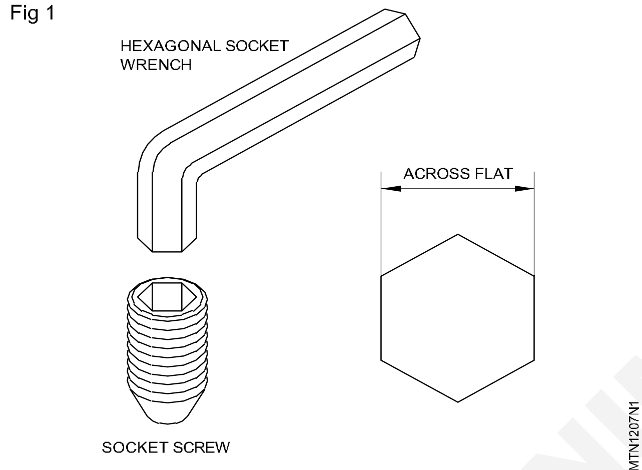
Hexagon socket screw keys/Allen keys are made from hexagonal section bars of chrom vanadium steel.

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

Uses

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

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

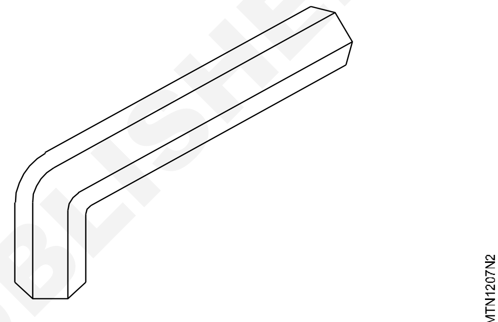
Sizes of Allen keys (Fig.1)

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.

Fig 1

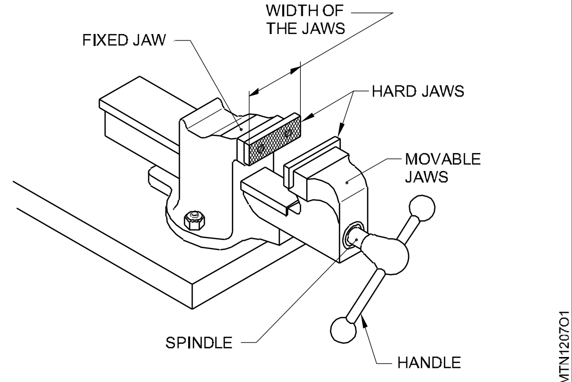
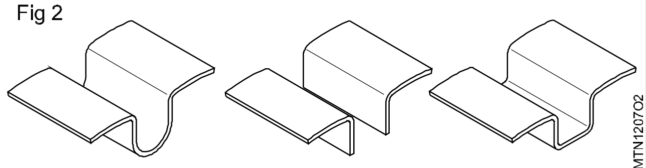


Fig 2



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

C - Clamps and toolmaker's clamps

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

Purpose of using clamps

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

Requirements of clamping devices

Should be able to manipulate for easy loading.

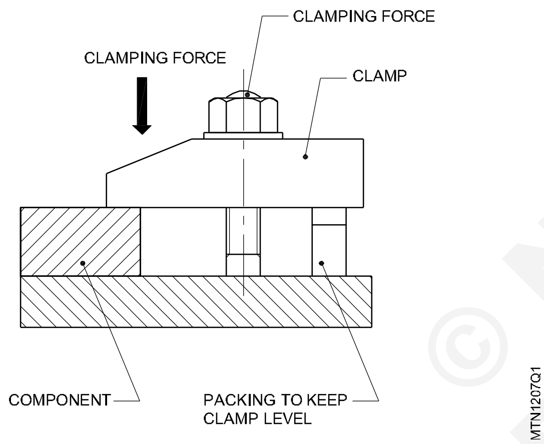
Should provide the required clamping force.

Should be capable of locking with minimum movement.

Should accommodate a range of sizes of jobs.

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

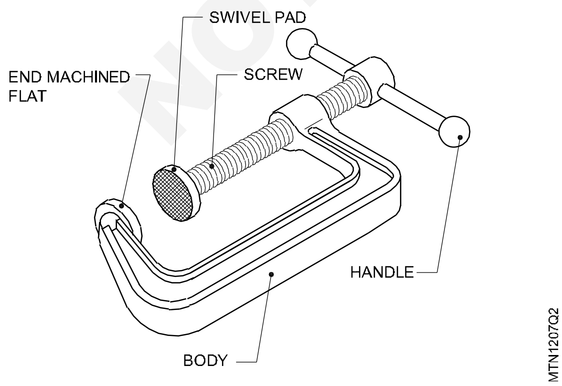
Fig 1



'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)

Fig 2



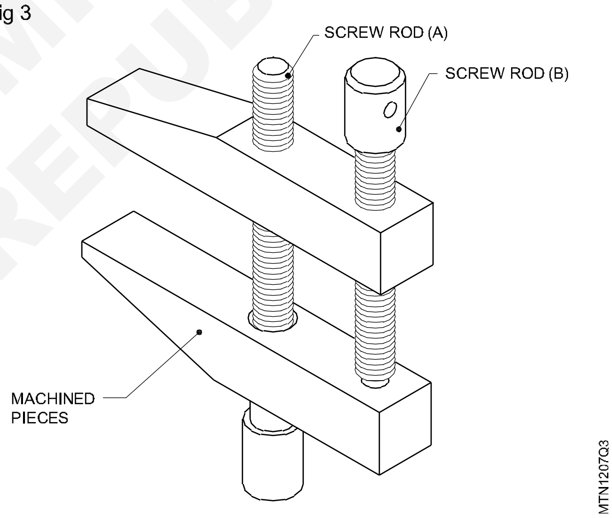
These clamps are used to hold work, on an angle plate or a drill press table, and also, for holding two or more workpieces together.

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

Toolmaker's clamps

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

Fig 3



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

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

'U' Clamps

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

Spanners and their uses

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

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

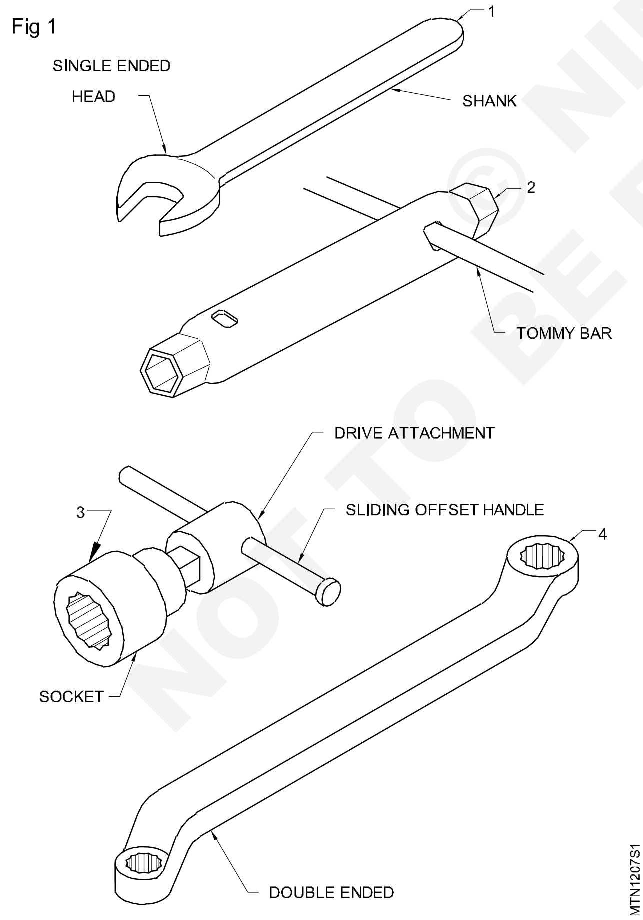
Spanners are considerably in shape to provide ease of operation under different conditions.

The basic types of spanners are (Fig. 1)

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

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

Fig 1



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

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

Use both hands for large spanners.

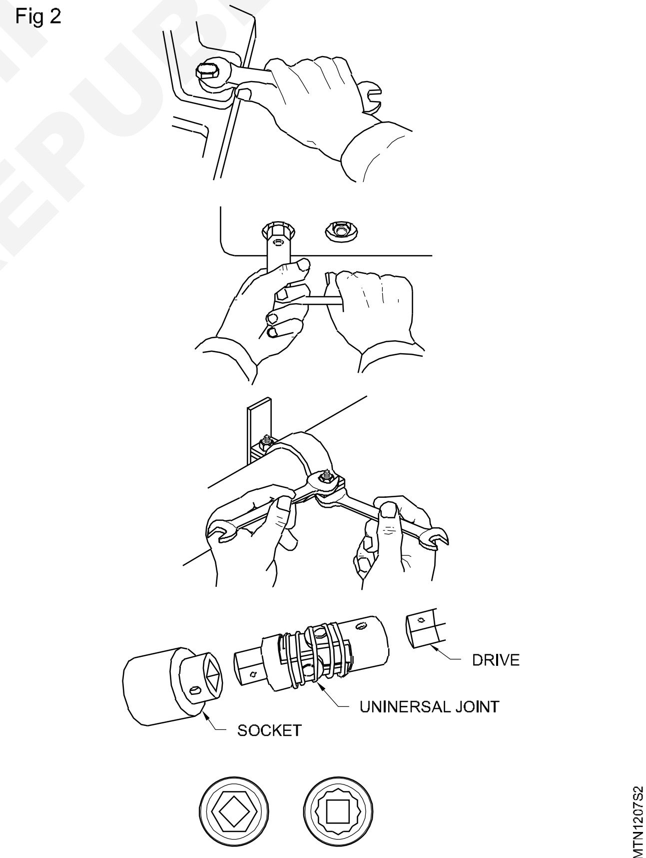
Keep yourself balanced and firm to avoid slipping yourself, if the spanner slips suddenly, Hold on to some support, if there is any chance of falling.

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

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

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

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)

Fig 3

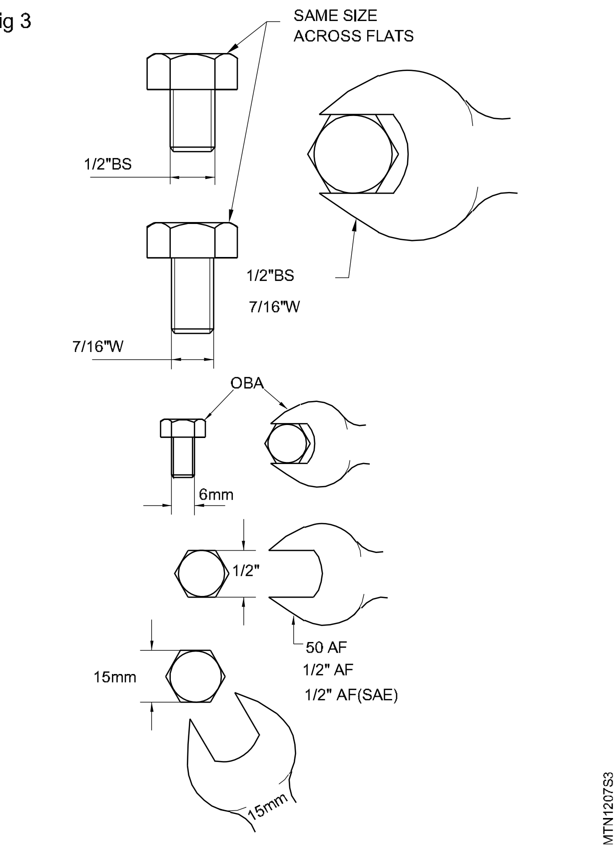
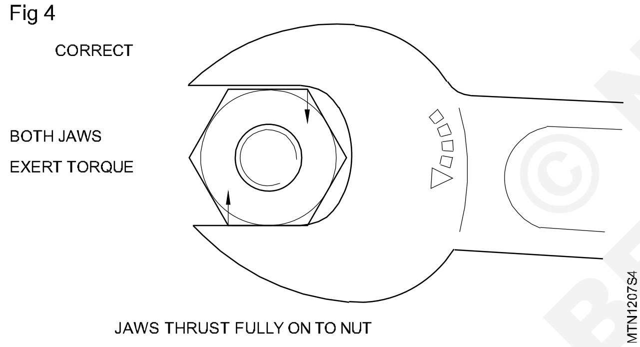


Fig 4



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.

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.

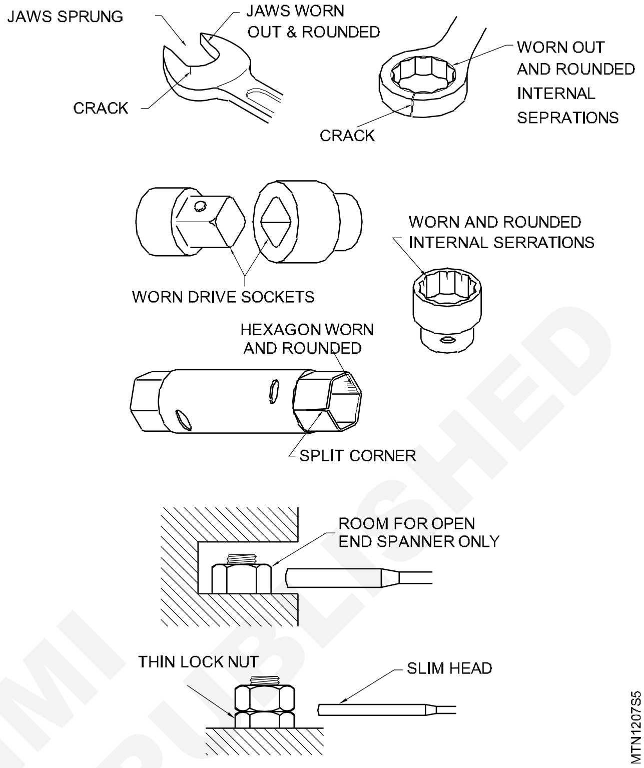
Incorrect use damages the spanners & the nuts too.

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)

Fig 5

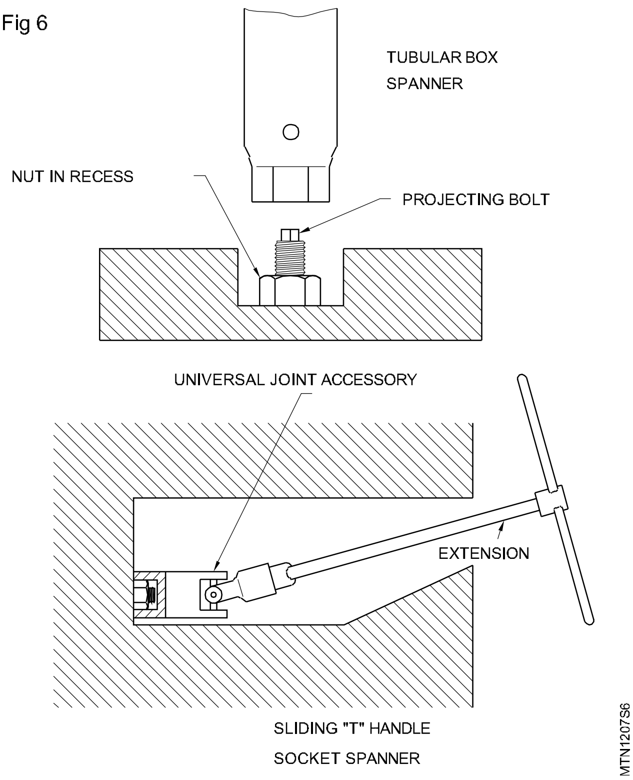


Length of spanners (Fig. 6)

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

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

Fig 6



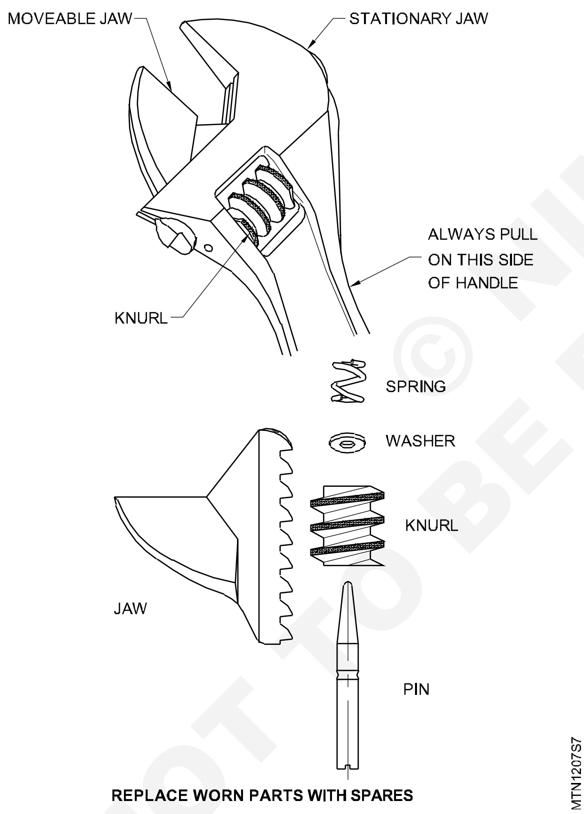
Excess turning effect of the spanner could result in:

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

Adjustable spanners (Figs 7 & 8)

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

Fig 7



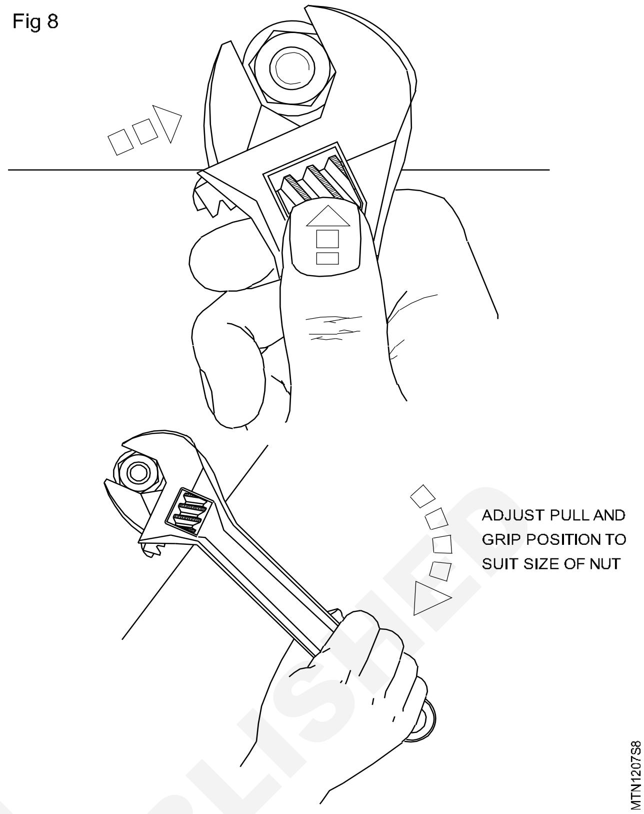
When using the adjustable spanner follow the steps given below.

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.

Fig 8



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.

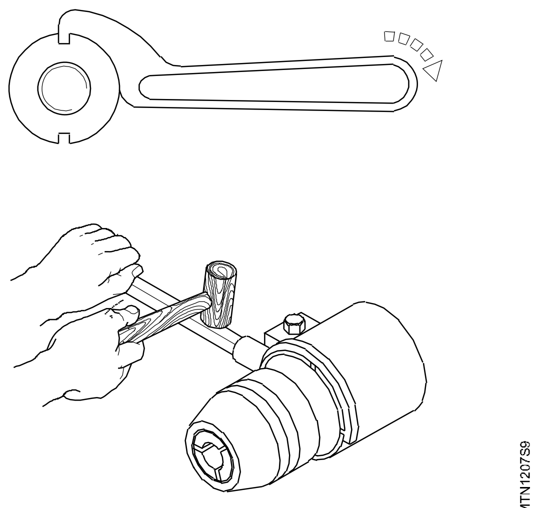
'C' spanners (Hook spanners) (Fig.9)

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.

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

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

Fig 9



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

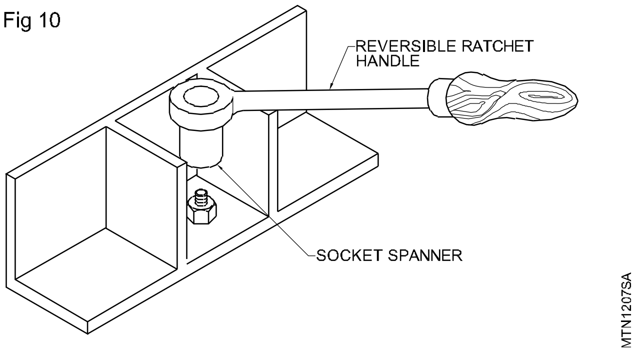


Fig 10

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

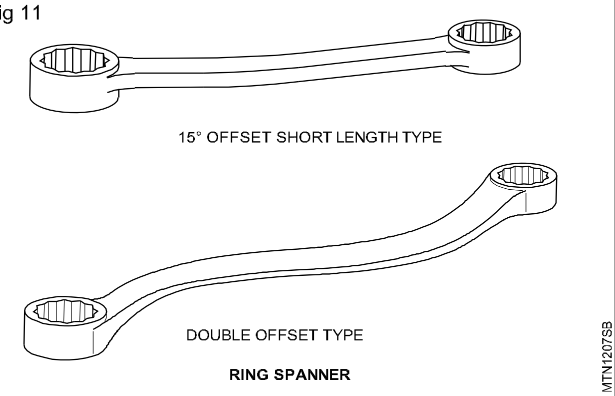


Fig 11

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

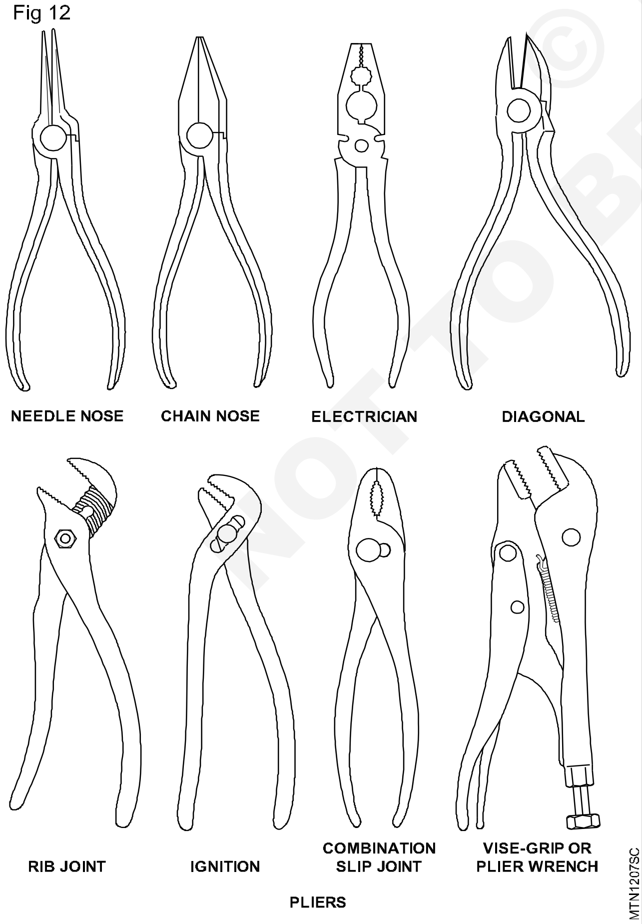


Fig 12

Safety

1 Avoid cutting hardened objects.

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

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

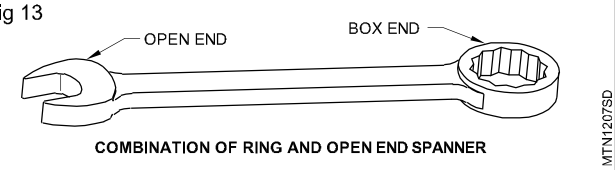


Fig 13

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

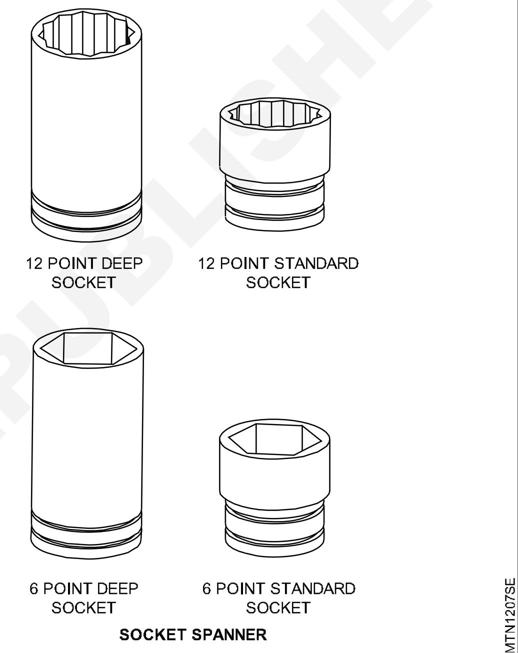


Fig 14

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.

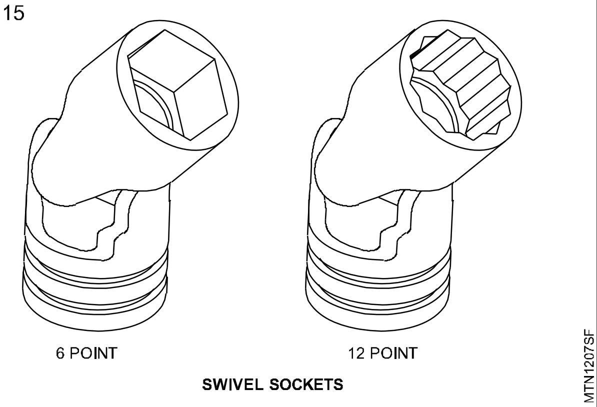


Fig 15

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

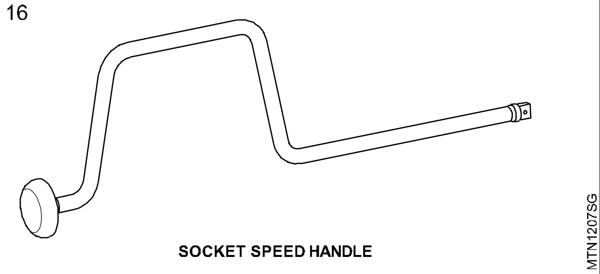
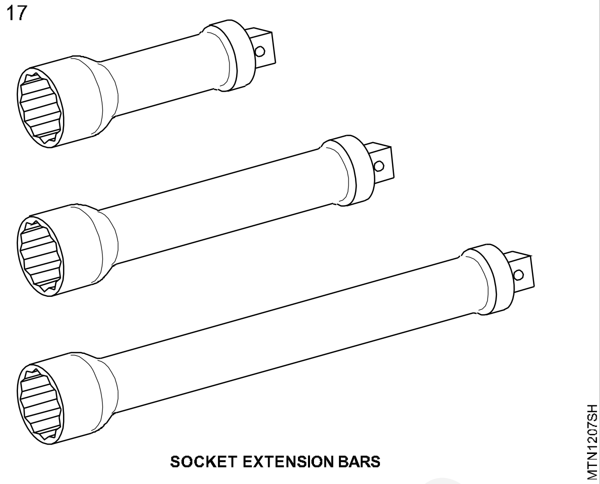


Fig 17



Pliers

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

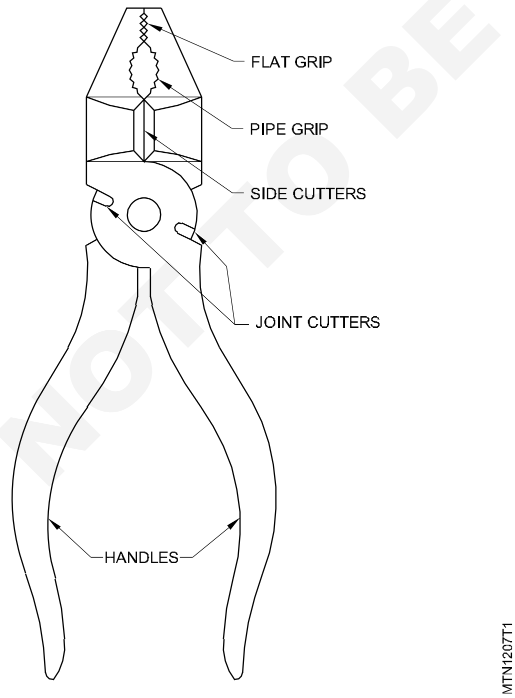
Features

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

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

- Flat jaw
- Pipe grip
- Side Cutters
- Joint cutters
- Handles

Fig 1

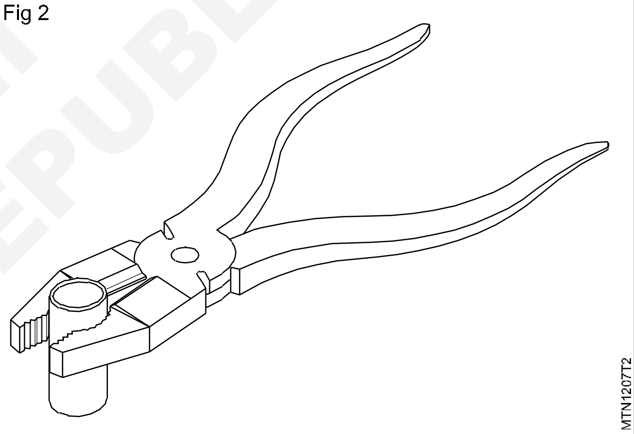


Features

Flat jaw tips are serrated for general gripping.

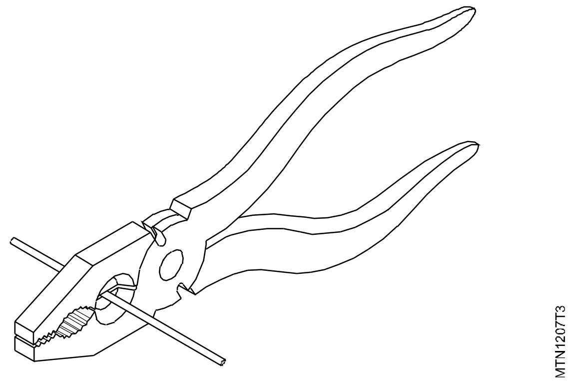
Pipe grip is serrated for gripping cylindrical objects. (Fig 2)

Fig 2



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

Fig 3

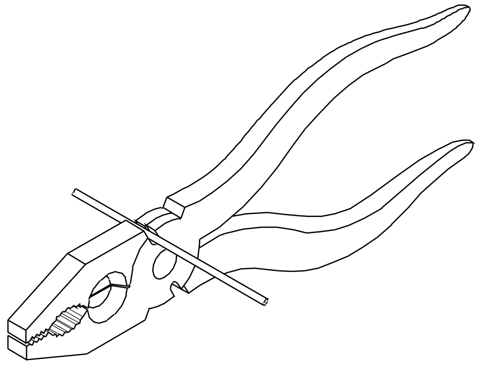


Two joint cutters are provided for cutting or shearing off steel wires (Fig 4)

Handles are used for applying pressure by hand.

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

Fig 4

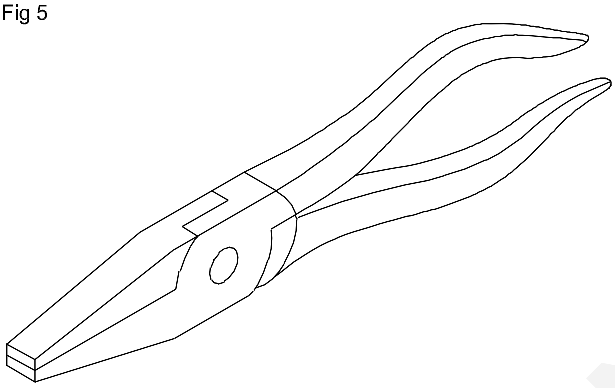


Other types of pliers

Flat nose pliers

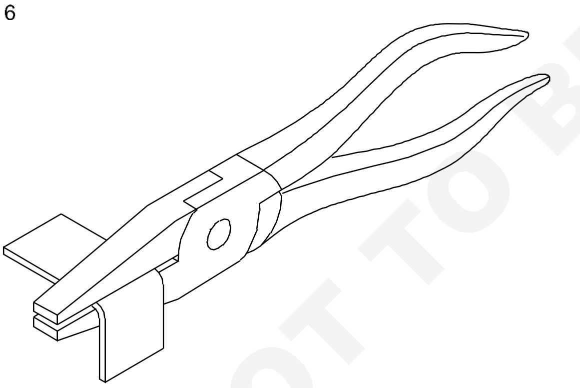
It has tapered wedge jaws with flat gripping surfaces which may be either smooth or serrated. (Fig 5)

Fig 5



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

Fig 6



Roundnose Pliers

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

Fig 7

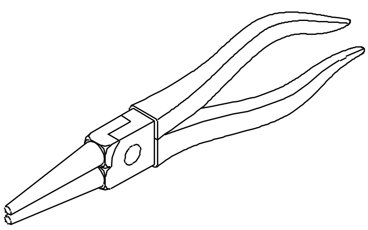
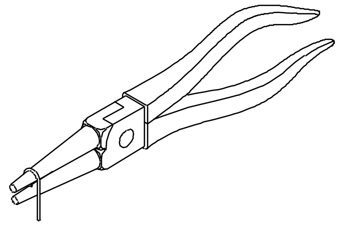


Fig 8

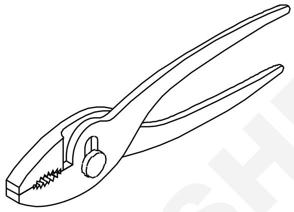


Slip-joint pliers

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

Mainly used for gripping. (Fig 9)

Fig 9



End cutting pliers

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

Fig 10

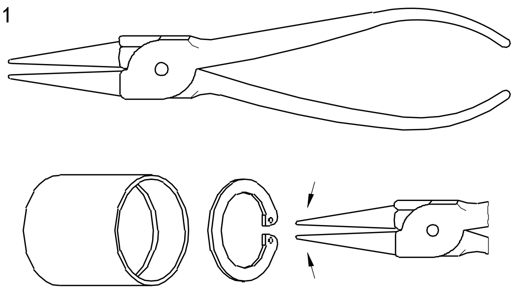
Circlip pliers

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

Internal circlip plier

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

Fig 11



Slip-joint, multi-grip pliers

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

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

Side cutting pliers

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

Fig 12

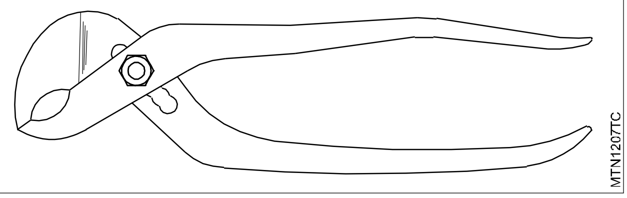


Fig 13

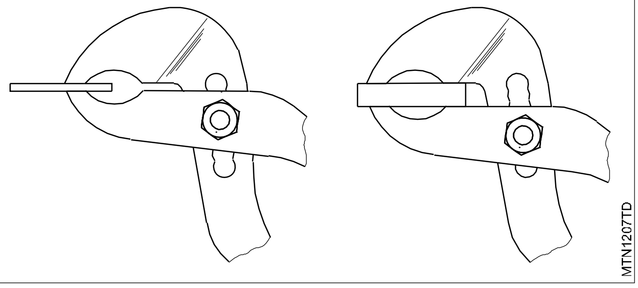
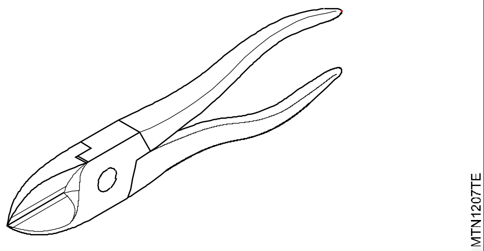
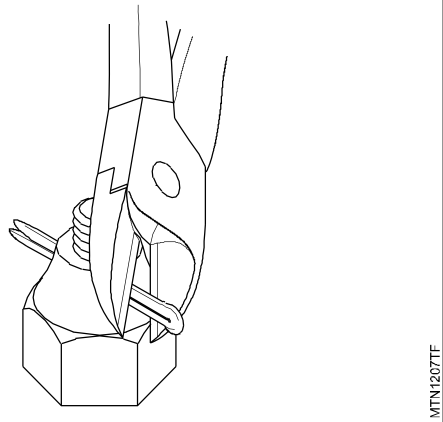


Fig 14



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

Fig 15



They are also used for spreading the cotter pin.

External circlip pliers

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

Locking pliers

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

It has high gripping power.

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

Air impact wrench, air ratchet

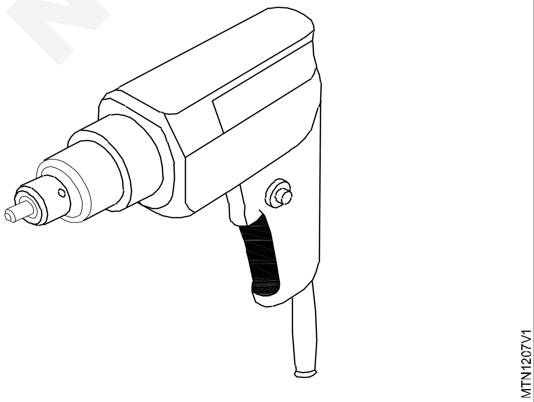
Objectives: At the end of this lesson you shall be able to
- **explain the use of air impact wrench**
- **explain the working principle of air impact wrench.**

Air impact wrench (Fig.1)

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

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

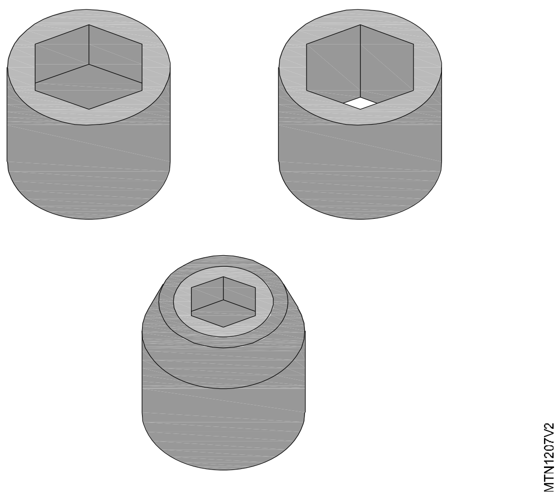
Fig 1



hardened impact socket extension and joints to withstand sudden force.

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

Fig 2



Air Ratchet (Fig.3)

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

It is also having square drive at different sizes.

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

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

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

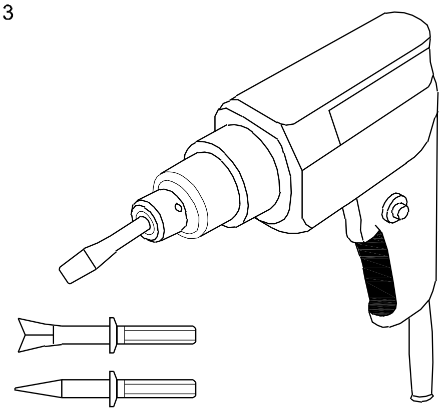
Air Chisel

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

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

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

Fig 3



Wrenches

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

Types of wrenches

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

Stillson pipe wrenches (Fig 1 & 2)

Fig 1

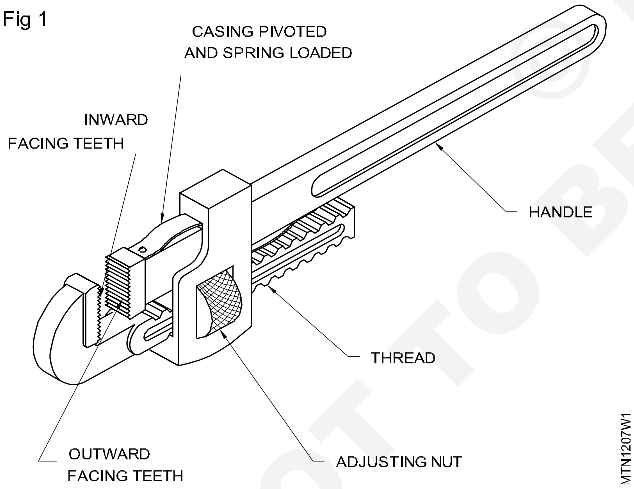
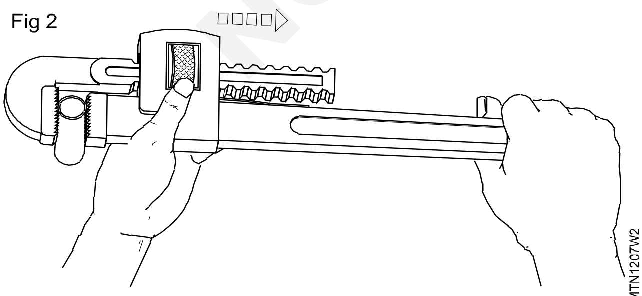


Fig 2



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

The parts and their names are shown in the diagram

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

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

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

Torque wrench (Fig.3)

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

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

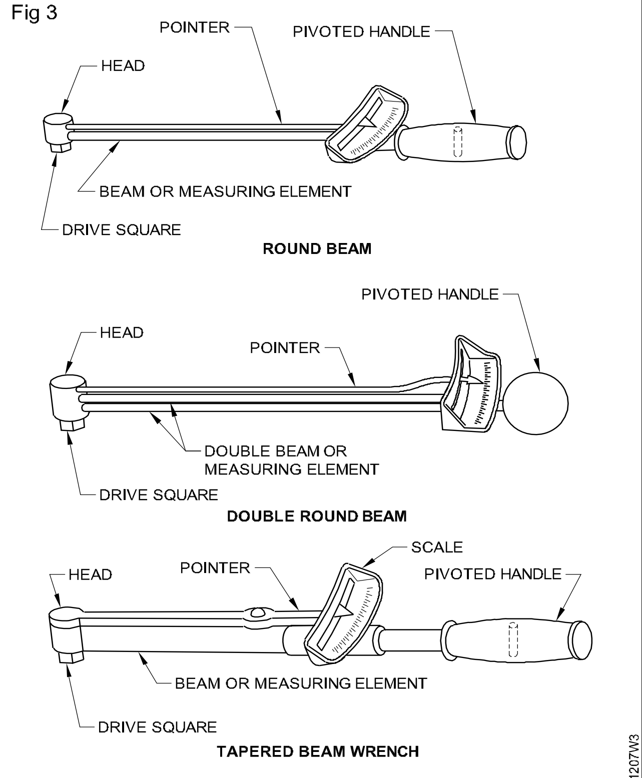
Dial type

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

Brake over (Micrometer)

It contains a micrometer scale (1) on the handle and a ratchet head (2). In this the torque can be set on the

Fig 3



TORQUE WRENCHES

micrometer scale: (Both pound-feet and metric scales are marked on the graduated barrel). The wrench makes a metallic 'click' that is heard and felt on the handle when fasteners are tightened at the correct.

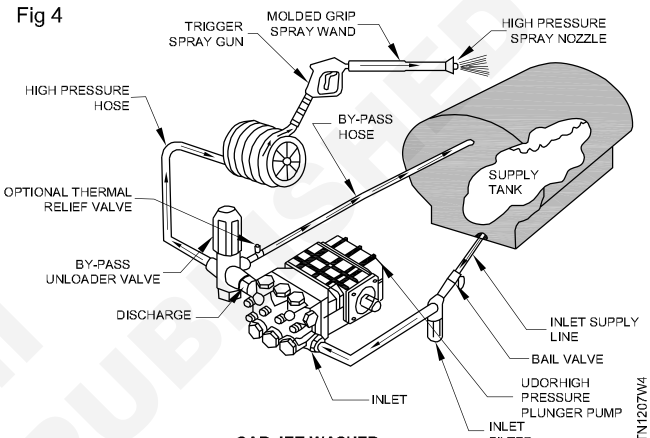
Torsion bar torque wrench: Its gauge is a simple pointer (3) that moves across a graduated scale (4) which shows the amount of torque being applied.

Digital read out torque wrenches are also available.

Car jet washer (Fig.4)

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

Fig 4



CAR JET WASHER

Puller

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

Puller

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

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

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

Another classification is based on the power utilized i.e. Mechanical puller and Hydraulic puller.

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

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

Safety

To avoid personal injury during system operation,

Always wear proper PPE gear

never use a tool to strike a puller

make sure that items are pulled is well and adequately supported

do not apply heat to a puller

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

use puller only with recommended attachment

do not over load a pulley which may cause to break

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

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

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

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

In Automobiles Hydraulic Puller especially used for marine engine liner from the cylinder block during engine Reconditioning Work.

Mechanical Puller Operation (Fig.1)

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

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

3 Tighten strap bolts to hold jaws lightly in place

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

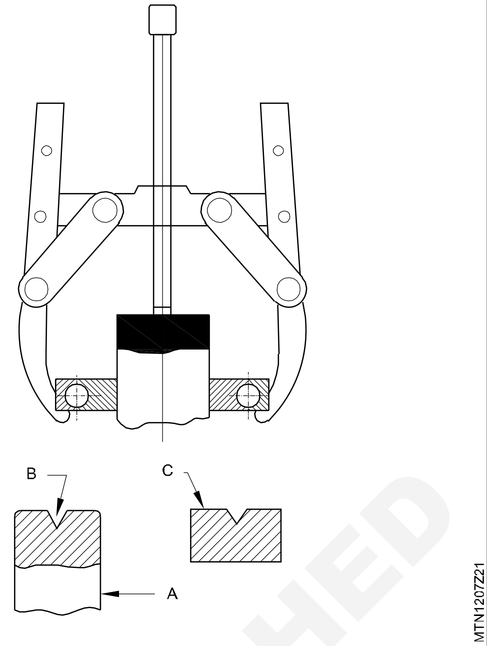
5 Tighten the spindle slightly by turning the spindle nut with proper wrench

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

7 Tighten the strap bolts.

8 Apply pulling force by turning the spindle.

Fig 1



Post lock puller operation (Manual pullers) (Fig.2)

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

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

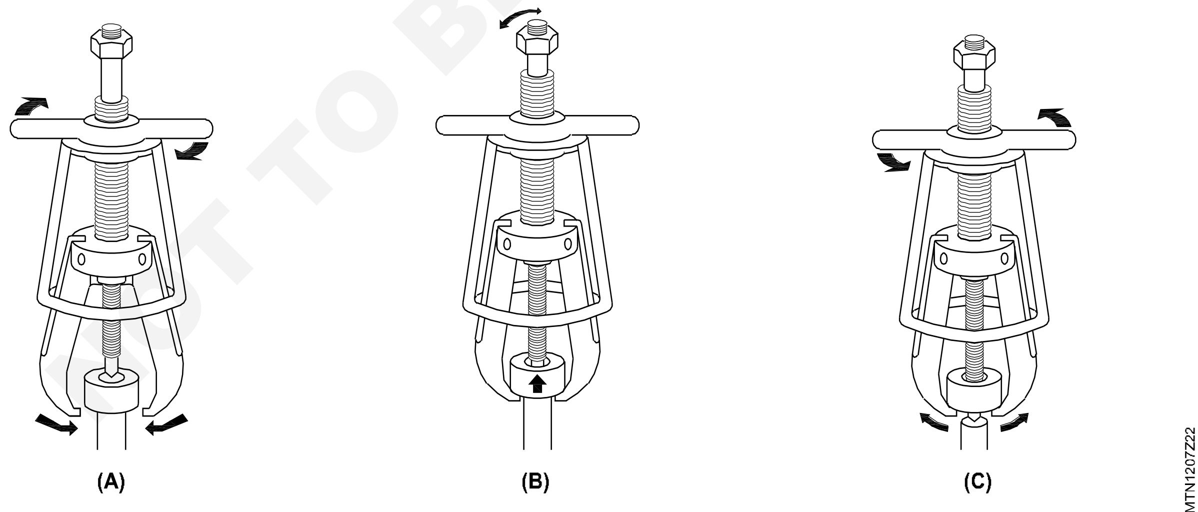
3 To operated the puller, grasp the puller with one hand and turn the T-handle counter-clockwise with the other hand until the jaw opening is big enough to fit over the component to be pulled.

4 Turn the T-Handle clockwise with the other hand until the jaw firmly onto the component. (Fig.2A)

5 Make sure that the centre of the puller is aligned with the centre of the component to be pulled. Using hand tools only, tighten the centre bolt to pull the component off of its shaft. Never exceed the maximum torque ratings of the puller’s drive bolt. (Fig.2B)

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

Fig 2

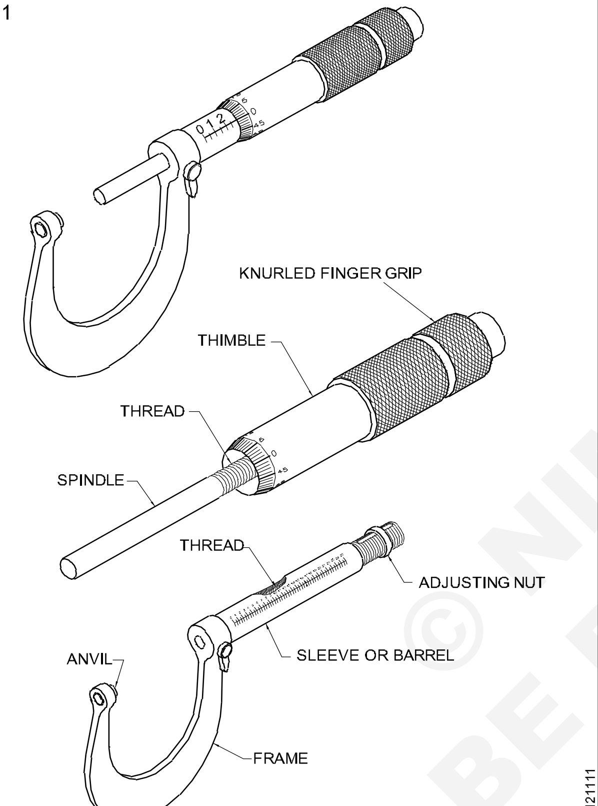


Outside micrometer

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

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

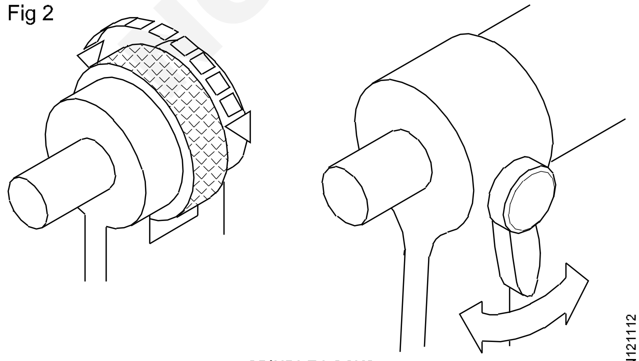
Fig 1



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.

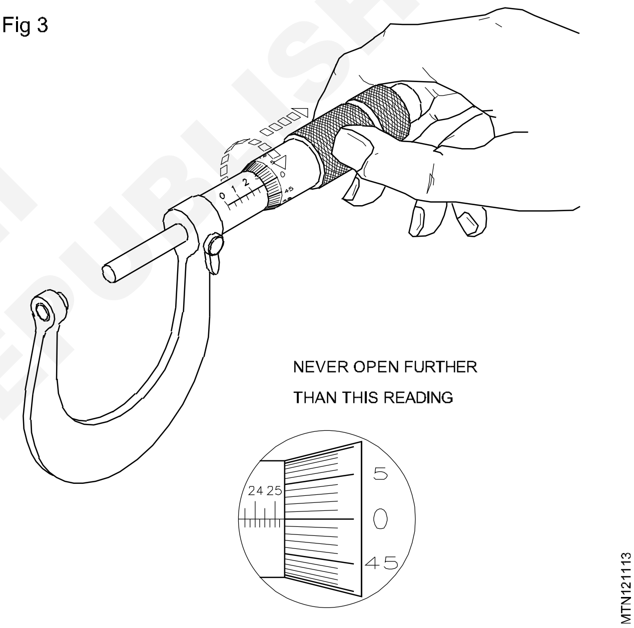
Fig 2



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.

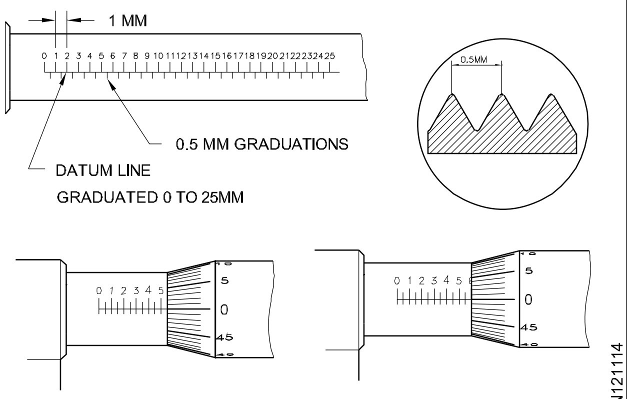
The spindle may be withdrawn by rotating the thimble in an anticlockwise direction. The thimble portion is knurled to provide a good grip for holding as well as for rotating the spindle.

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)

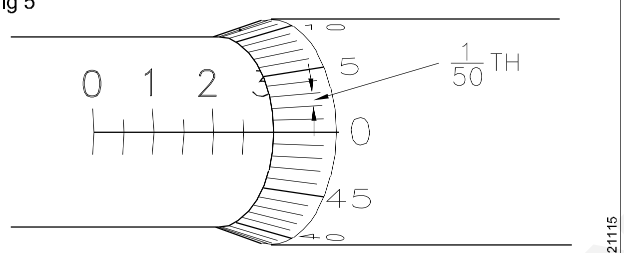
By turning one complete revolution of the thimble in a clockwise or an anticlockwise direction, the spindle moves exactly ½ mm in the forward direction or the reverse direction. As the circumference of the thimble graduated into 50 equal divisions, the advancement of the spindle for each division of 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 4



NOTE RELATIVE POSITIONS OF SLEEVE GRADUATIONS

Fig 5



THIMBLE GRADUATED INTO 50 PARTS

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.

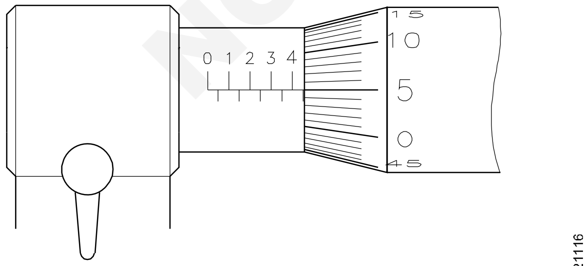
The faces of the anvil spindle must be free from dust.

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



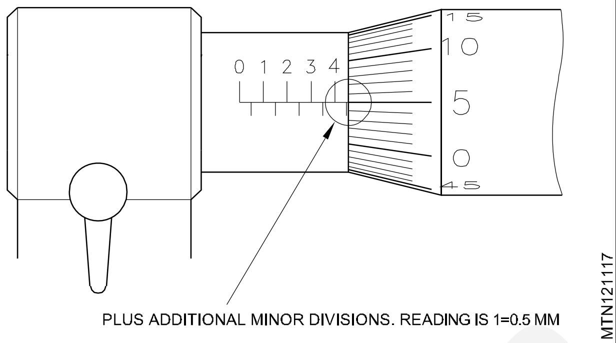
EACH MAJOR DIVISION ON BARREL =1 MM READING IS 4 = 4 MM

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)

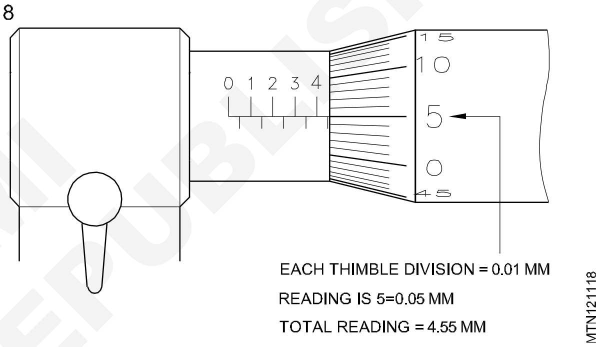
Add the thimble reading to the two earlier readings. (Fig 7)

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)

Fig 8



a 4.00 mm

b 0.50 mm

c 0.05 mm

Total reading 4.55 mm

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

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 (Fig 9)

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

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

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

Fig 10

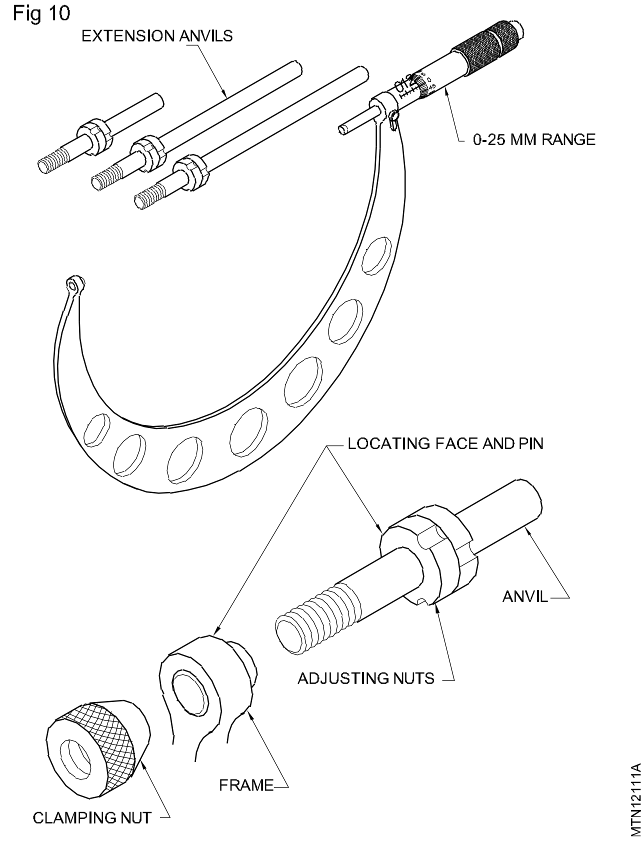


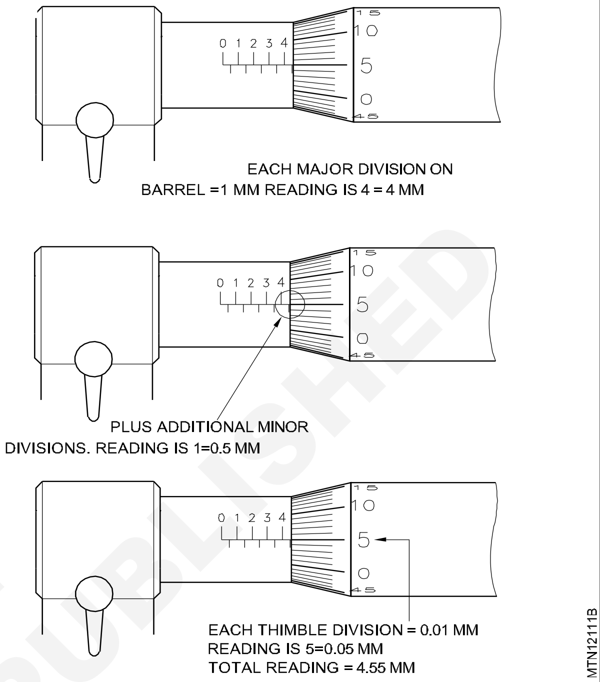
Figure 'b' shows 1 division = 0.5 mm.

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

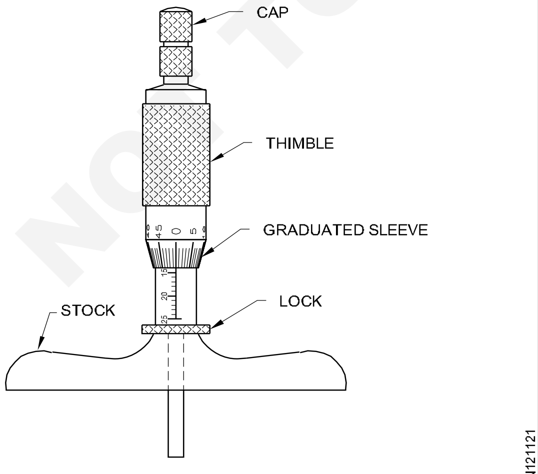


Depth micrometer

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)

Fig 1



DEPTH MICROMETER

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.

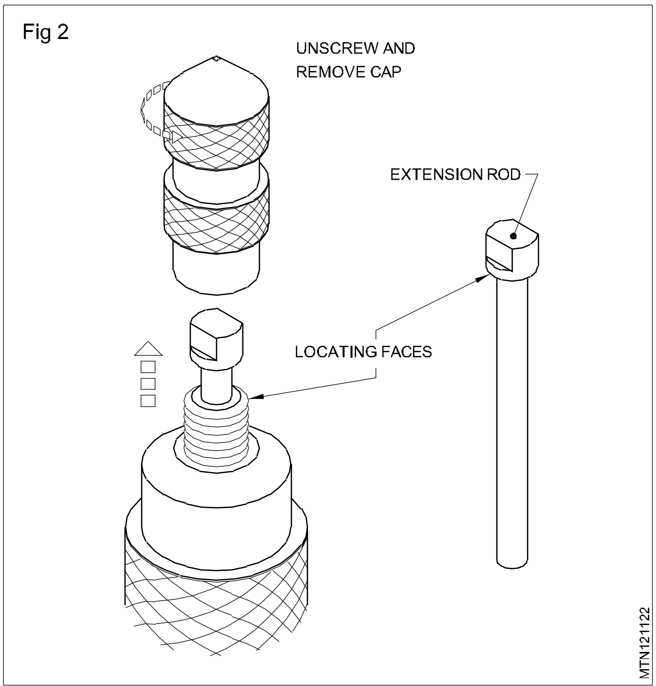
The other end of the thimble has an external step machined and threaded to accommodate a thimble cap.

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.

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

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

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



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

Graduation and least count

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

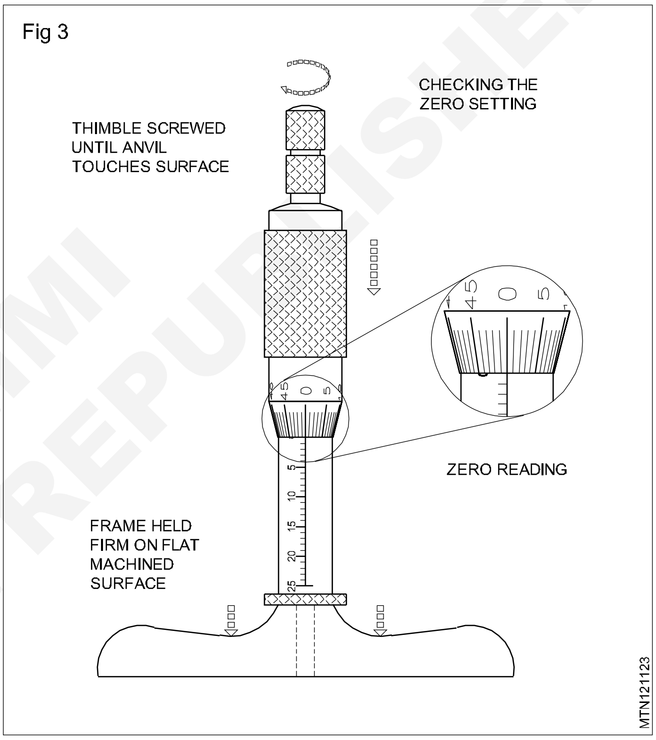
Therefore the advancement of the extension rod for one division movement of the thimble will be equal to 0.5 / 50 = 0.01 mm.

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.



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 its functional features**
- **list out the points for taking the measurements.**

This one of the precision instruments having the principle of vernier applied to it 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)

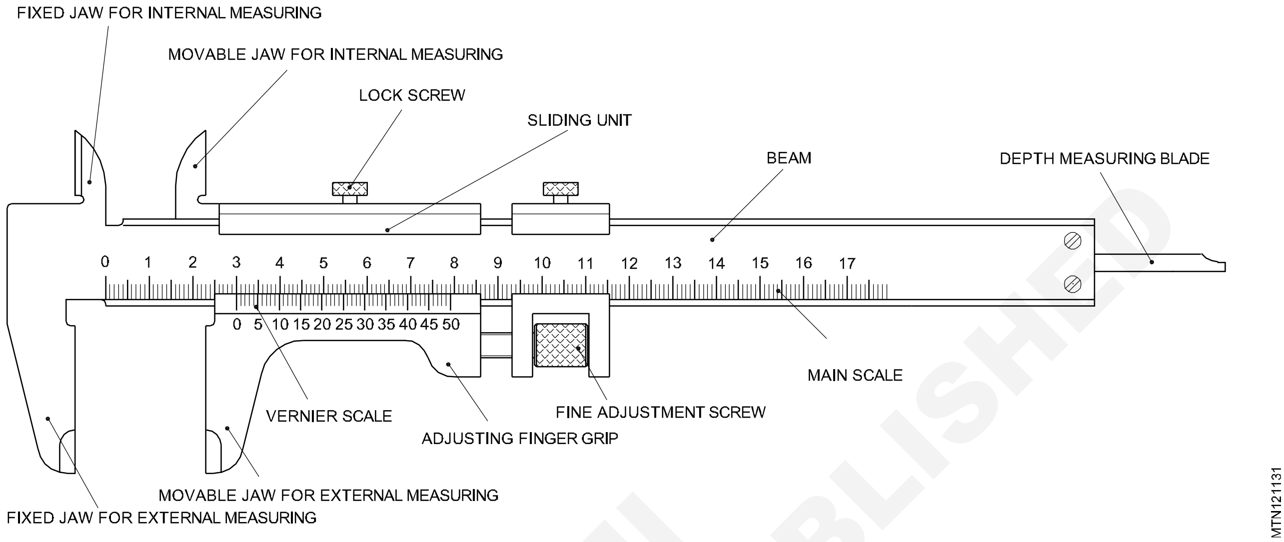
The beam is the main part and the main scale graduations are marked on it. The markings are in millimeters and every tenth line is drawn a little longer and brighter than the other graduations and numbered as 1,2,3 ….

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.

Fig 1



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

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

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

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

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

Least count

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

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

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

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

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

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

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

Advantages

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

Disadvantages

Accuracy of reading depends on the skill of the operator.

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

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

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

To read a measurement

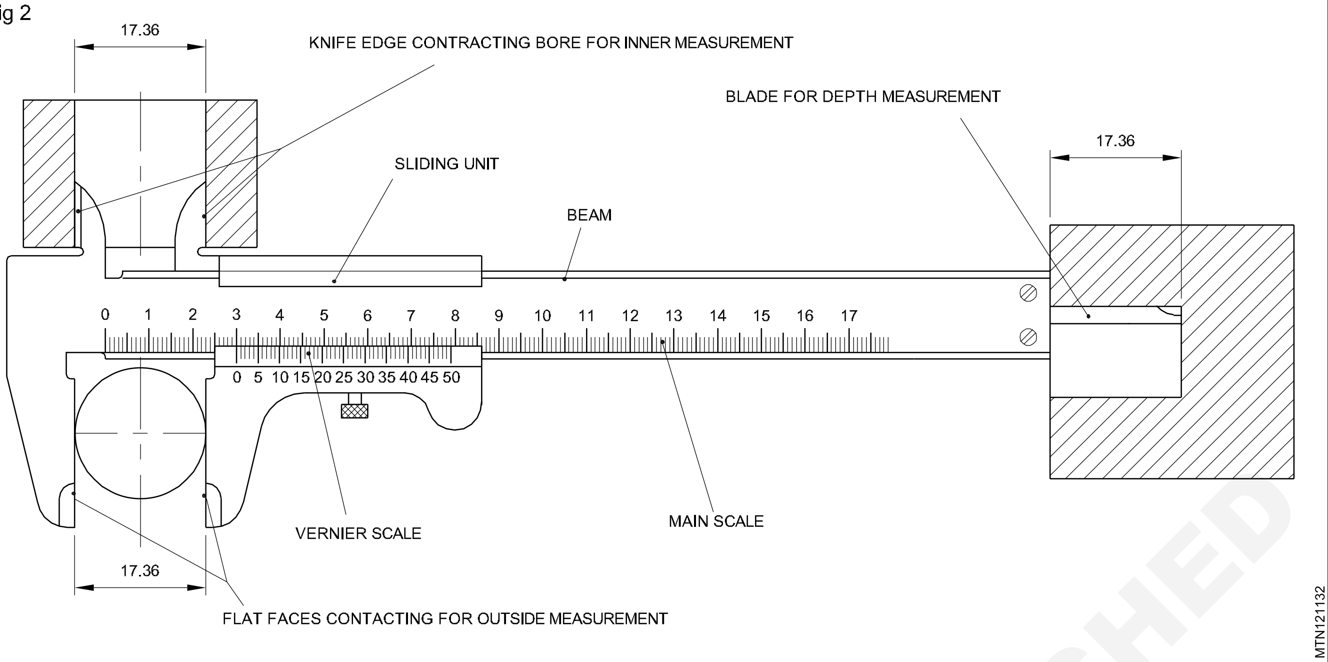
Note the number of graduations on the main scale passed by the zero of the vernier. This gives the full mm.

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

Multiply this number with the least count.

Add the multiplied value to the main scale reading.

Fig 2



Telescope gauge

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

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

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

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

Measuring Technique

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

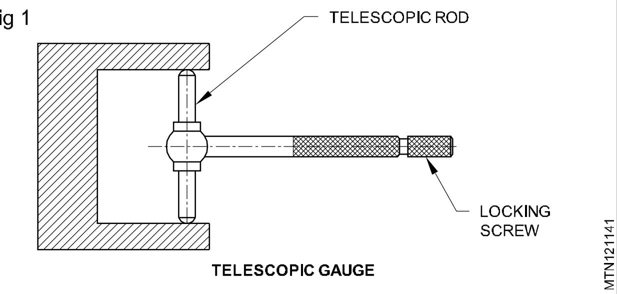
(b) Insert the gauge ends into the hole to be measured.

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

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

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

Fig 1



Dial bore gauge

Objectives: At the end of this lesson you shall be able to
- **name the parts of a bore dial gauge**
- **state the features of a bore dial gauge**
- **read the measurement using a graduated dial.**

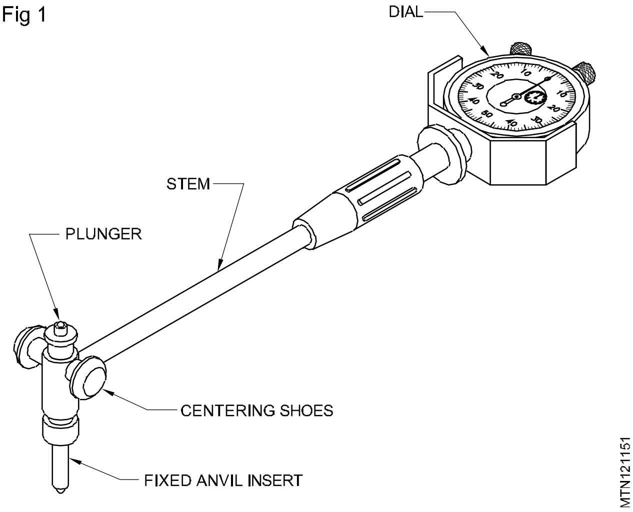
This is a precision measuring instrument used for measuring the internal dimensions. The dial bore gauge is normally available as a two-point, self-cantering type

Dial bore gauge (Fig.1)

Stem

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

Fig 1



Fixed anvil/inserts

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

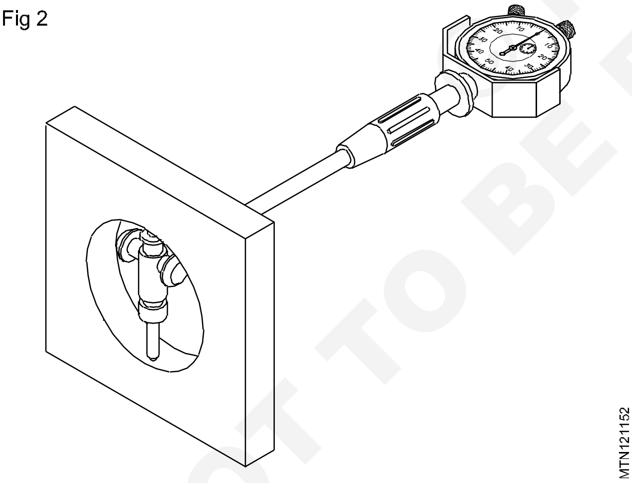
Sliding plunger

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

Centering shoes/spherical supports

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

Fig 2

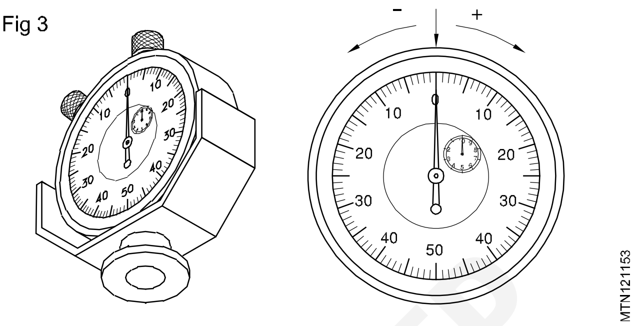


This maintains the alignment of the measuring faces in the centre of the bore. For some types, two spherical supports which are spring-loaded are provided.

Dial Indicator (Fig 3)

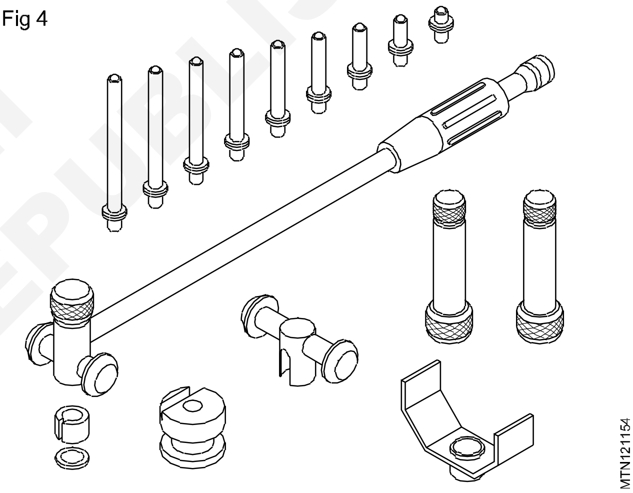
This has graduations marked on the dial. The graduations has marked in clockwise and anticlockwise directions.

Fig 3



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

Fig 4



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

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

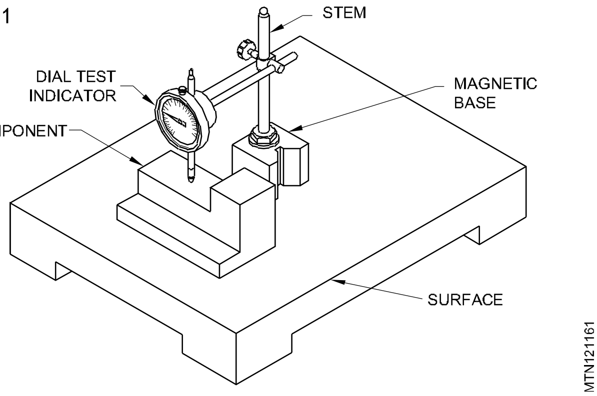
Dial test indicators

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

Dial test indicators

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

Fig 1



Principle of working

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

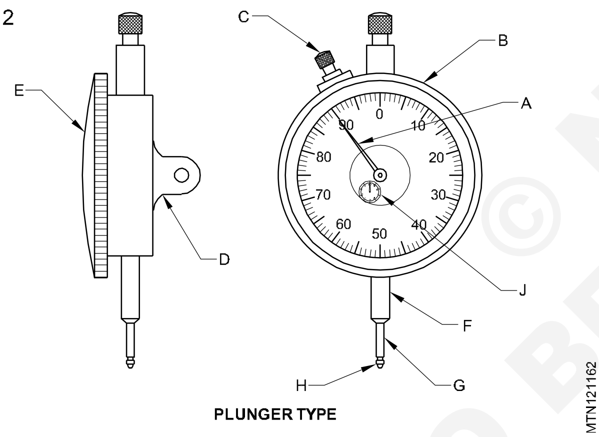
Types

Two types of dial test indicators are in use.

They are the

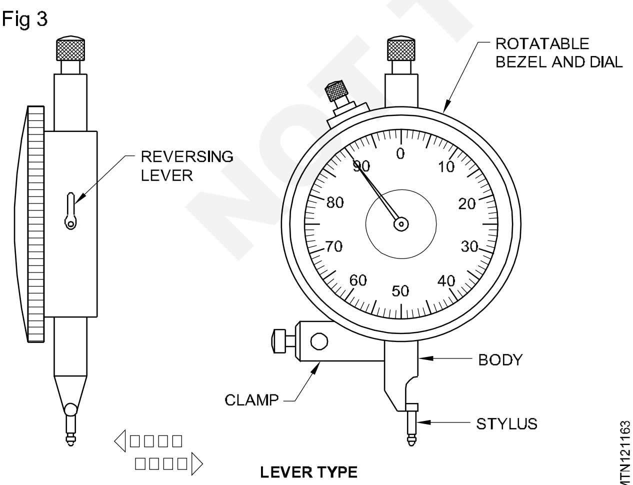
- Plunger type (Fig 2)

Fig 2



- Lever type. (Fig 3)

Fig 3



The plunger type dial test indicator

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

Pointer (A)

Rotatable bezel (B)

Bezel clamp (C)

Back lug (D)

Transparent dial cover (E)
Stem (F)
Plunger (G)

Anvil (H)

Revolution counter (J)

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

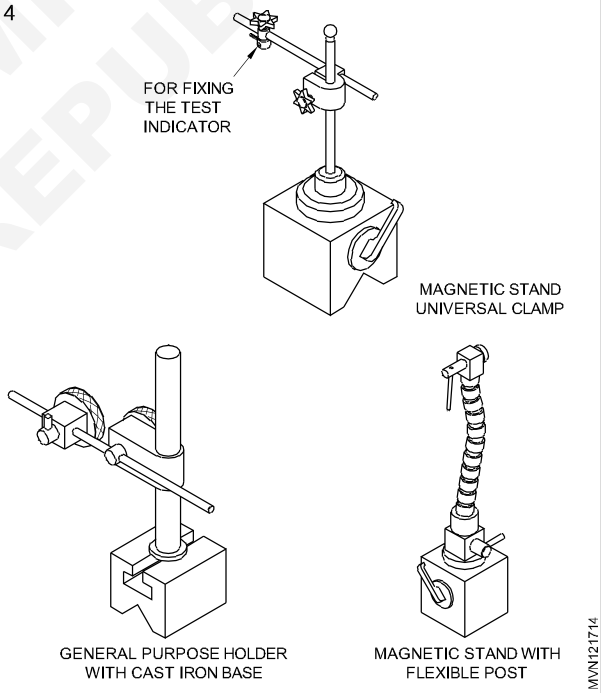
The lever type dial test indicator (Figs 3,4,5)

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

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.

Fig 4



Important features of dial test indicators

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

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

Uses

- To compare the dimensions of workpiece against a known standard, eg. Slip gauges.

- To check plane surfaces for parallelism and flatness.
- To check straightness of shafts and bars.
- To check concentricity of holes and shafts.

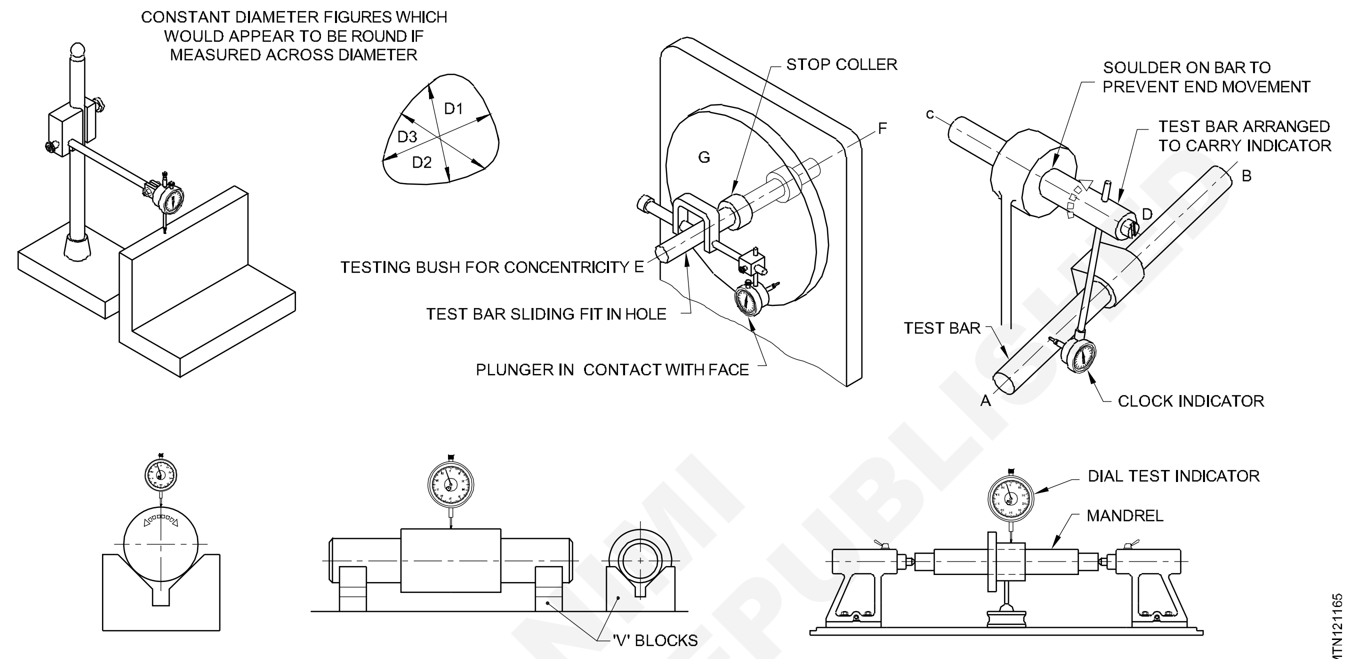
Indicator stands (Fig 4 & 5)

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

The different types of stands are:

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

Fig 5



Straight edges

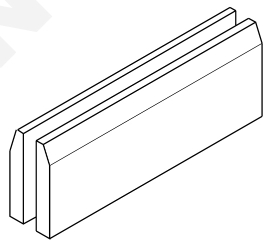
Objectives: At the end of this lesson you shall be able to
- **name the different types of straight edge**
- **state the straight edge uses edge**
- **state the different method of testing straightness.**

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

Steel straight edges

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

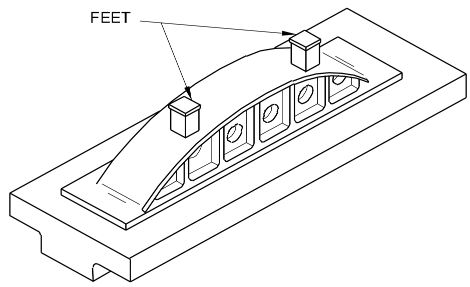
Fig 1



Cast iron straight edges (Fig 2)

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

Fig 2

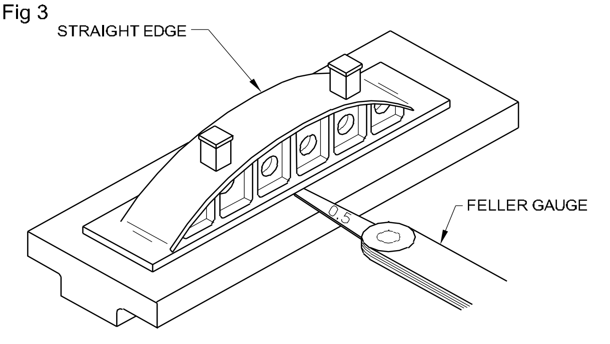


Use of straight edges

Checking with feeler gauges

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

Fig 3



USE OF STRAIGHT EDGE -FELLER GAUGE

Feeler gauge & uses

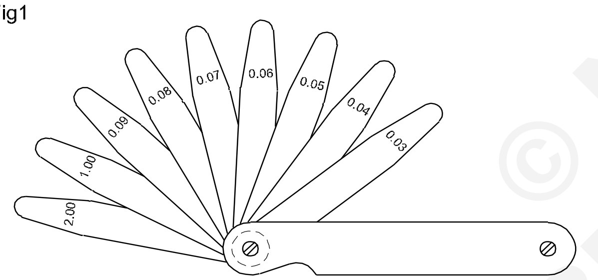
Objectives: At the end of this lesson you shall be able to
- **state the constructional features of a feeler gauge**
- **state the method of indicating different ranges of feeler gauges**
- **state the method of setting a feeler gauge**
- **state the different type of feeler gauges.**

Features

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

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

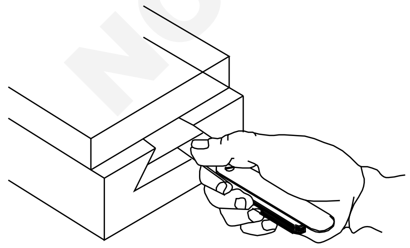
Fig1



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

The dimension being tested is judged to be equal to the thickness of the leaves used. When a slight pull is felt while with drawing them. Accuracy in using these gauges requires a good sense of feel. (Fig.2)

Fig 2



B.I.S

The Indian standard establishes four sets of feeler gauges Nos.1,2,3 and 4 which differ by the number of blades in each and by the range of thickness(minimum) is 0.03mm to 0.1mm the length of blade is usually 100mm

Example

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

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

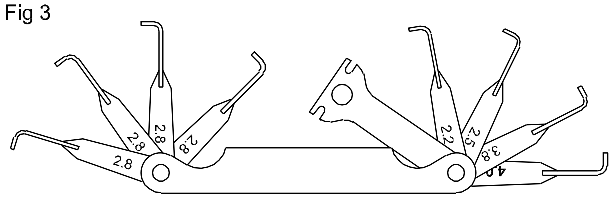
Uses

Feeler gauges are used:

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

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

Fig 3



WIRE GAUGE SET FOR CHECKING SPARK PLUG GAP

Types of feeler gauge

1 universal master gauge

2 standard feeler gauge

3 ignition and wire gauge

Classification of feeler gauge

- Universal master gauge containing 25 leaves
- Standard feeler gauge containing 10 leaves

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.

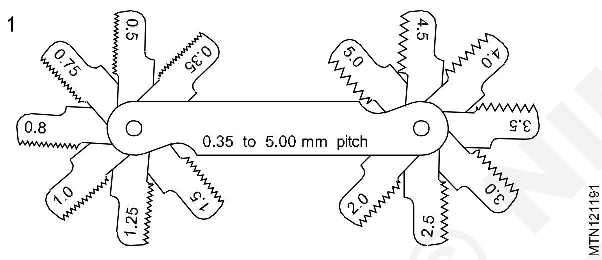
Constructional features

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.

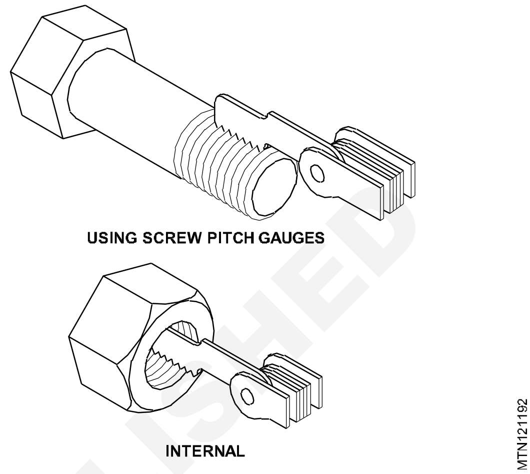
The thread profile on each blade is cut for about 25 mm or 30 mm. The pitch of the blade is stamped on each blade. The standard and range of the pitches are marked on the case. (Fig 1)

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



Vacuum gauge

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

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

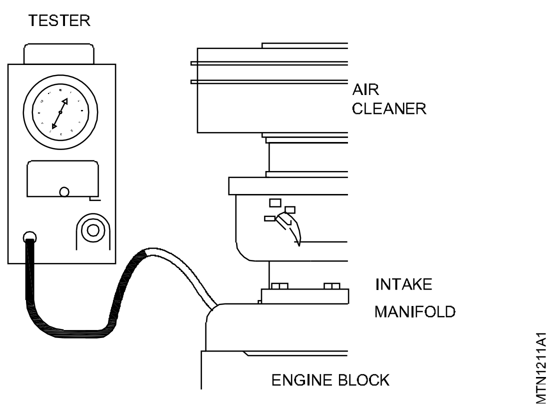
It is used to detect vacuum leaks at idle speed, sticking valves, worn rings, clogged exhaust, incorrect timing and positive crank case ventilation (PCV)

Attaching Vacuum Gauge

At normal operating temperature connect the vacuum gauge to the intake manifold. Some manifolds incorporated a plug that may be removed so that vacuum line adopter may be installed.

- A relative study high vacuum reading indicate an absence vacuum leak in the system (i.e) values and rings are in good sealing.
- Fairly study vacuum reading indicate vacuum leak in the system (i.e) value and rings are not in good sealing.
- Vacuum reading indicate uneven, valve are burned or sticky and damaged piston or blown gasket.

Fig 1



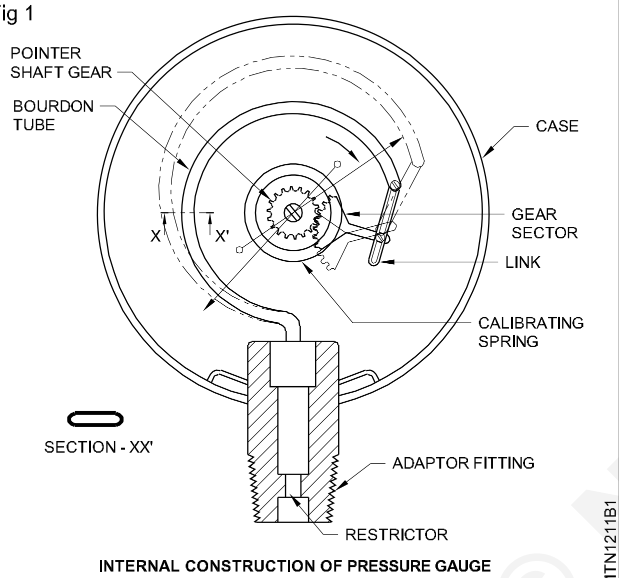
Tyre pressure gauge

Objectives: At the end of this lesson you shall be able to
- **state the construction and features of tyre pressure gauge**
- **use a tyre pressure gauge to check & set tyre pressure.**

Pressure gauge (Figs 1,2)

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

Fig 1



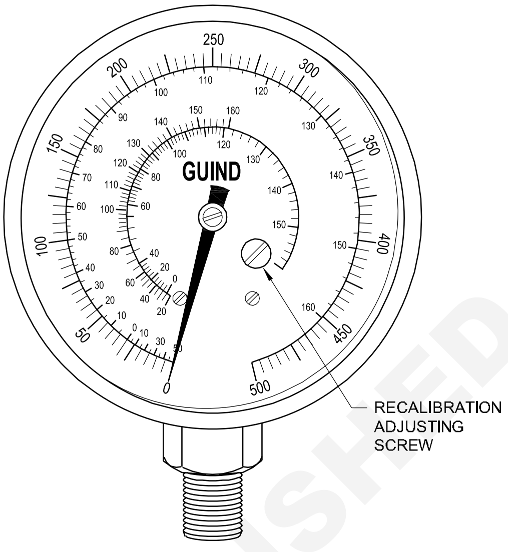
INTERNAL CONSTRUCTION OF PRESSURE GAUGE

Special features

- Excellent load-cycle stability and shock resistance.
- All stainless steel construction
- Positive pressure ranges 0-200 P.S.I (Fig 3)

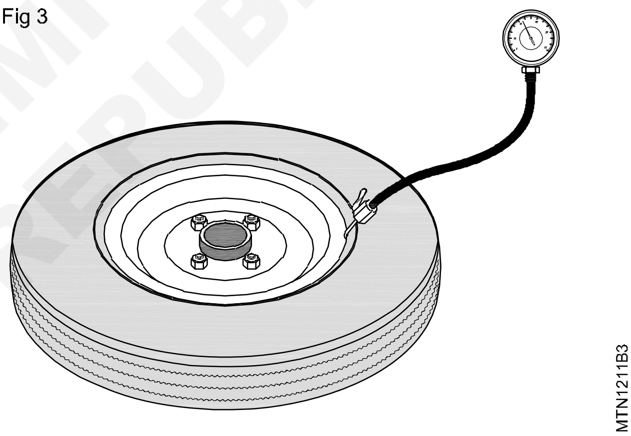
The pressure gauge hose has a adapter, which depresses the valve pin of tyre and compressed air get into the tube of the gauge. The pressure is indicated in the dial. Compare the pressure to the recommended pressure by the manufacturer. If it is less, refill the tyre with compressed air by operating the trigger. When the required pressure is shown in the gauge stop filling.

Fig 2



PRESSURE GAUGE

Fig 3



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.**

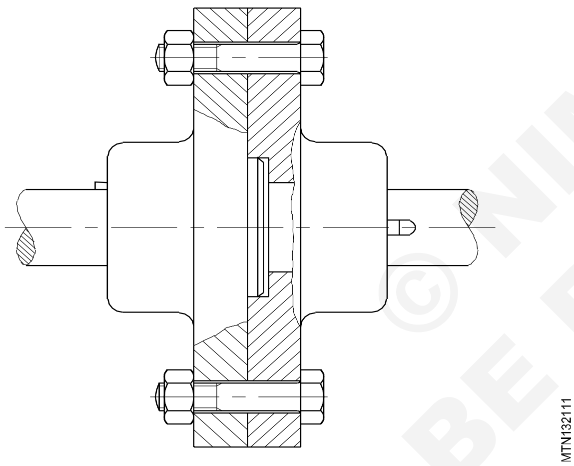
Bolts and nuts (Fig.1)

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

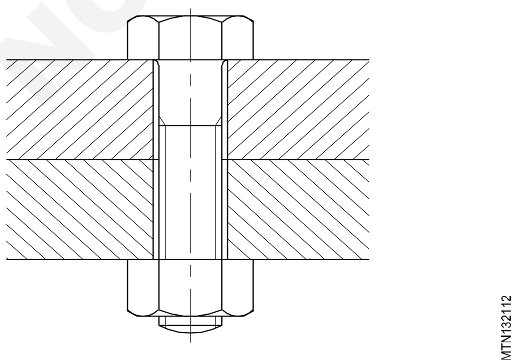


Bolts with clearance hole (Fig.2)

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

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

Fig 2

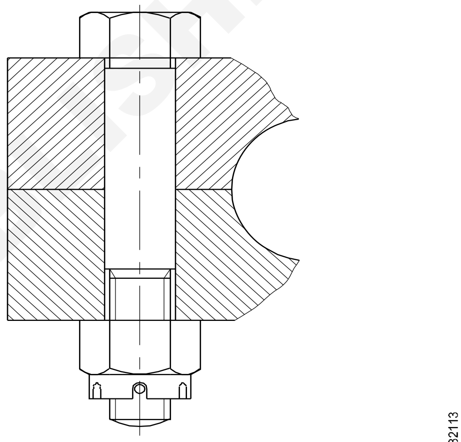


Body fit bolt (Fig.3)

This type of bolt assembly is used when the relative movement between the workpieces has to be prevented. The diameter of the threaded portion is slightly smaller than the shank diameter of the bolt.

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

Fig 3



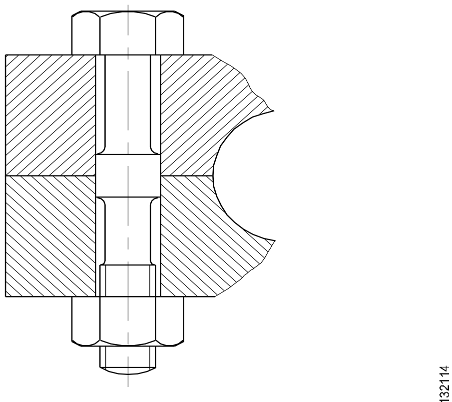
BODY FIT BOLT

Anti-fatigue bolt (Fig.4)

This type of bolt is used when the assembly is subjected to alternating load conditions continuously. Connection rod big ends in engine assembly are examples of this application.

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

Fig 4

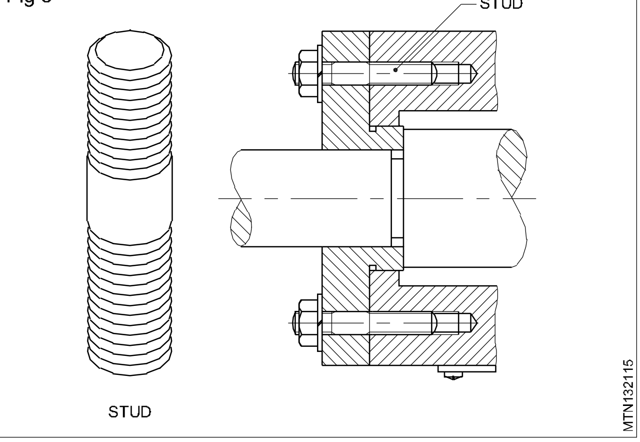


ANTI-FATIGUE BOLT

Studs (Fig.5)

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

Fig 5



When excesssively tightened, the variation in the thread pitch allows the fine thread or nut end to slip. This prevents damage to the casting.

Designation of bolts as per B.I.S. specifications

Hexagon head bolts shall be designated by name, thread size, nominal length, property class and number of the Indian Standard.

Example

A hexagon head bolt of size M10, nominal length 60mm and property class 4.8 shall be designated as:

Hexagon head bolt M10x60 - 4.8-IS: 1363 (Part 1)

Explanation about property class

The Part of the specification 4.8 indicates the property class (mechanical properties). In this case it is made of steel with minimum tensile strength = 40kgf/mm2 and having a ratio of minimum yield stress to minimum tensile strength = 0.8.

NOTE

Indian standard bolts and screws are made of three product grades - A,B, & C, `A' being precision and the others of lesser grades of accuracy and finish.

While there are many parameters given in the B.I.S. specification, the designation need not cover all the aspects and it actually depends on the functional requirement of the bolt or other threaded fasteners.

For more details on the designation system, refer to IS: 1367, Part XVI 1979.

Locking Devices

Objectives : At the end of this lesson you shall be able to
- **state the locking device**
- **state the classification of lock nuts**
- **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

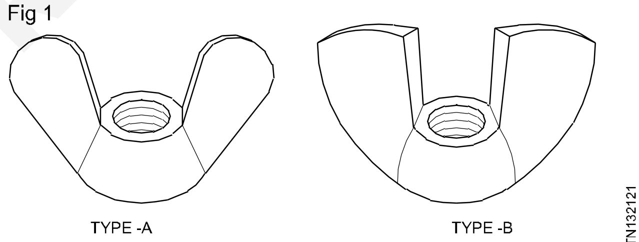
These nuts have special provision in the form of slots for fixing split pins for locking the nuts.

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).

Fig 1



Thumb-nut (Fig. 2)

These are used in places where frequent adjustments are required and mere finger tightening enough. They are available in two types - Types A & Type B.

Cap nut (Fig. 3)

These are used to protect the bolt end threads from damages and also as a protector for safe working. They serve to provide a decorative appearance.

Hexagonal nuts with collar (Fig. 4)

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

Fig 2

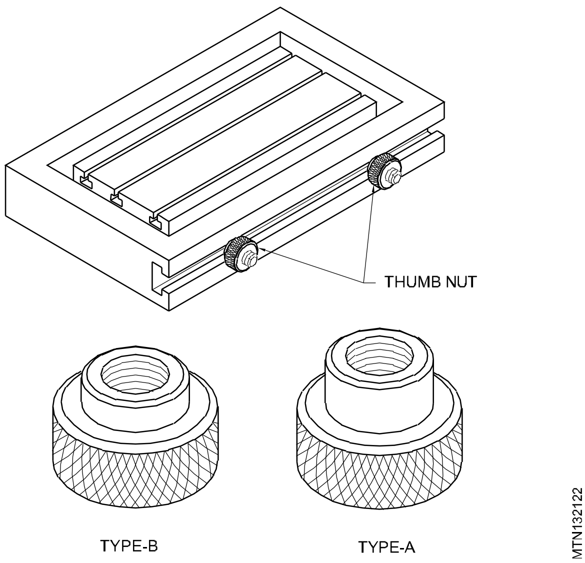


Fig 3

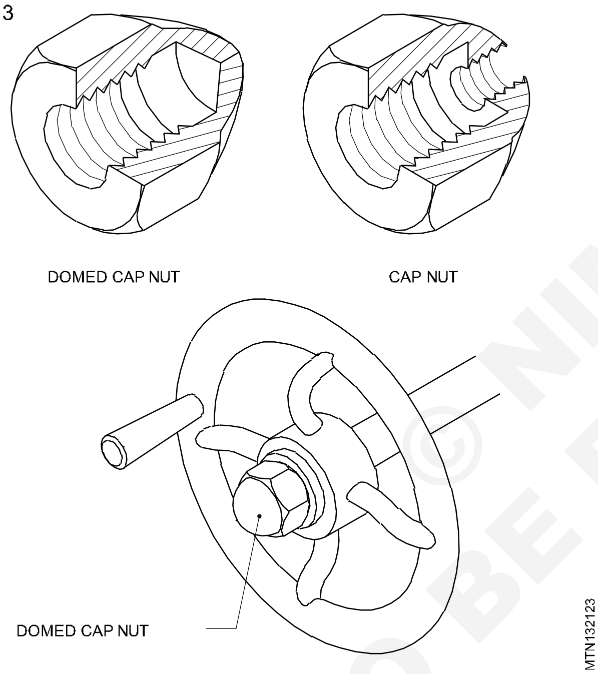
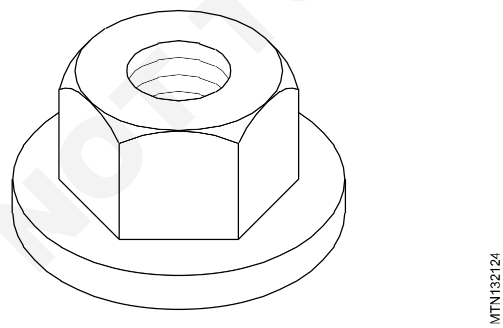


Fig 4

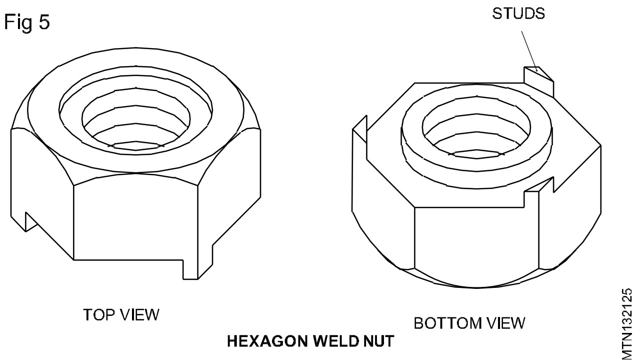


Hexagonal weld nuts (Fig. 5)

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

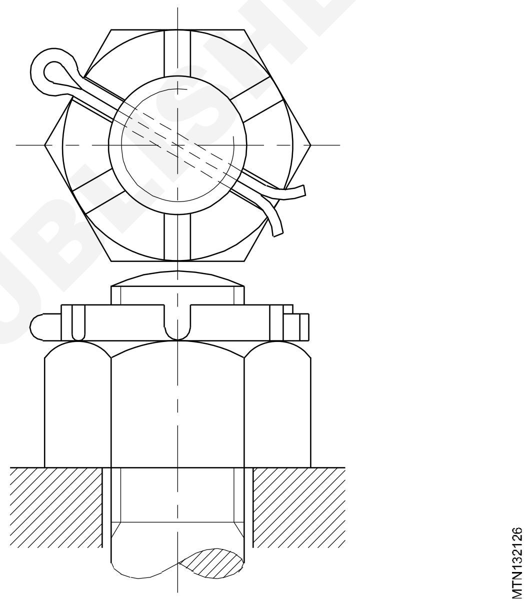
- a spigot ring which fits in the hole of the plate
- three projections to provide a uniform contact on the surface, that is to be welded
- a countersunk hole on one end to protect the thread during welding.

Fig 5



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

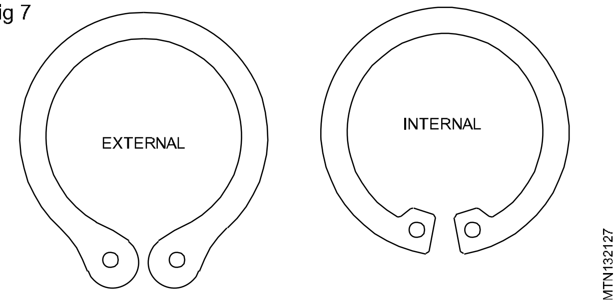
Fig 6



Circlip (Fig. 7)

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

Fig 7

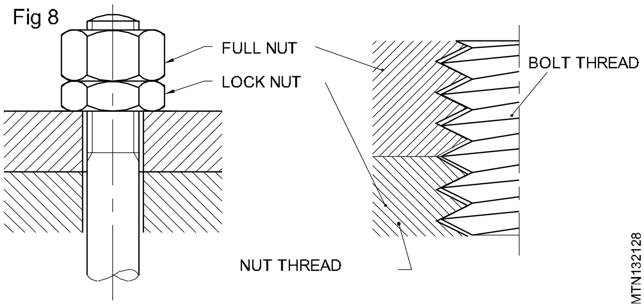


Chuck nut (Fig. 8)

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

A chuck nut is also called a lock-nut. The two nuts are thus locked or wedged tightly against each other and against the bolt. This will prevent slackening.

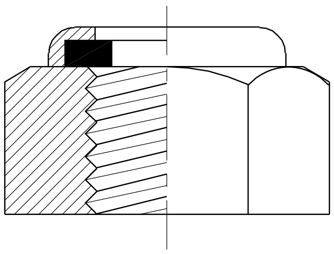
Fig 8



Self-locking nut (Fig. 9)

Self-locking nut will have a nylon insert to prevent the loosening of the nut from shock, vibration and temperature.

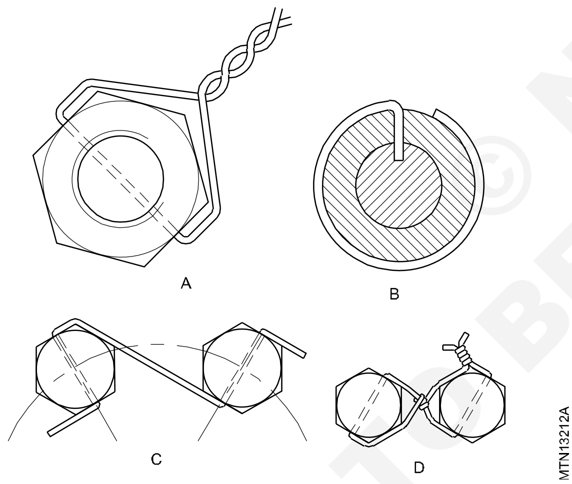
Fig 9



Wire lock (Fig. 10)

Wire locks are used for light engineering works. The wire is passed through the groove.

Fig 10



Nut applied with a sealant

These locking devices are for permanent locking in light works.

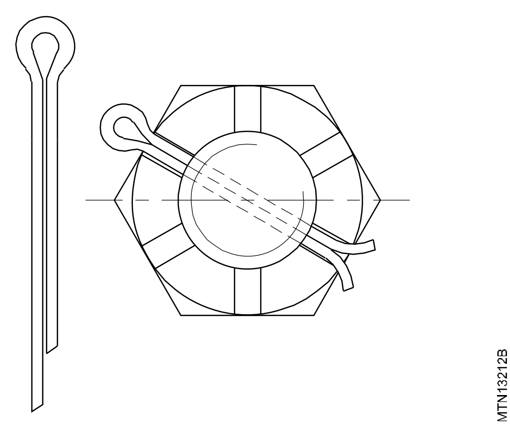
Split pin (Fig. 11)

A split pin is made from a steel wire of semicircular cross section, bent as shown in the figure. It is inserted in a hole drilled in the bolt so that it exerts pressure on the top face of the nut to prevent it from turning.

Sawn nut (Wiles nut)

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

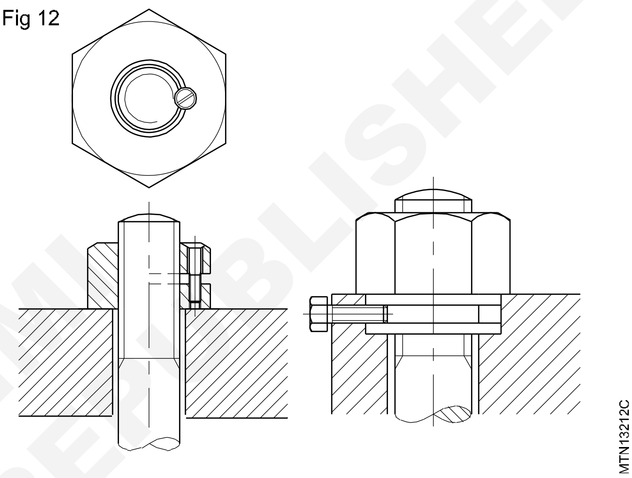
Fig 11



Positive locking device (Fig. 12)

Frictional locking device

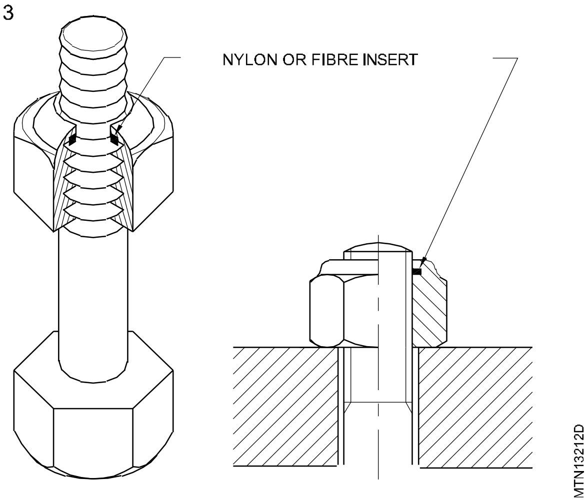
Fig 12



Positive locking device (Fig. 13)

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

Fig 13



Eg. Clutches, brakes, controls etc.

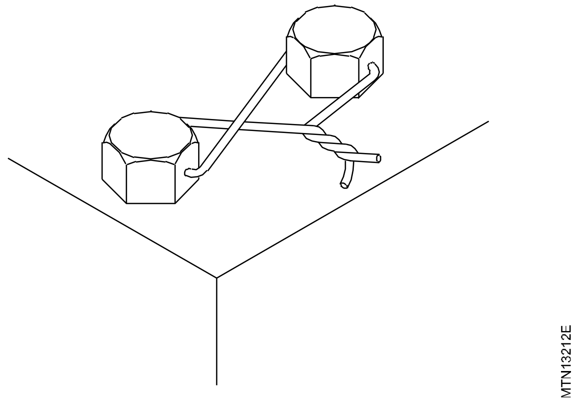
The positive locking devices are:

- standard hexagonal nut, cross-drilled and pinned

- standard slotted nut
- standard castle nut
- hexagonal nut and locking plate
- wiring bolt heads.

Frictional locking devices (Fig 14)

Fig 14



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

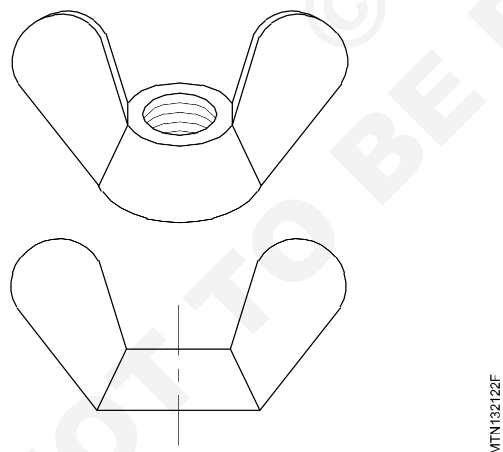
The frictional locking devices are:

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

Commonly used locking devices

Wing-nut (Fig. 15)

Fig 15



A wing-nut is used where frequent adjustment or removal is necessary. It can be loosened or tightened rapidly without the need of a wrench. These nuts are manufactured with the same material as is used for the bolts.

Thumb-nut

A thumb-nut is used where the movement of the spindle is to be locked, as in a micrometer. Stopping the movement of the spindle is necessary for taking a correct reading.

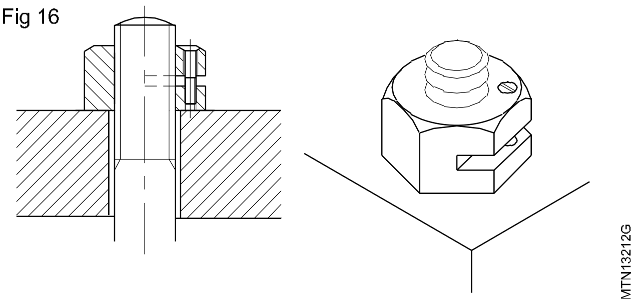
Locking ring

A locking ring is used in taper nose spindles of lathes to lock the chuck.

Castle nut (Fig. 16)

Slots are cut in a cylindrical collar provided on the top of the nut, thus overcoming the disadvantage of the slotted.

Fig 16



Slotted and castle nut with a split pin

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

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

Fig 17

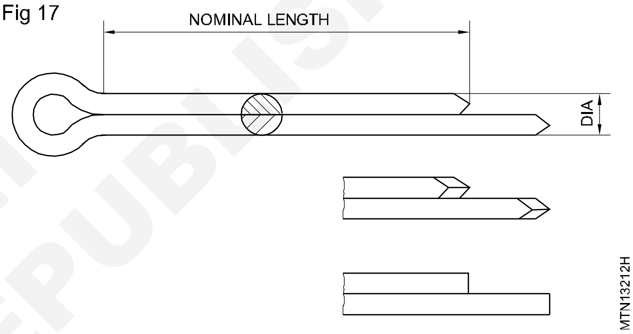
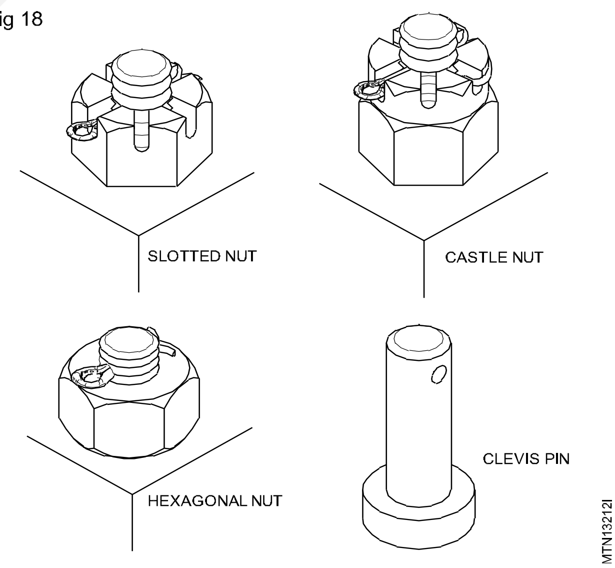


Fig 18



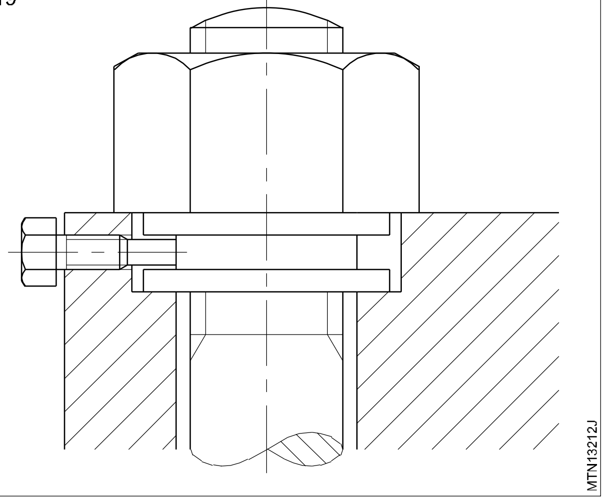
The nominal length is the distance from the underside of the eye to the end of the short leg.

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

Grooved nut (Penning nut) (Fig. 19)

This is a hexagonal nut with the lower part made cylindrical. On the cylindrical surface there is a recessed groove in which a set screw is used to lock the nut.

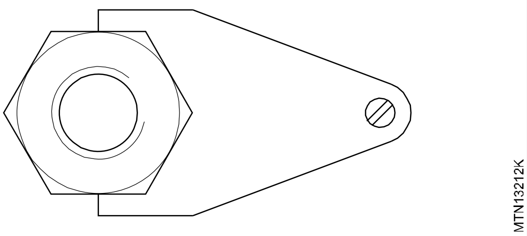
Fig 19



Locking plate (Fig. 20)

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

Fig 20

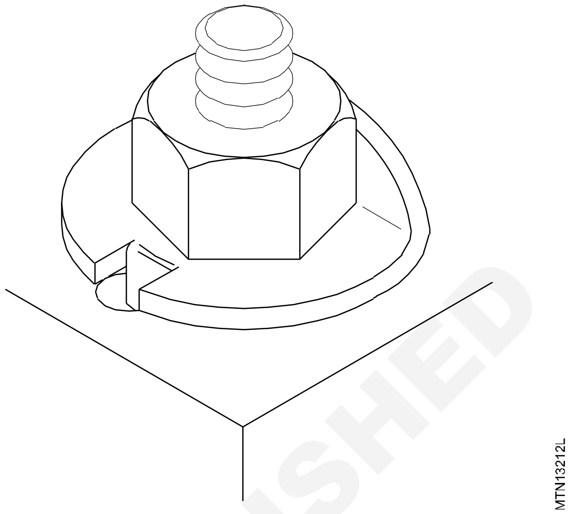


Lock washers with lug (Fig. 21)

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 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.

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 1

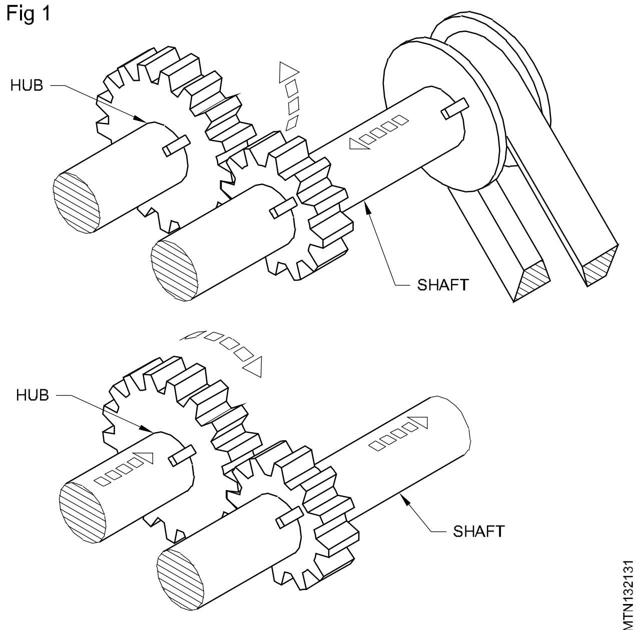


Fig 2

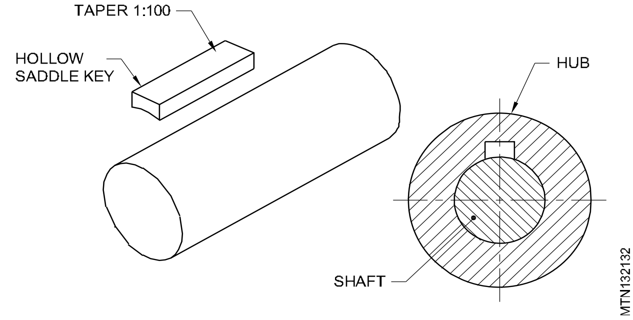
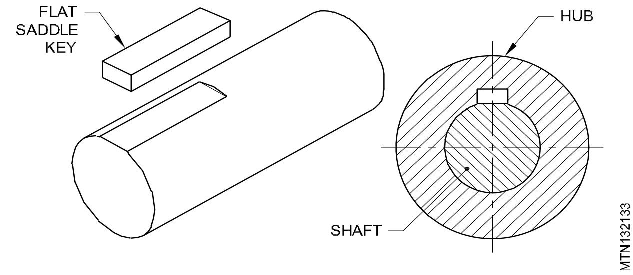
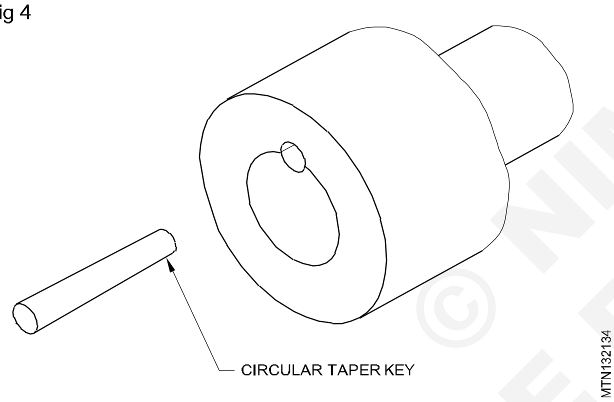


Fig 3



Circular taper key (Fig 4)

Fig 4



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

Sunk key (Fig 5 & Fig 6)

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

Fig 5

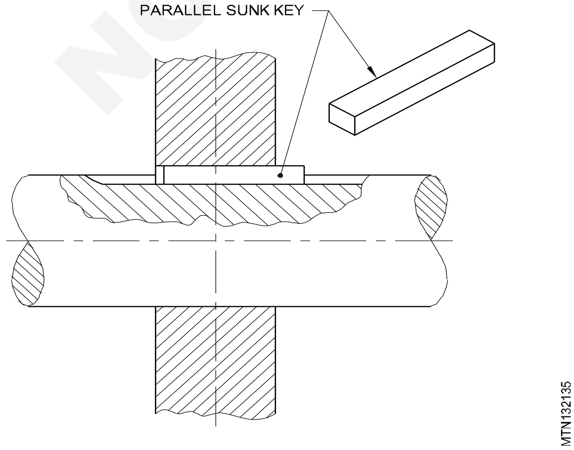
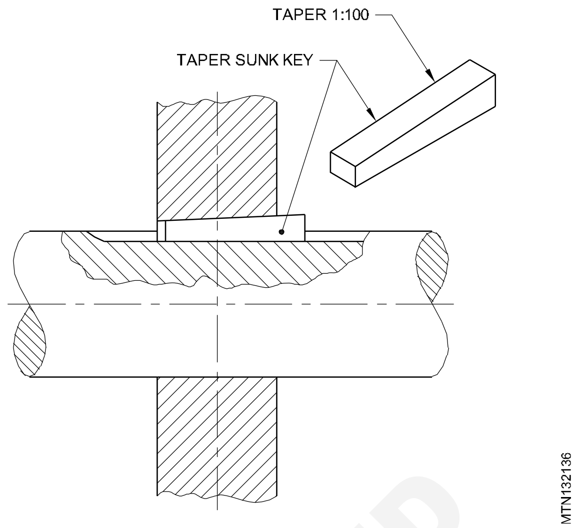
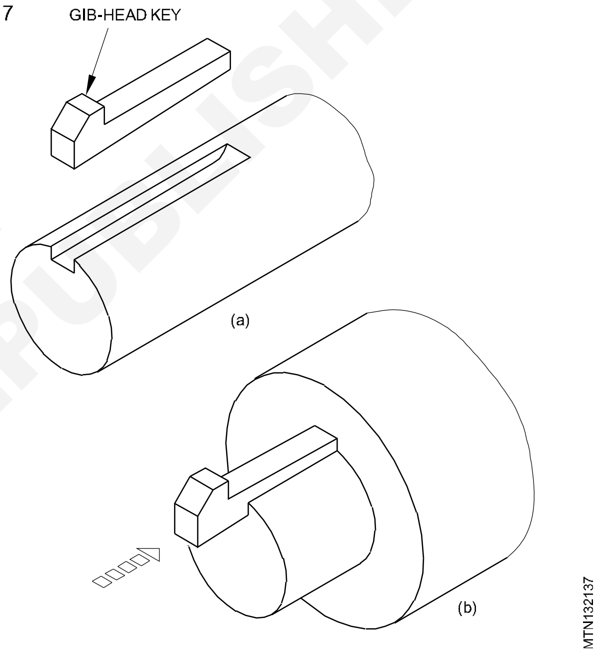


Fig 6



Gib-head key (Fig 7)

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)

Feather key (Fig 8)

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

Woodruff key (Fig 9)

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

This key is particularly useful on tapered fittings of shafts.

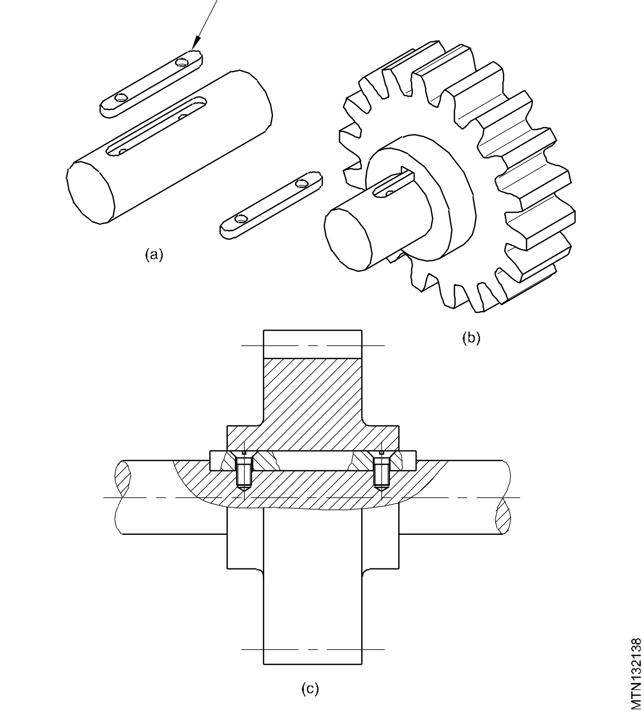


Fig 8

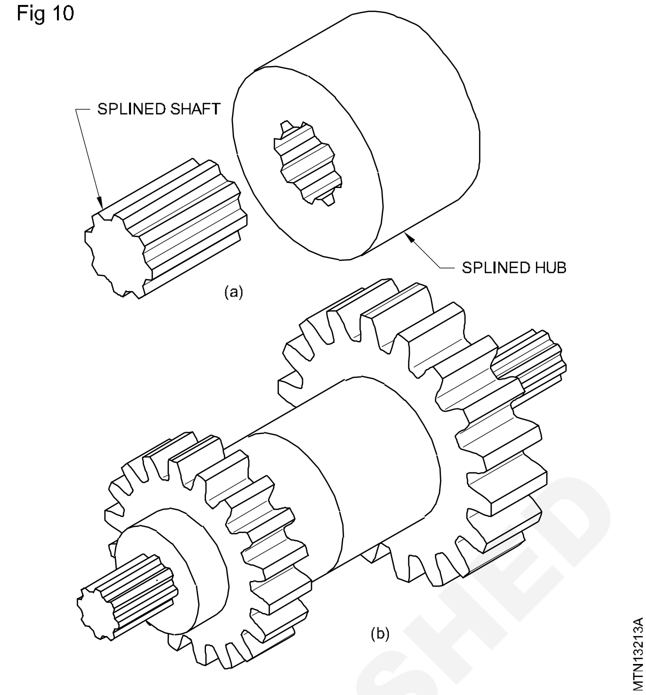


Fig 10

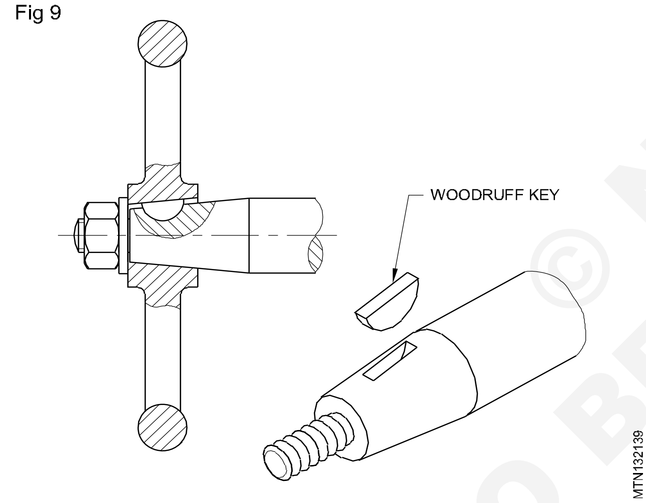


Fig 9

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

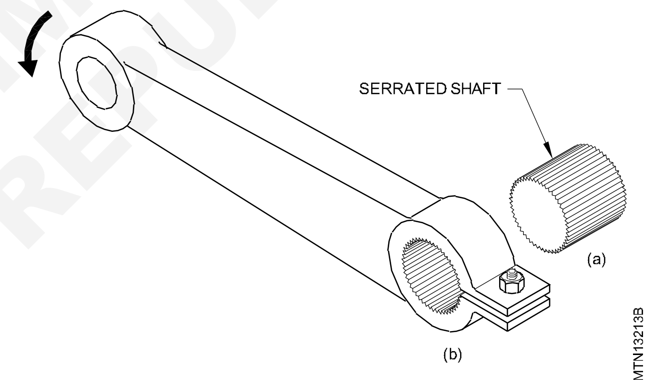


Fig 11

Splined shaft & serrated shaft

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

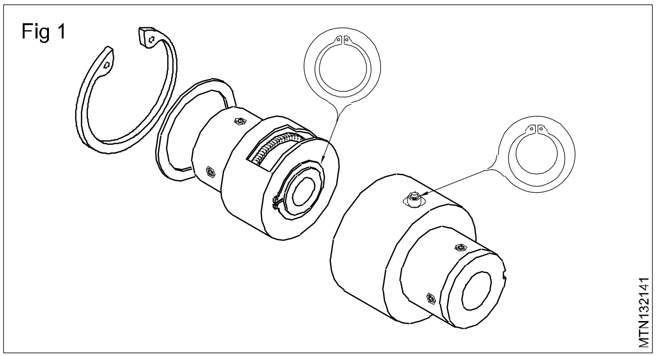
Circlips

Objectives : At the end of this lesson you shall be able to
- **state the functions of circlips**
- **state the different types of circlips**
- **state the advantages of circlips over other fastening devices**
- **state the material used for circlips.**

Circlips are fastening devices used to provide shoulders for positioning or limiting the movement of parts in an assembly (Fig.1) Circlips are also called `Retaining rings.

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

Fig 1



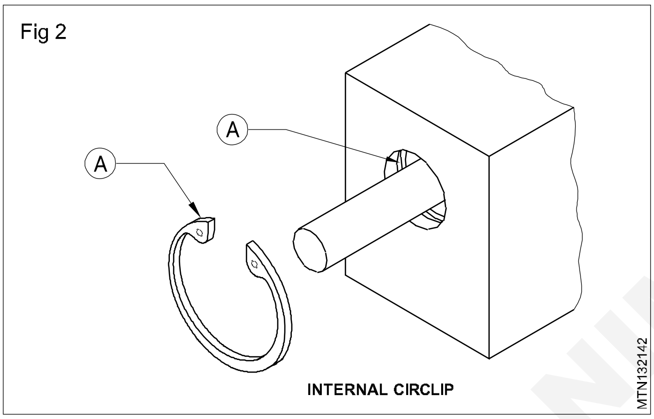
Types

There are two types.

Internal circlips (Fig.2)

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

Fig 2



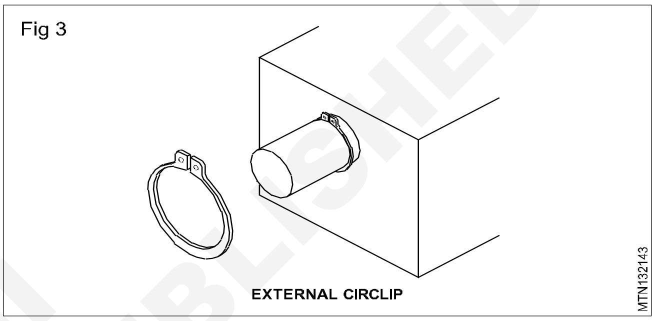
External circlip (Fig.3)

This type of rings are installed on shafts, pins, studs and similar parts.

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

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

Fig 3



Material

Because retaining rings depend for their function largely on their ability to be deformed elastically during assembly and disassembly, the materials must have good spring properties. Circlips are manufactured from spring steel with high tensile and yield strength.

Washers - Types and Uses

Objectives : At the end of this lesson you shall be able to
- **state the purpose of washers**
- **name the types of washers**
- **state the uses of each type of washers**
- **specify the washers as per B.I.S.**

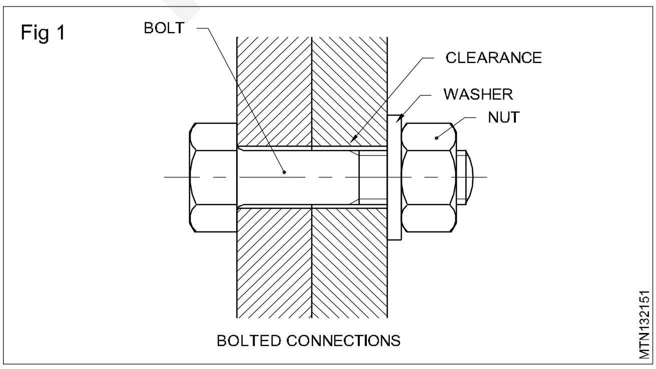
Purpose

It is a common practice to provide washers under the nuts in bolted joints.

Washers help to (Fig 1)

- increase the frictional grip
- prevent loosening of nuts due to vibration
- prevent damage to the work piece and
- distribute force orver a larger area.

Fig 1



Types of washers

There are different types of washers available. They are

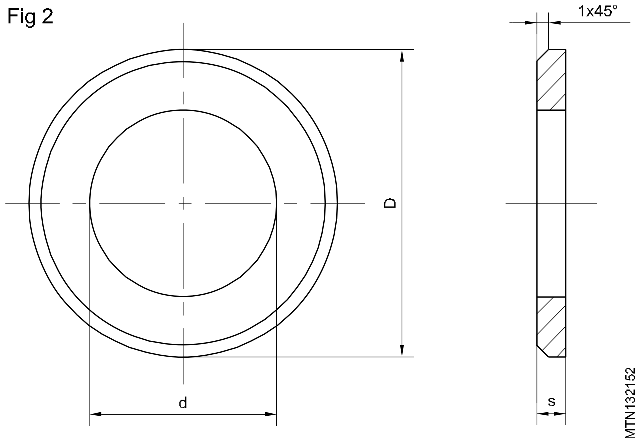
- plain or flat washers
- taper washers
- spring washers
- tab washers
- toothed lock washers.

Plain or flat washers (Fig 2)

These washers are used for bolting assemblies with flat surfaces. The diameter thickness and the bore diameter are proportional to the diameter of the bolt. (I.S. 2016)

Plain washers are available as machined or punched washers.

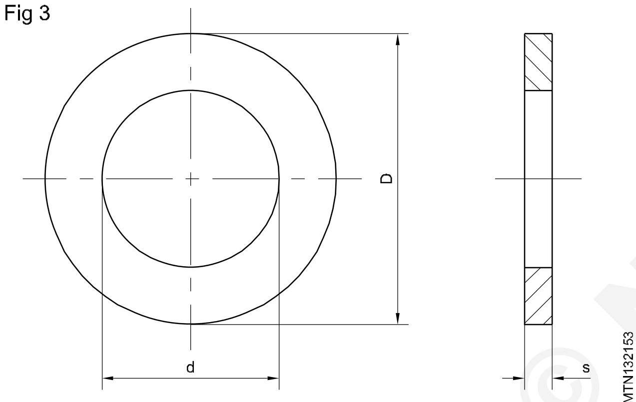
Fig 2



Machined washers (Fig 3)

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

Fig 3



Punched washers

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

Tapered washers (Figs 4 & 5)

These are used in structural assemblies with tapered surfaces like the inside of beams, channels etc. These washers help bolt head or nut to seat square to the hole.

Fig 4

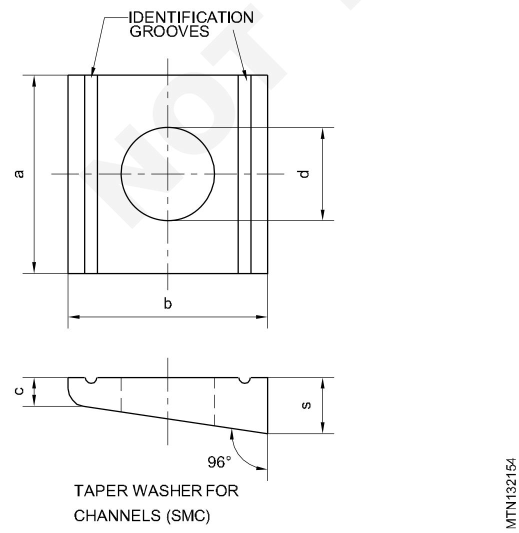
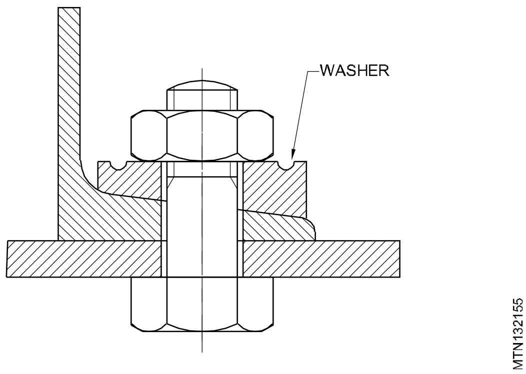


Fig 5



Spring washers (Figs 6 & 7)

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

Fig 6

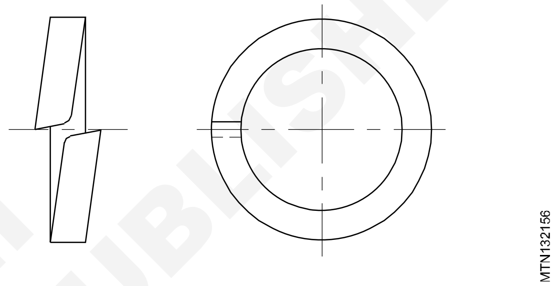
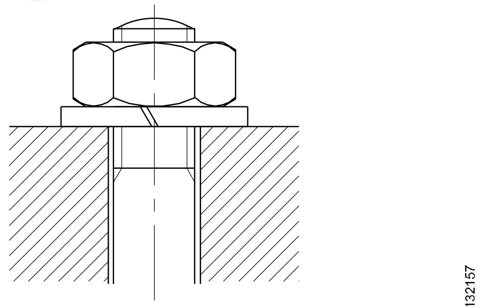


Fig 7

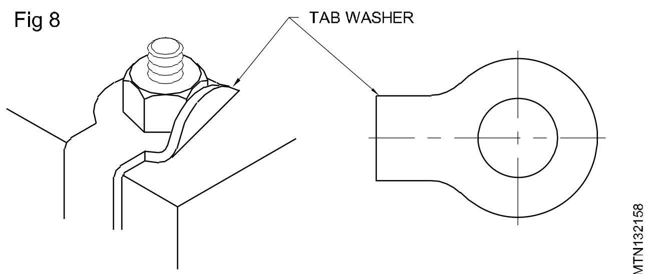


SPRING LOCK WASHER

Tab washers (Fig. 8)

These washers are used for locking the nuts.

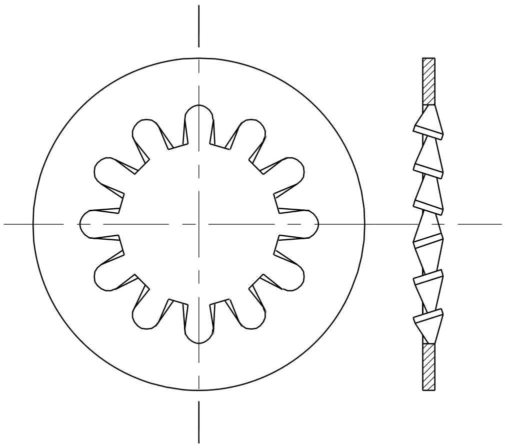
Fig 8



Toothed lock washers (Fig. 9)

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

Fig 9



INTERNALLY TOOTHED

MTN132159

Specifications

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

Example

A machined washer of size 10.5 mm made of brass shall be designated as machined washer 10.5 IS:2016 Brass.

Note

For detailed specification of different types of washers refer to the following IS specifications.

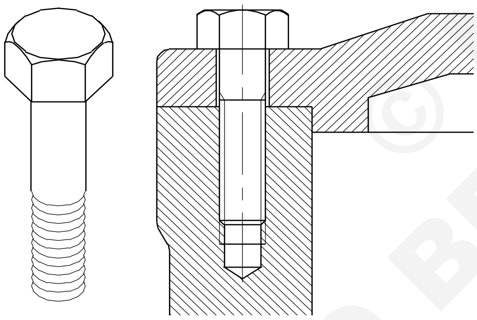
Taper washer	- IS: 5374 and IS: 5372
Tab washer	- IS: 8068
Toothed lock washer	- IS: 5371
Plain washer	- IS: 2016

Different types of screws, nuts, studs and bolts

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

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

Fig 1



MTN132161

Types of machine screws (Heavy duty)

Hexagon head screws

Hexagon socket head cap screws

Square head countersink head screws

These are heavy duty screws.

Hexagon head screws

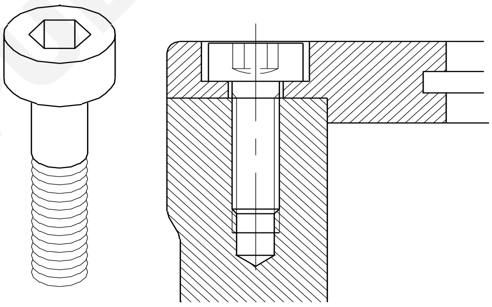
These are used when the projection of the screw head will not be an obstruction in the assembly (Fig.1)

Hexagon socket head cap screws

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

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

Fig 2



MTN132162

Countersink head screws

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

They are:

- slotted countersink head screws (Fig.3)
- cross-recessed countersink head screws (Fig 4)

Fig 3

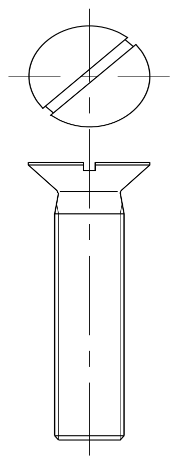
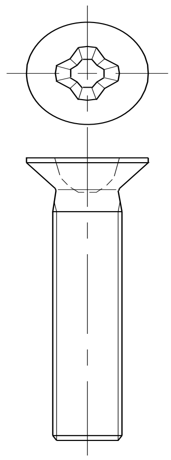


Fig 4



MTN132163

- slotted raised countersink head screws (Fig.5)
- cross recessed, raised countersink head screws. (Fig.6)

Fig 5

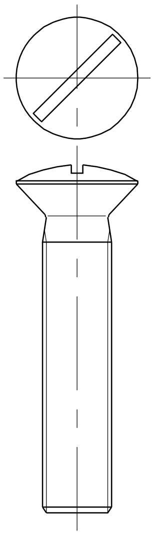
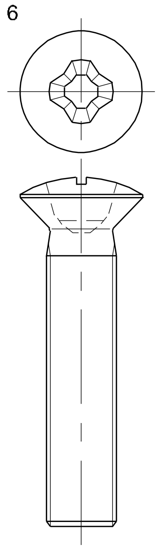
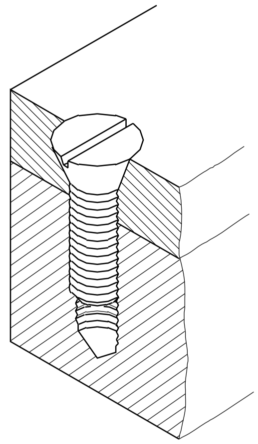


Fig 6



Countersink screws are capable of aligning the matching component correctly with the threaded hole. (Fig.7)

Fig 7



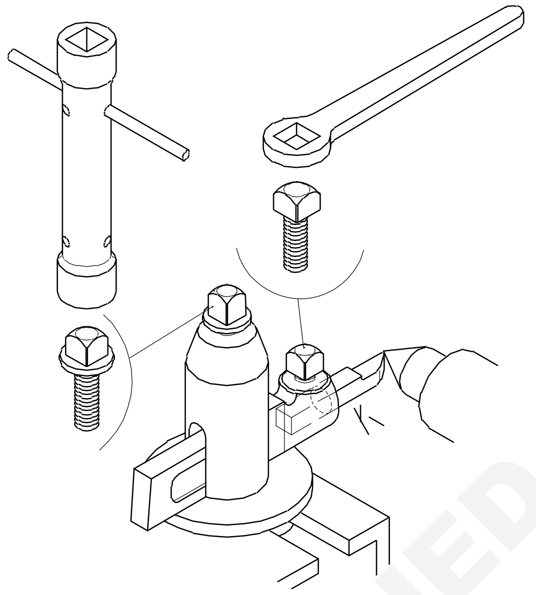
The projection of the screw head above the assembly is also avoided. B.I.S. specification covers the following ranges of countersink head screw sizes in different types.

- Slotted countersink head screws M1 - M20
- Cross-recessed countersink head screws M1.6 to M10.
- Slotted raised countersink head screws M1 to M20.
- Cross-recessed raised countersink head screws M1.6 to M10.

Square head screws. (Fig. 8)

Square head screws are used in places where there is frequent removal and refitting of the assembly. These screws are tightened to a higher torque using a wrench. (Fig.8) Square head screws are also available with a collar. In this there is a washer at the base which is an integral part of the head. The purpose of this collar is to protect the work-surface from damages due to constant use of wrenches.

Fig 8



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

Pan head (Fig 9) ; Cheese head (Fig 10)

Fig 9

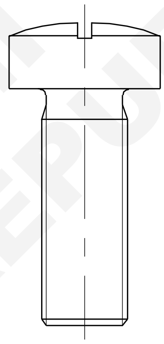
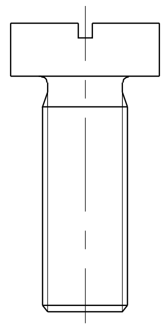


Fig 10



Raised cheese head (Fig 11) ; Round head (Fig 12)

Fig 11

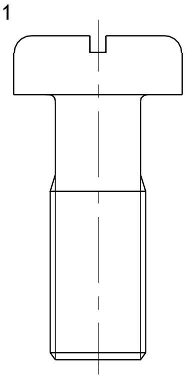
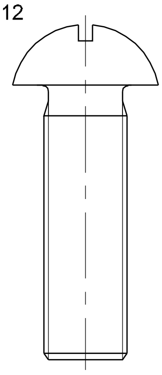


Fig 12



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

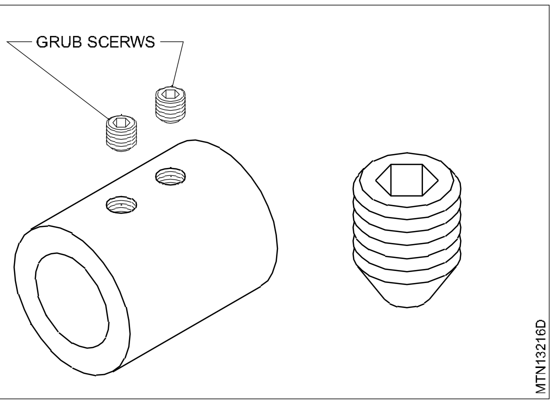
The screws used for light duty are normally available up to 10mm thread diameter.

These screws are made of steel, stainless steel or brass. These screws are either plain finished, zinc-coated or chrome-plated.

Set screws and grub screws

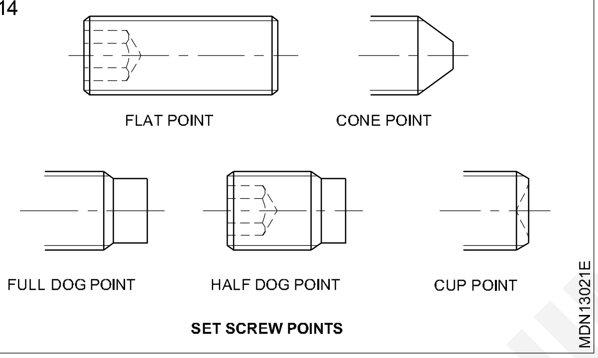
Hexagonal socket set screws (Fig.13)

Fig 13



These are headless socket screws available with different points for various functional requirements. (Fig.14)

Fig 14



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

Square set screws (Fig.15)

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

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

Grub screws

Grubs have similar application as hexagon socket set screws but are used for light holding. (Fig. 16)

Grub screws are also available with different types of points (Fig.17)

Fig 15

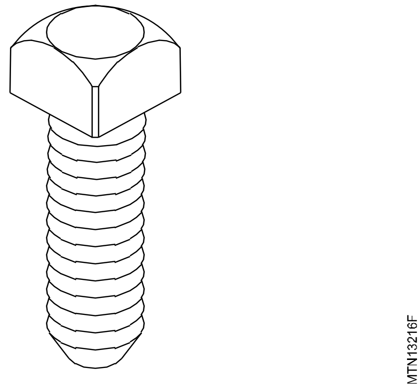


Fig 16

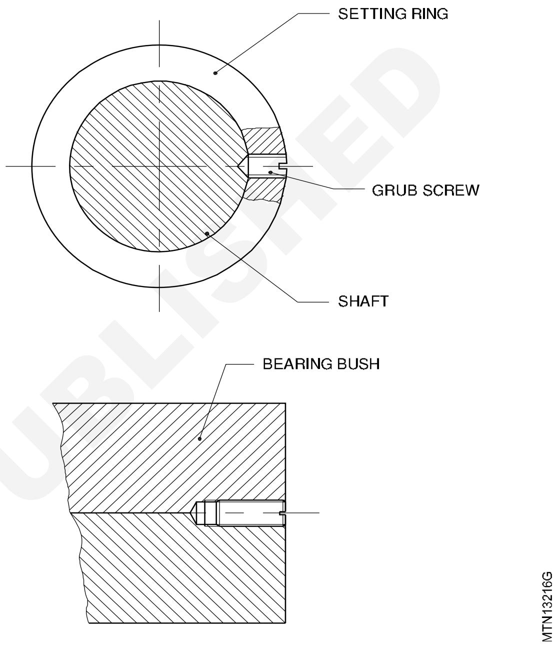
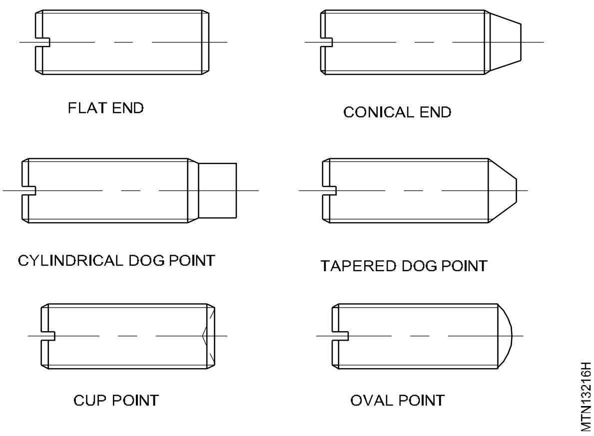


Fig 17



Thumb Screws

Objectives : At the end of this lesson you shall be able to
- **state the types of thumb screws**
- **state the uses of thumb screws**
- **designate thumb screws as per B.I.S. specification**.

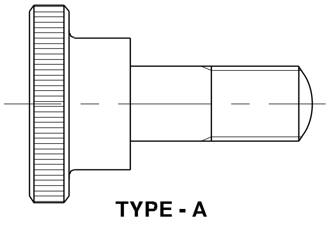
Thumb screws are used in places where fixing and removal of components are frequent. Tightening and loosening of the assembly is finger tight only.

Types

As per the Indian standard specification IS:3726-1972 there are five types of thumb screws.

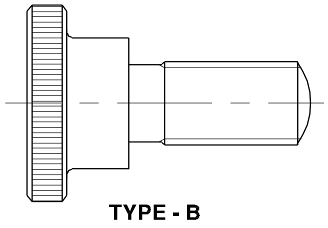
Type-A Thumb screws partially threaded (Fig 1)

Fig 1



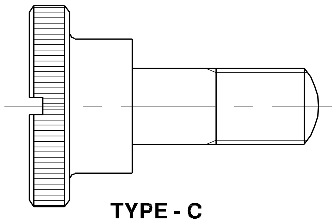
Type-B Thumb screws fully threaded (Fig 2)

Fig 2



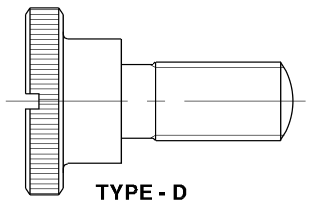
Type-C Slotted thumb screw partially threaded (Fig 3)

Fig 3



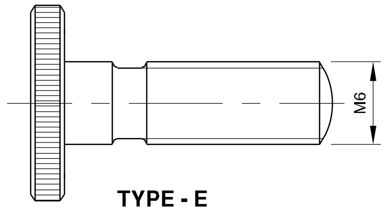
Type-D Slotted thumb screw fully threaded (Fig 4)

Fig 4



Type-E Flat thumb screws (Fig 5)

Fig 5



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

Sizes

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

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

Designation of thumb screws

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

Example

A thumb screw of Type `A', size M6, nominal length 12mm and of property class 4.6 shall be designated as:
Thumb screws A M6 x 12 IS: 3726-4.6
When brass or any other non-ferrous metal is used for the manufacture of thumb screws, the word Brass or the name of the non-ferrous metal used will replace the property class number in the designation.

Types of nuts

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

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

Hexagonal nuts (Figs 1 & 2)

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

Fig 1

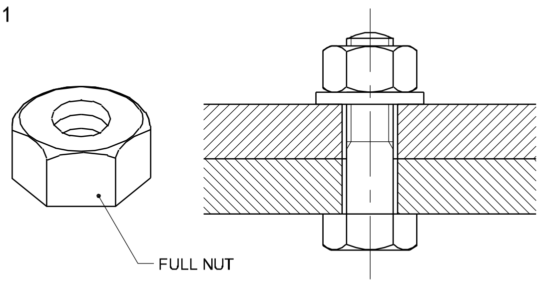
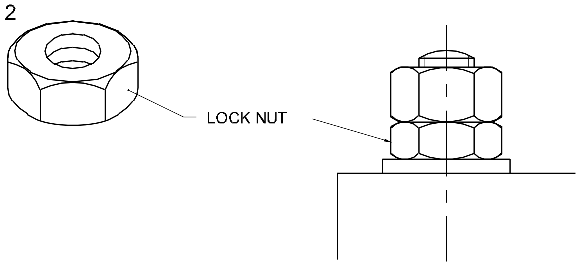


Fig 2

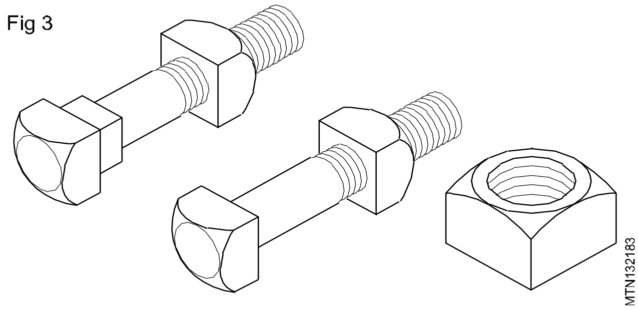


Hexagonal nuts are available in different thicknesses. Thin nuts are used as lock-nuts.

Square nut (Fig. 3)

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

Fig 3



Self-locking nuts (Simmonds lock-nut)

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

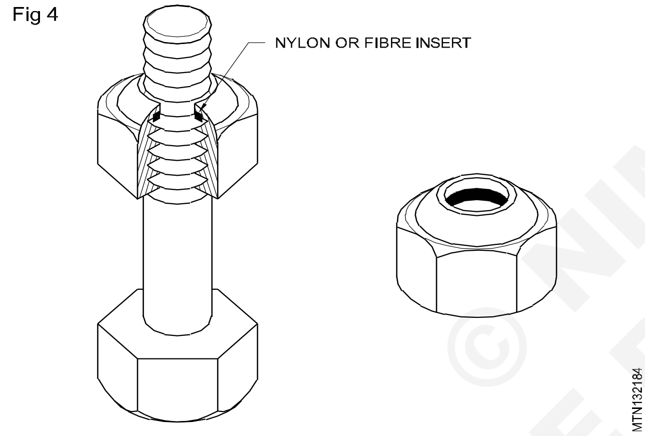
Self-locking nuts are not used with studs.

T-nuts.

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

Slotted and castle nuts (Fig. 4)

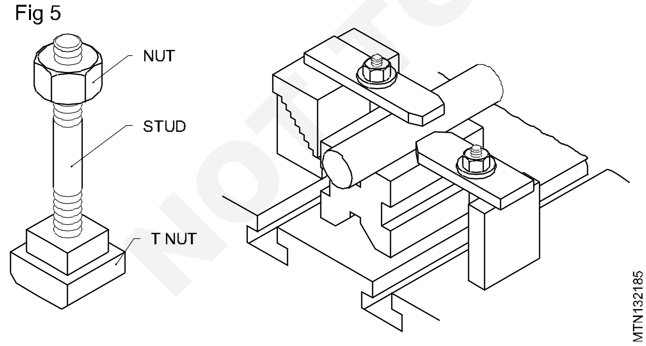
Fig 4



Round nuts (Fig. 5)

Round nuts of different types are available for special applications.

Fig 5



Slotted round nut (Figs 6, 7, 8, 9 & 10)

Slotted round nut for hook wrench.

Round nut with set pin holes on sides

Round nut with holes in the face.

Round nut with set pin holes on sides

Round nut with holes in the face.

Fig 6

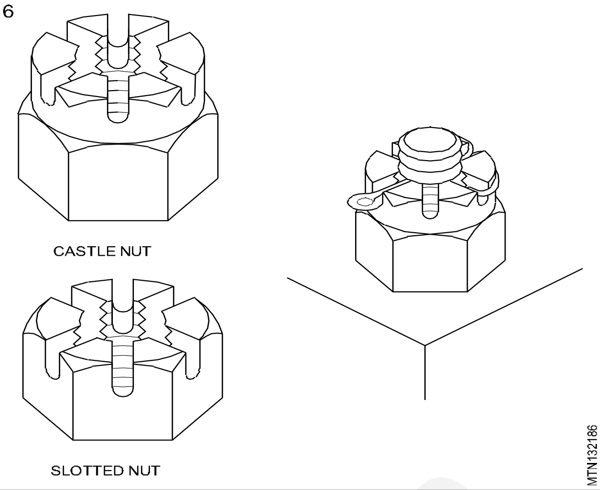


Fig 7

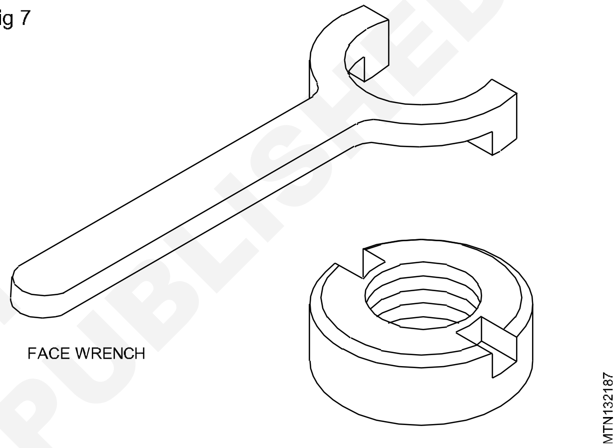


Fig 8

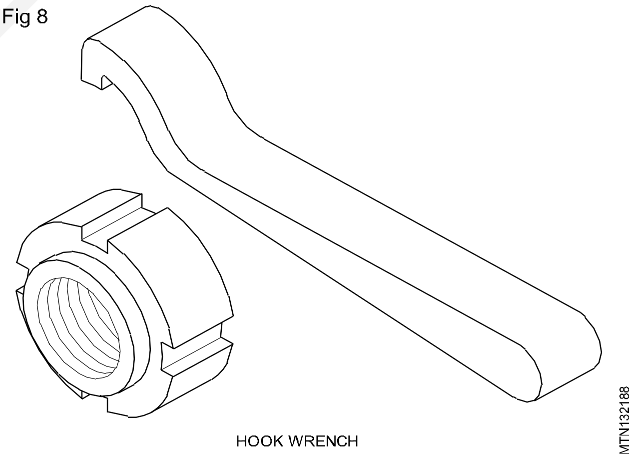


Fig 9

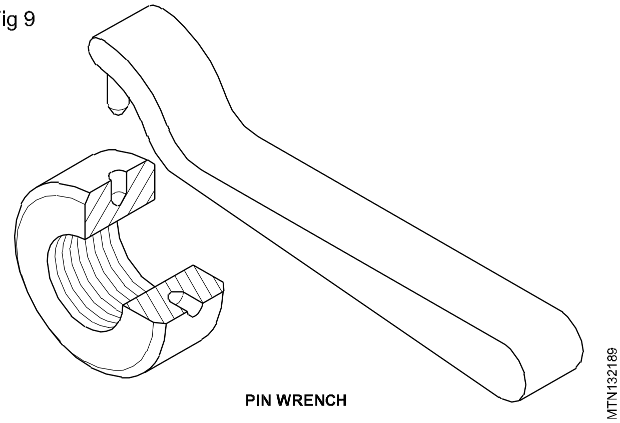
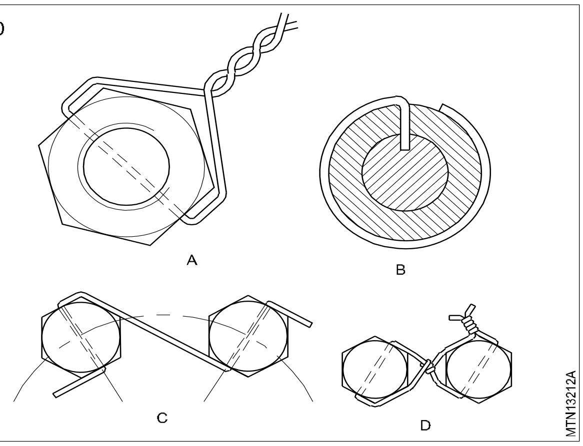


Fig 10



Gasket

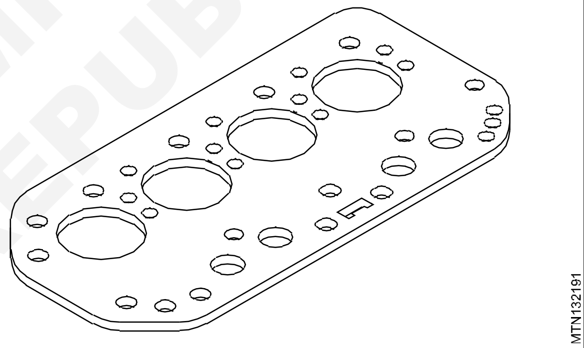
Objectives : At the end of this lesson you shall be able to
- **state the need of gaskets**
- **state the materials of gaskets**

The gasket (Fig. 1) in automobiles has to combat sealing problems caused by high and low temperatures, expansion and contraction, vibration, pressure or vaccum, corrosion and oxidation, inadequate sealing reduces the service life and efficiency of the components.

The seals which are used between two stationary components are called static seats. The most common static seal is gasket. Gaskets are designed to suit particular needs and are manufactured from different materials like copper, aluminium, cork fibre, asbestos, synthetic rubber, paper and various combinations of these materials. In latest In latest semi-liquid is also used as gasket.

Cylinder head gaskets are the most complicated in design and construction because they must withstand extreme pressure, vibration, high temperature and expansion changes. They must seal against compression, oil and coolants. They must resist extrusion, elongation, oxidation and chemicals. The cylinder head gasket consists of a multi-layer of materials with coolant and oil passages.

Fig 1



Oil seal

Objectives : At the end of this lesson you shall be able to
- **state the use of oil seals**
- **explain different types of oil seals**
- **state the material used for oil seals.**

Seals

Seals are sealing parts on static or moving inter faces of machines, devices pipes and tank reservoir seals are used for sealing spaces as different pressure against each other, ie combustion chamber & oil ways etc. oil seals have flexible lip that rubs against a shaft or housing to prevent leakage of fluid (grease, oil etc.)

All seal are used to retain or separate lubricant on fluid

Types of oil seal

i) Flexible lip

ii) radial lip

iii) rotary shaft seal

configuaration

a) single lip

b) double lip

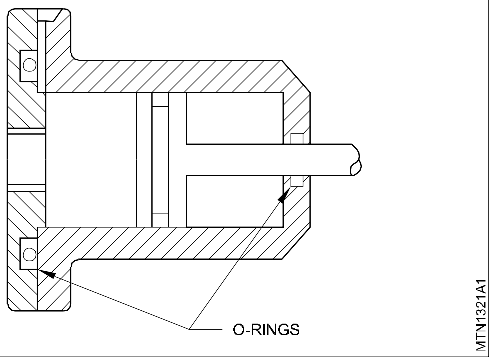
c) triple lip

d) Fan lip

Seals capable of sealing two components which move or rotate insulation to each other are called dynamic seals. The most common dynamic seal is called 'O' rings which are moulded to close tolerances in the cross-sectional areas and to the inner and outer diameters.

Bearing Isolator (Fig. 1)

Fig 1



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

Specifications

Sealing orientation (Fig 2 & 3)

Fig 2

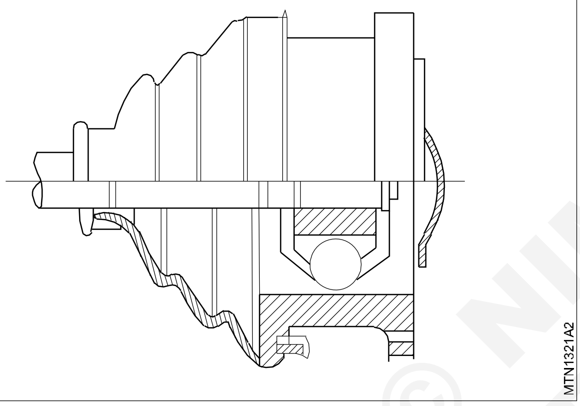
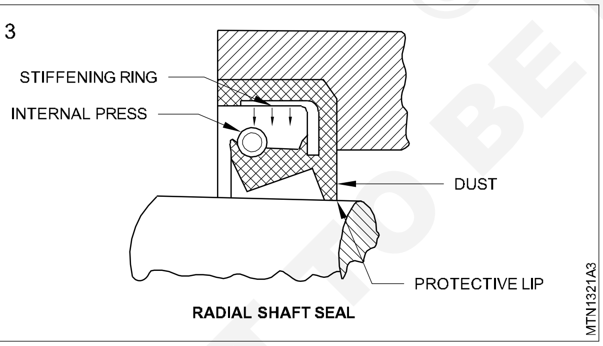


Fig 3



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

Sealants

Type of sealant

There are three types of sealant used.

1 The Teflon tape

2 Pipe tape

3 Anaerobic resin compound

1 Teflon tape

The purpose of this Teflon tape (whir), no sticking tape is the serve as a lubricant when threaded part of pipe a piping system are being assembles.

2 Pipe tape

This material relies on a solvent carrier and hardware when the solvent evaporator. The resulting seal adheres to all plastic, metal pipes and effective blocks leak paths.

3 Anaerobic resin compound

This sealant is confined within the threads of the metal pipe connection and air in exuded. It maintains the sealing properties even after heat aging, excellent then prelature and solvent remittance.

Key concepts

- Tape does not truly seal, it lubricator.
- Tape can harden and become brittle.
- Anaerobic must be combatable with pipe fitting material.

Sealant selection factors

- Material
- Temperature
- Pressure
- Vibration

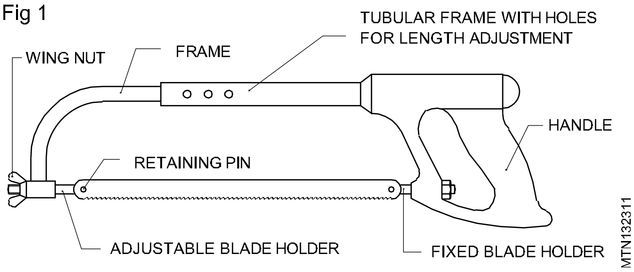
Hacksaw frame and blade

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 prticular standard length of blade can be fitted to this frame.

Adjustable frame (Flat type)

Different standard lengths of blades can be fitted to this frame.

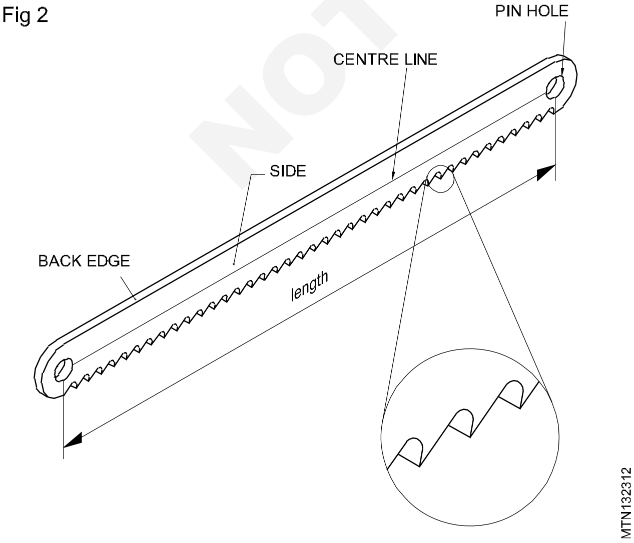
Adjustable frame (Tubular type)

This is the most commonly used type. It gives a better grip and control, while sawing.

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

Hacksaw blades (Fig. 2)

Fig 2



A hacksaw blade is a thin narrow steel band with teeth and two pin holes at the ends. It is used along with a hacksaw frame. The blade is made of either low alloy steel (LAS) or high speed steel (HSS) and is available in standard lengths of 250 mm and 300 mm.

Types of hacksaw blades

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

All hard blades

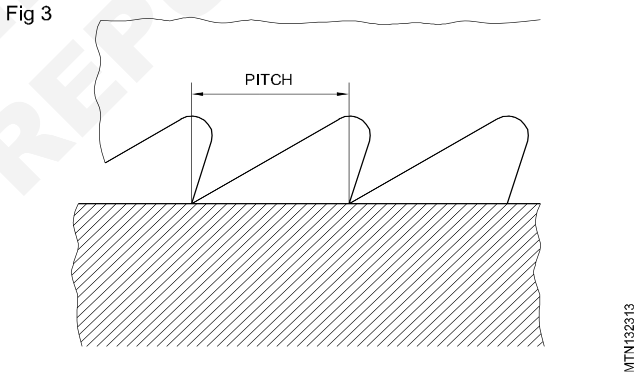
These are hardened to the full width between the pin holes.

Flexible blades

For these types of blades. Only the teeth are hardened. Because of their flexibility, these blades are useful for cutting along curved lines.

Pitch of the blade (Fig. 3)

Fig 3



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

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

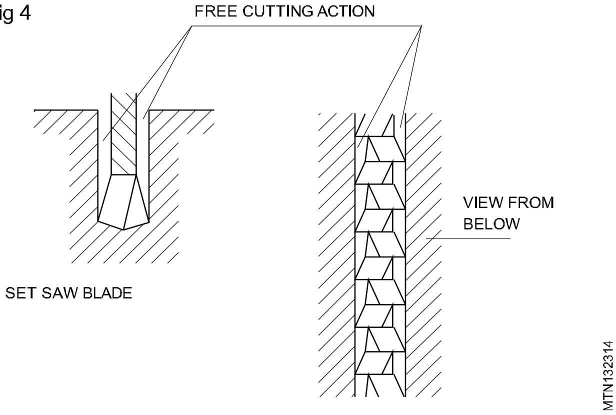
Hacksaw blades are designated according to their length, pitch and type.

To prevent the saw blade binding when penetrating into the material and to allow free movement of the blade, the cut is to be broader than the thickness of the saw blade. This is achieved by the setting the saw teeth. There are two types of saw teeth settings.

Staggered set (Fig. 4)

Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting and provides for good chip clearance.

Fig 4



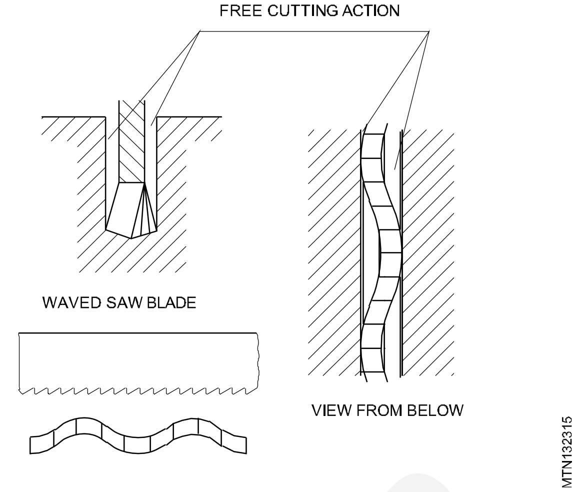
Wave set (Fig. 5)

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

Fig 5



For the best results, the blade with the right pitch should be selected and fitted correctly.

Elements of a file

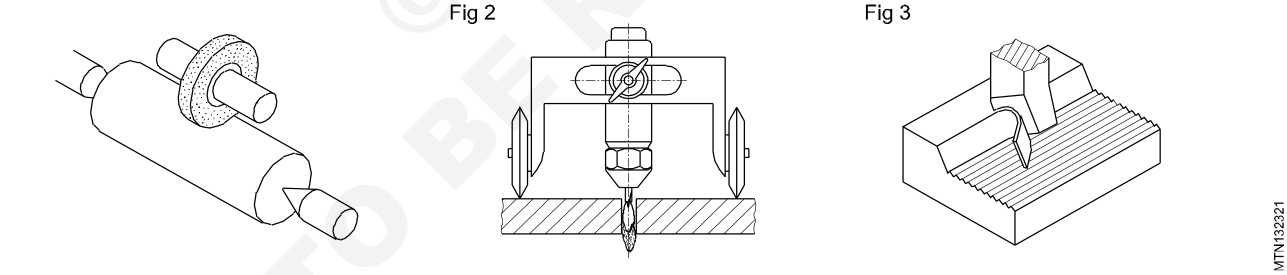
Objectives: At the end of this lesson you shall be able to

- **name the parts of a file.**

Methods of Material Cutting

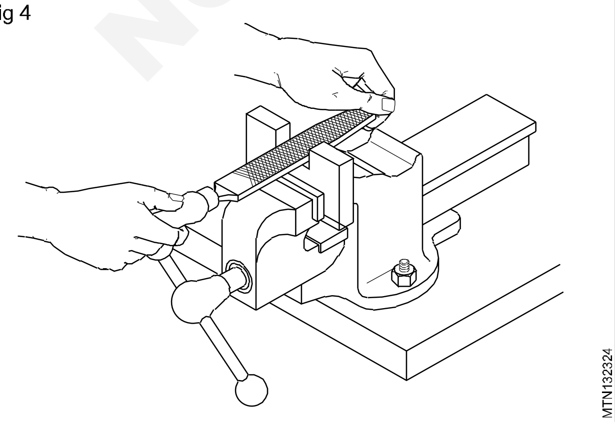
The three methods of metal cutting are abrasion (Fig.1). Fusion (Fig 2) and Incision (Fig 3)

Fig 1 Fig 2 Fig 3



Filing is a method for removing excess material from a work pieces by using a file which acts as a cutting tool. (Fig 4) shows how to hold a file. Files are available many shapes and sizes.

Fig 4



Parts of a file (Fig 5)

The parts of a file as can be seen in figure 5, are

Tip or Point

The end opposite to tang

Face or side

The broad part of the file with teeth cut on its surface

Edge

The thin part of the file with a single row of parallel teeth

Heel

The portion of the broad part without teeth.

Shoulder

The curved part of the file separating tang from the body

Tang

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

Handle

The part fitted to the tang for holding the file

Parts of a file (Fig 5)

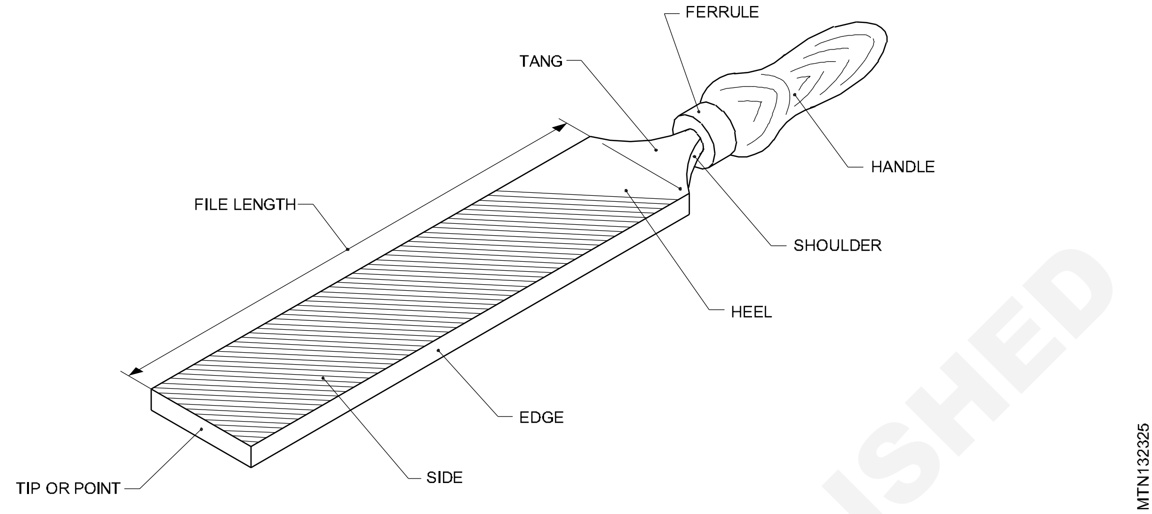
Ferrule

A protective metal ring to prevent cracking of the handle.

Materials

Generally files are made of high carbon or high grade cast steel. The body portion is hardened and tempered. The tang is however not hardened.

Fig 5



Cut of files

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

The teeth of a file are formed by cuts made on its face. Files have cuts of different types. Files with different cuts have different uses.

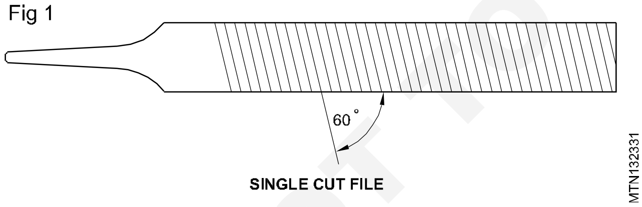
Types of cuts

Basically there are four types.

Single cut. Double cut. Rasp cut and curved cut.

Single cut file (Fig. 1)

Fig 1



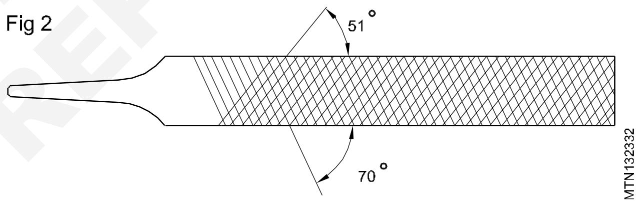
A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60° to the centre line. It can chips as wide as the cut of the file. Files with this cut are useful for filing soft metals like brass, aluminium, bronze and copper.

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

Double cut file (Fig. 2)

A double cut file has two rows of teeth cut diagonal to each other. The first row of teeth is know as OVERCUT and they are cut at an angle of 70°. The other cut, made diagonal to this, is known as UPCUT and is at an angle of 51°. This removes stock faster than the single cut file.

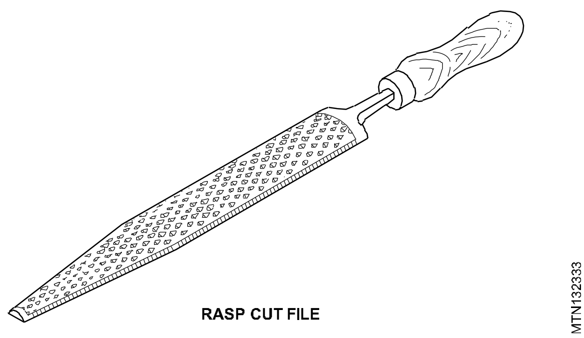
Fig 2



Rasp cut file (Fig. 3)

The rasp cut has individual sharp pointed teeth in a line and is useful for filing wood, leather and other soft materials. These files are available only in half round shape.

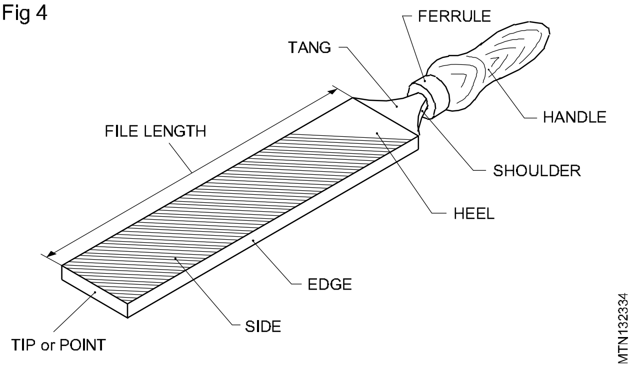
Fig 3



Curved cut file (Fig. 4)

These files have deeper cutting action and are useful for filing soft materials like - aluminium, tin, copper and plastic. The curved cut files are available only in a flat shape.

Fig 4



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

File specifications and grades

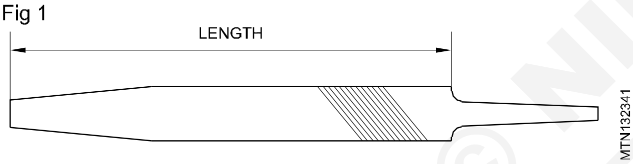
Objectives : At the end of this lesson you shall be able to
- **state how files are specified**
- **name the different grades of files**
- **state the application of each grade of file.**

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

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

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

Fig 1



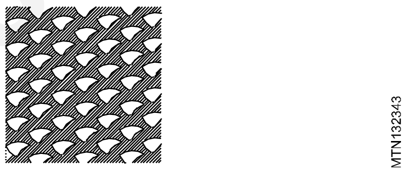
File grades are determined by the spacing of the teeth.

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

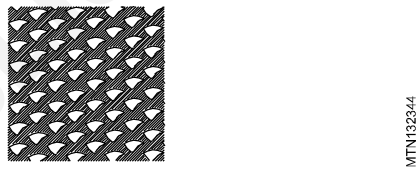
A bastard file (Fig 3) is used in cases where there is a heavy reduction of material.

Fig 3



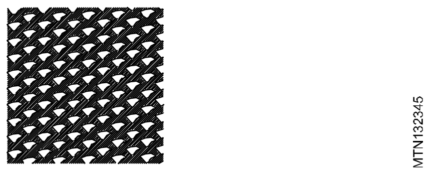
A second cut file (Fig 4) is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.

Fig 4



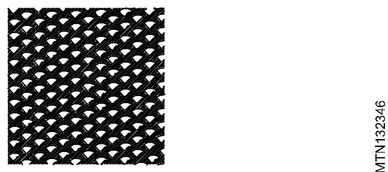
A smooth file (Fig 5) is used to remove small quantity of material and to give a good finish.

Fig 5



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

Fig 6



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

Different sizes of files with the same grade will have varying sizes of teeth. In longer files, the teeth will be coarser.

File - Applications

Objectives : At the end of this lesson you shall be able to
- **state the features of flat and hand files**
- **state the application of flat and hand files.**

Files are made in different shapes so as to be able to file and finish components to different shapes.

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

The files useful for this exercise are flat files and hand files.

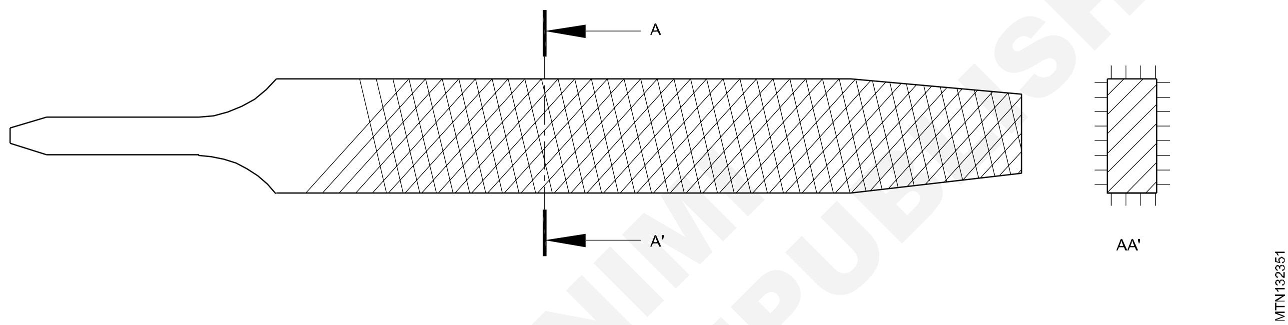
Flat files

These files are of a rectangular cross section. The edges along the width of these files are parallel up to two-thirds of the length, and then they taper towrads the point. The faces are double cut, and the edges single cut. These files are used for general purpose work. They are useful for filling and finishing external and internal surfaces.

Hand files (Fig 1)

These files are similar to the flat files in their cross section. The edges along the width are parallel through the length. The faces are double cut. One edge is single cut whereas the other is safe edge. Because of the safe edge, they are useful for filling surfaces which are at right angles to surfaces already finished.

Fig 1



Shapes of files

Objectives : At the end of this lesson you shall be able to
- **name the different shapes of files**
- **state the uses of Square, Round, Half Round, Triangular and Knife-edge files.**

For filing and finishing different profiles, files of different shapes are used.

The shape of files is stated by its cross section.

Common files of different shapes

Flat file, Hand file, Square file, Round file

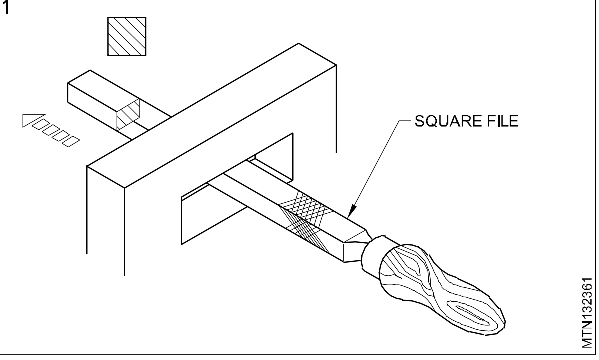
Half found file, Triangular file and Knife-edge file.

(Flat and hand files have already been discussed).

Square File

The square file is square in its cross sectiion. 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)

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)

Knife-edge File

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

Fig 2

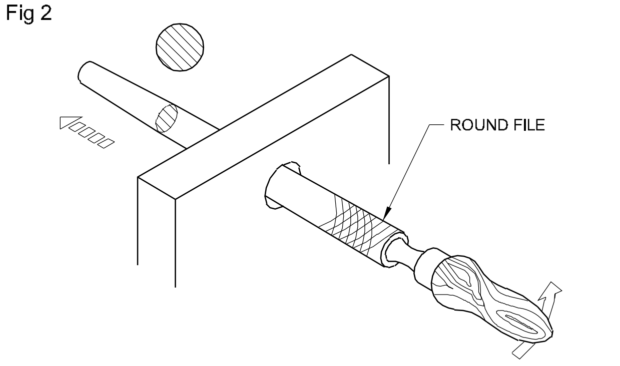
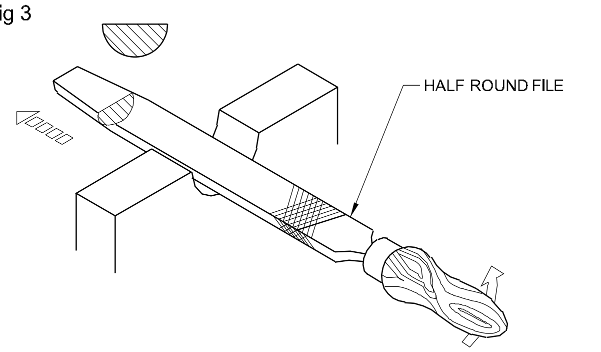


Fig 3



The above files have one third of their lengths tapered. They are available both in single and double cuts.

Fig 4

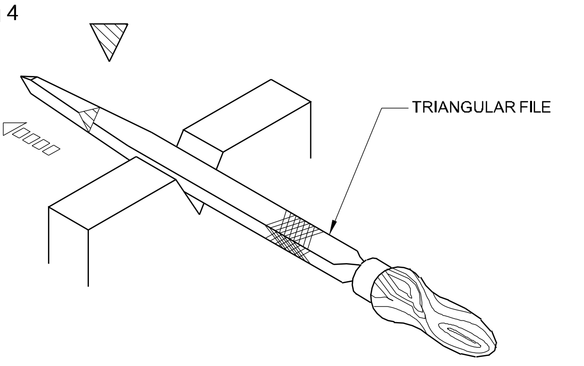
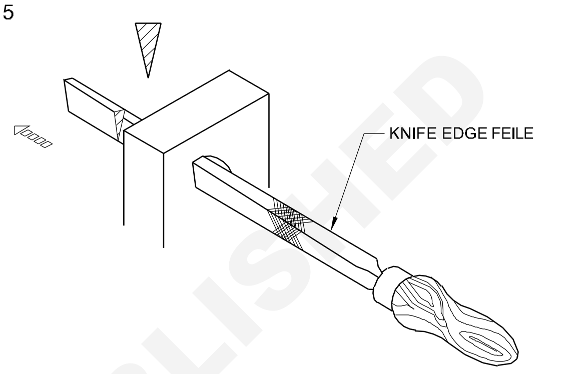


Fig 5



Square, round, half-round and triangular-files are available in lengths of 100, 150, 200, 250, 300 and 400 mm. These files are made in bastard, second cut and smooth grades.

Off- hand grinding with bench and pedestal grinders

Objectives : At the end of this lesson you shall be able to
- **state the purpose of off-hand grinding**
- **state the features of bench and pedestal grinders.**

Off-hand grinding is the operation of removing material which does not require great accuracy in size or shape. This is carried out by pressing the workpiece by hand against a grinding wheel.

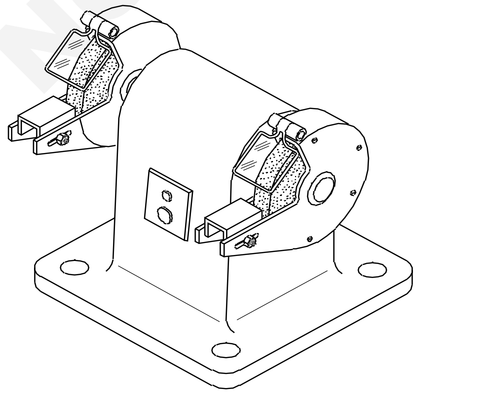
Off-hand grinding is performed for rough grinding of jobs and resharpening of

scribers, punches, chisels, twist drills

single point cutting tools etc.

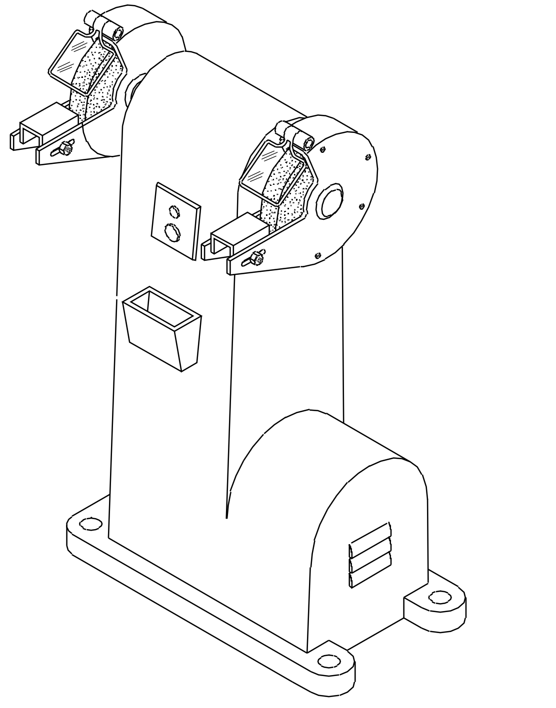
Off-hand grinding is performed with a bench or pedestal grinder (Fig 1 and 2)

Fig 1



BENCH GRINDER

Fig 2



PEDESTAL GRINDER

Bench grinders

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

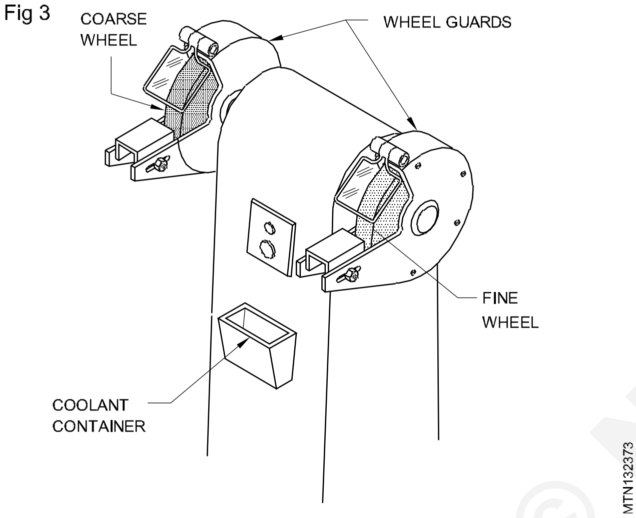
Pedestal grinders

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

These grinders consist of an electric motor and two spindles for mounting grinding wheels. On one spindle a coarse-grained wheel is fitted, and on the other, a fine grained wheel. For safety, while working, wheel guards are provided. (Fig 3)

A coolant container is provided for frequent cooling of the work. (Fig 3)

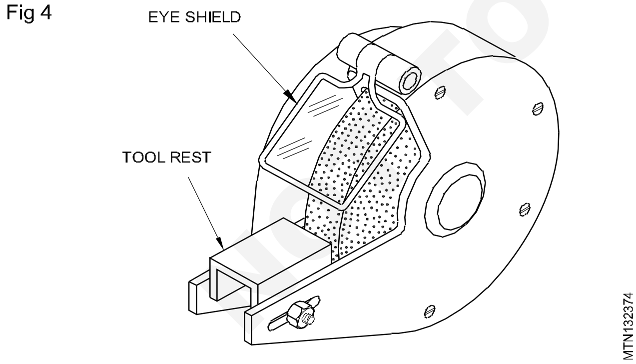
Fig 3



Adjustable work-rests are provided for both wheels to support the work while grinding. These work-rests must be set very close to the wheels. (Fig 4)

Extra eye-shields are also provided for the protection of the eyes. (Fig 4)

Fig 4

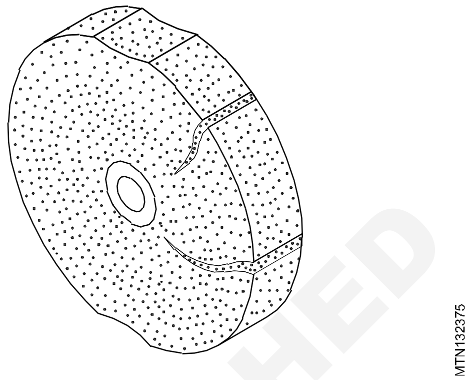


While grinding

Adjust the tool-rest as close to the wheel as possible. The maximum recommended gap is 2 mm. This will help to prevent the work from being caught between the tool-rest and the wheel. (Fig 5)

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

Fig 5

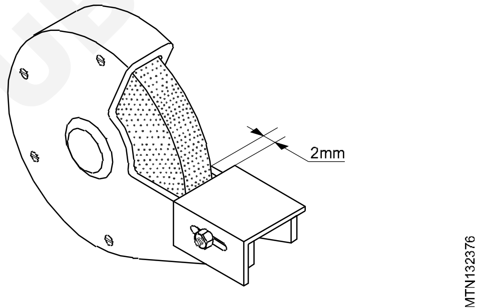


Never hold jobs with cotton waste or similar materials.

Use gloves for your hands while grinding heavy jobs.

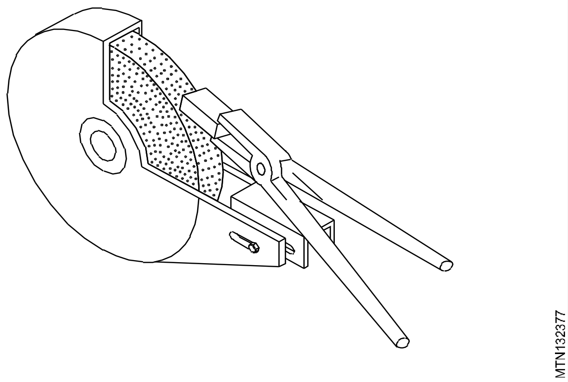
Do not grind on the side of the grinding wheels. (Fig 6)

Fig 6



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

Fig 7



Safe working on off - hand grinders

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

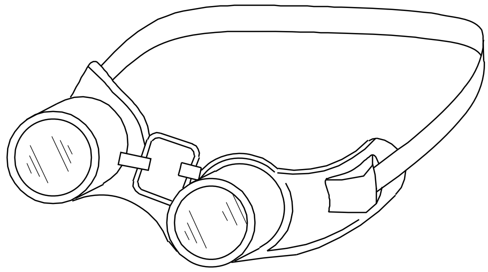
While working on off-hand grinders, it is important to observe the following safety measures.

Before starting the off-hand grinder

Make sure the grinding wheel guards are in place.

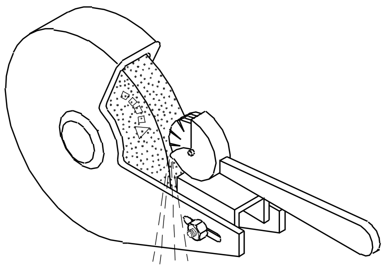
Wear safety goggles while grinding. (Fig 1)

Fig 1



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

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.

Drilling machine (portable type)

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

Necessity

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

Types

There are two types of portable drilling machines,

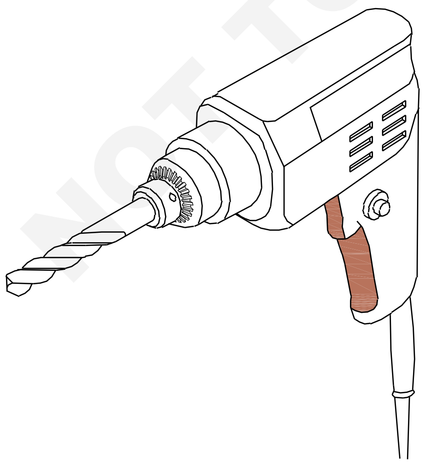
power operated and hand operated.

Power Operated drilling machines

Electric hand drill (light duty) (Fig 1)

These are available in different forms. The electric hand drill has a small electrical motor for driving the drill. On the end of the spindle, a drill chuck is mounted. Electric hand drills used for light duty will have, usually, a single speed.

Fig 1



Electric hand drill (heavy duty) (Figs 2 and 3)

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

Fig 2

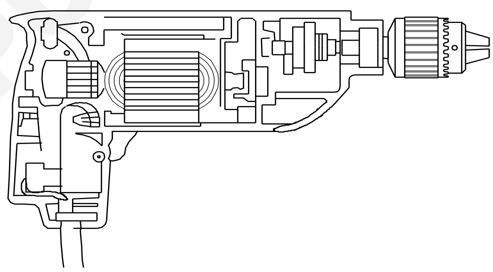
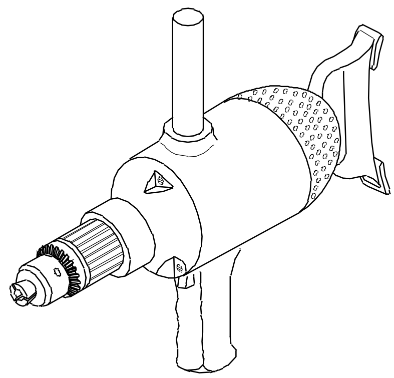


Fig 3

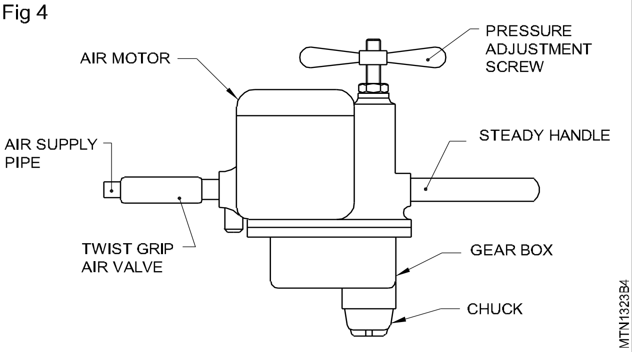


Hand operated drilling machines

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

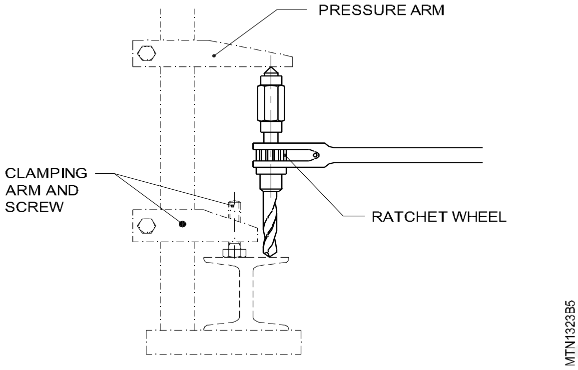
The ratchet drilling machine (Fig 4) is commonly used in structural fabrication. Square head, taper shank drills are used on these machines.

Fig 4



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

Fig 5



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

Fig 6

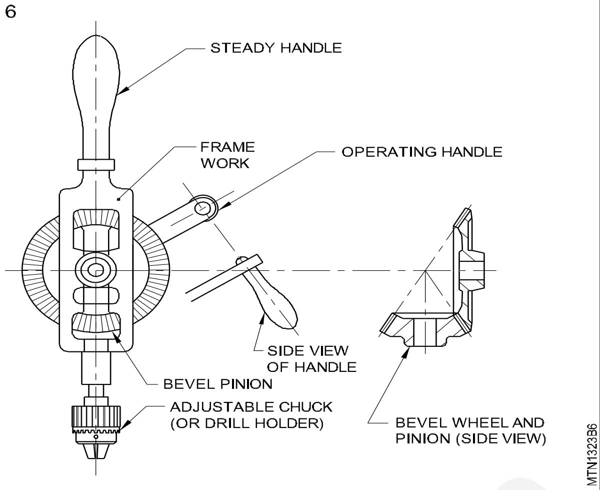
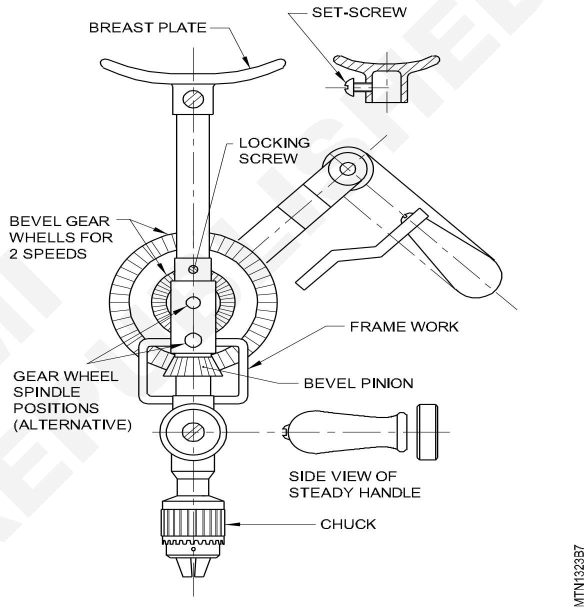


Fig 7



Drilling machines (bench and pillar type)

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

Types of drilling machine

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.

For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted.

Different spindle speeds are achieved by changing the belt position in the stepped pulley. (Fig 2)

The pillar drilling machine (Fig 3)

This is an enlarged version of the sensitive bench drilling machine. These drilling machines are mounded on the floor and driven by more powerful electric motors. They are used for heavy duty work. Pillar drilling machines are available in different sizes.

Fig 1

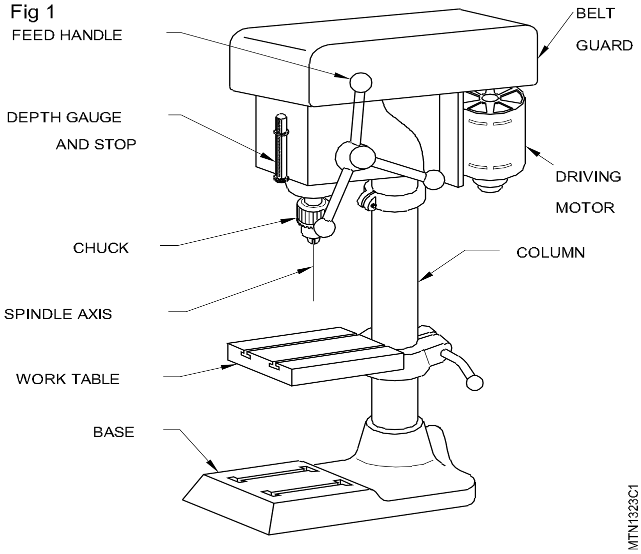


Fig 2

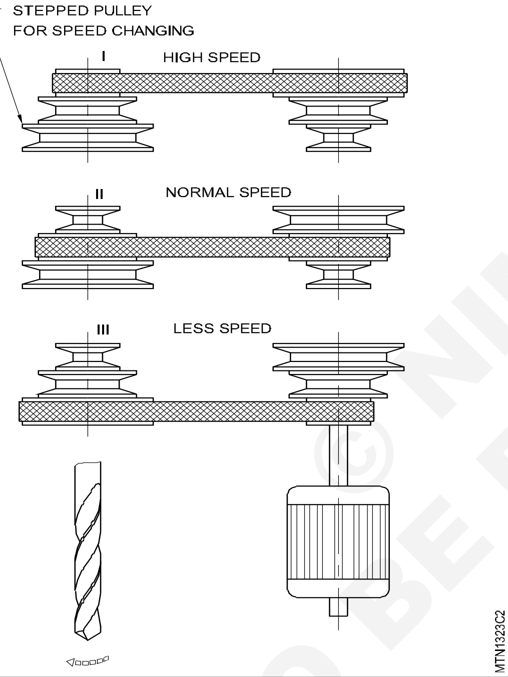
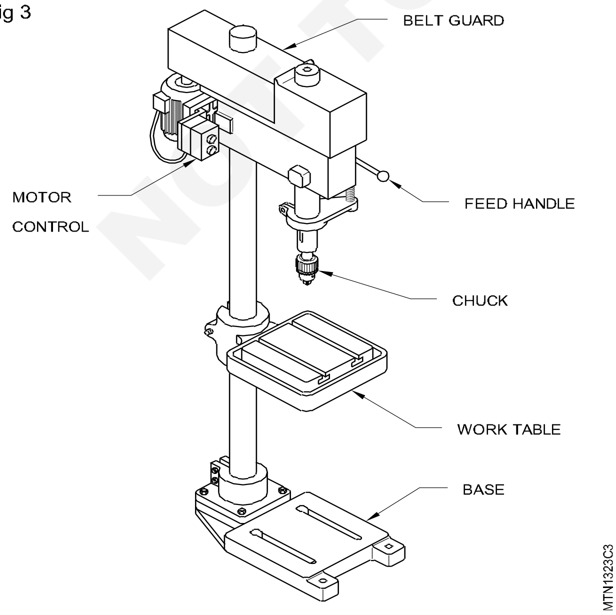


Fig 3



Radial drilling machines (Fig 4)

These are used to drill :

- large diameter holes
- multiple holes in one setting of the work
- heavy and large workpieces.

Features

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

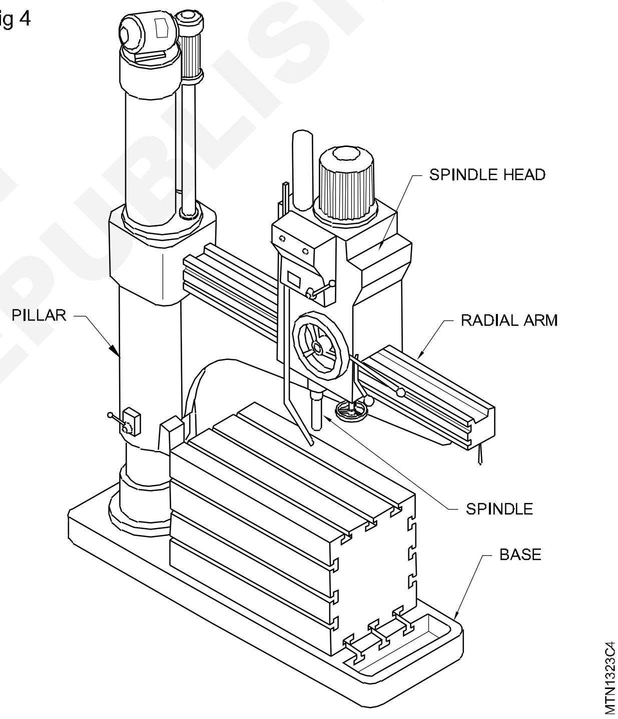
The spindle head can be moved along the radial arm and can be locked in any position.

The arm is supported by a pillar (column). It can be rotated about with the pillar as centre. Therefore, the drill spindle can cover the entire working surface of the table. The arm can be lifted or lowered.

The motor mounted on the spindle head rotates the spindle.

The variable-speed gearbox provides a large range of r.p.m.

Fig 4



Cutting speed and RPM

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

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

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

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

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

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

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

Calculate r.p.m

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

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

n= r.p.m

v= cutting speed in m/min

d= diameter of drill in mm

b= 3.14

Material being drilled for HSS	Cutting speed (m/min)
Aluminium	70 -100
Brass	35-50
Bronze (Phosphor)	20-35
Cast Iron (grey)	25-40
Copper	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.**

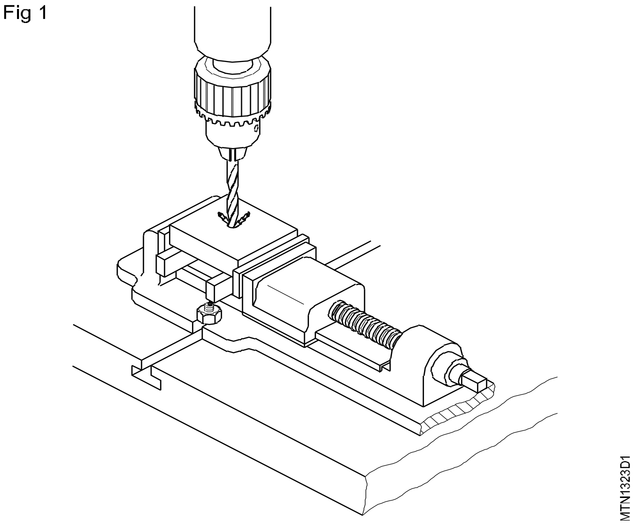
Workpieces to be drilled should be properly held or clamped to prevent them from rotating along with the drill. Improperly secured work is not only a danger to the operator but can also cause inaccurate work, and breakage to the drill. Various devices are used to ensure proper holding.

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 2,3,4 & 5)

Drilling machine tables are provided with T-slots for fitting bolt heads. Using clamps and bolts, the workpieces can be held very rigidly. While using this method, the packing should be, as far as possible, of the same height as the work, and the bolt nearer to the work.

There are many types of clamps and it is necessary to determine the clamping method according to the work.

Fig 2

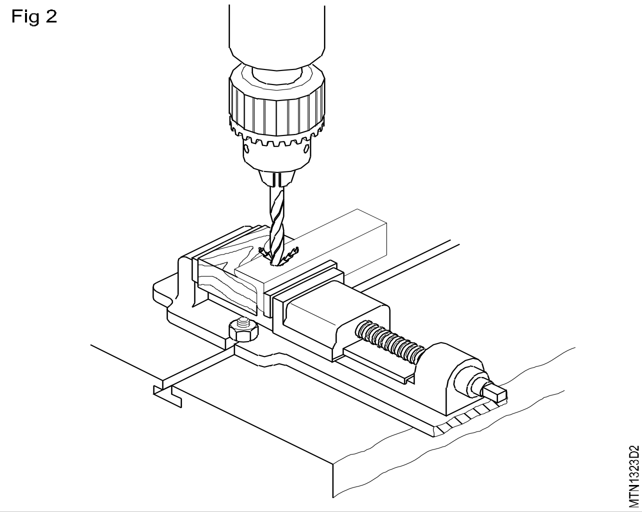


Fig 3

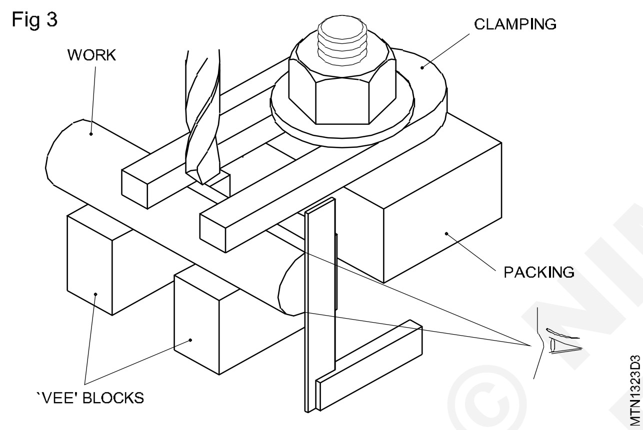


Fig 4

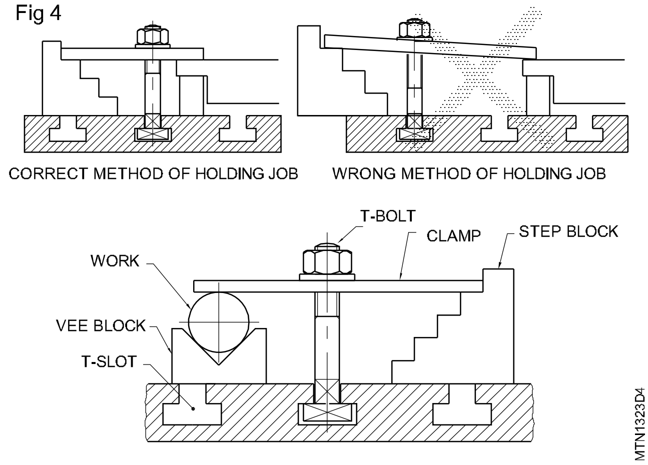
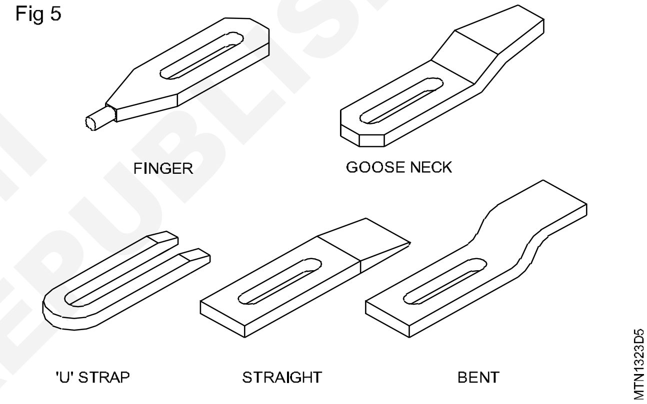


Fig 5



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 sprindle by means of an arbor fitted or the drill chuck. (Fig 1)

Taper Sleeves and Sockets (Fig 1)

Taper shank drills have a morse taper.

Sleeves and sockets are made with the same taper so that the taper shank of the drill. When engaged, will give a good wedging action. due to this reason morse tapers are called self-holding tapers.

Drills are provided with five different sizes of morse tapers, and are numbered from MT 1 to MT5.

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

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

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

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

Fig 1

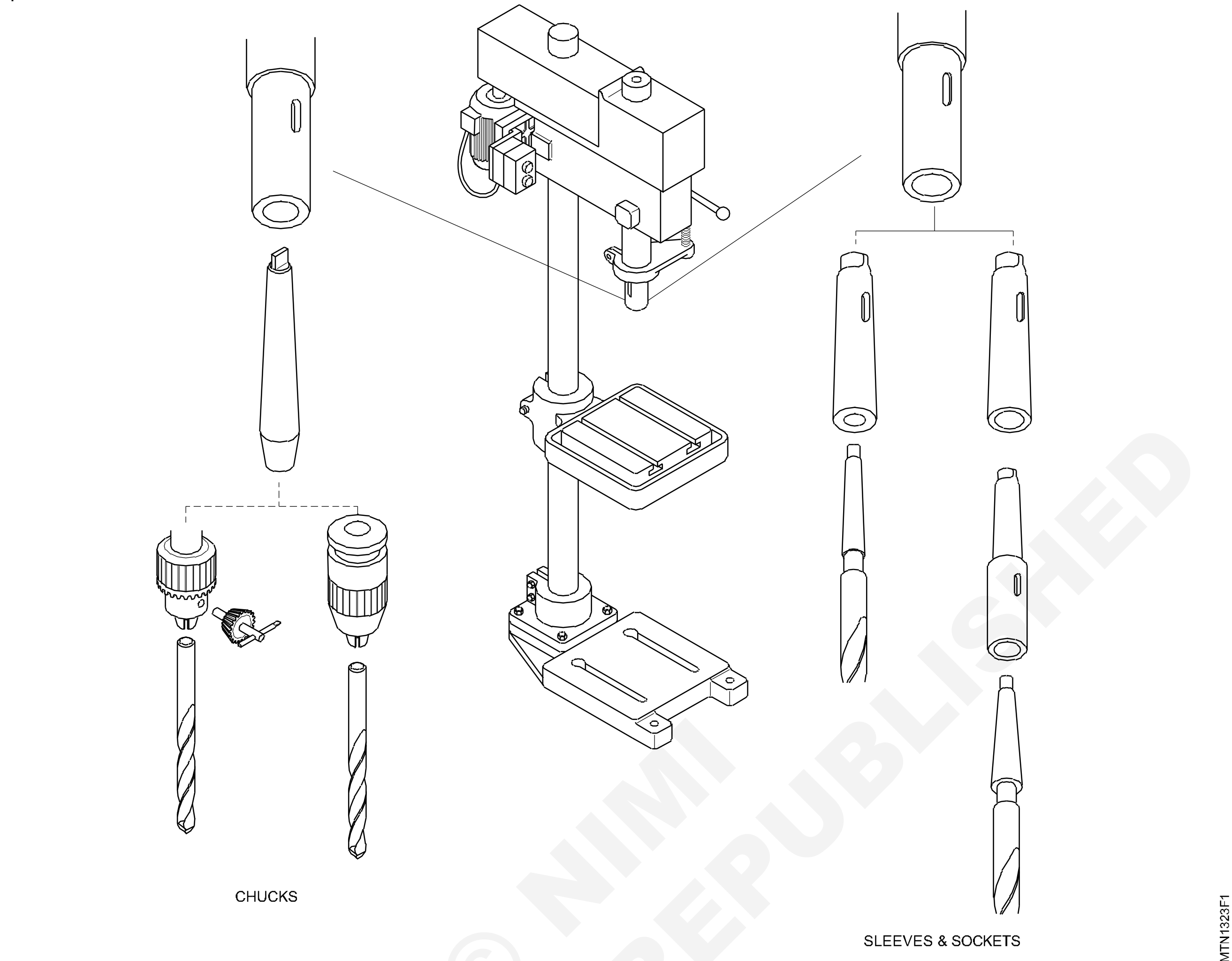


Fig 2

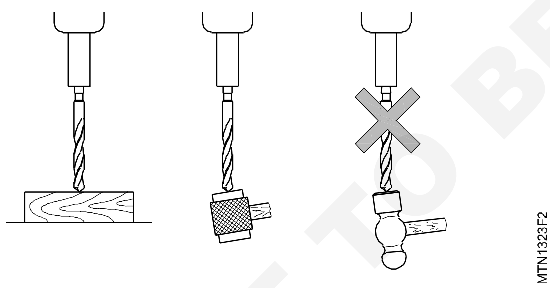
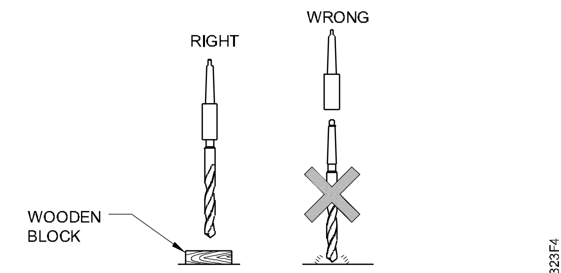
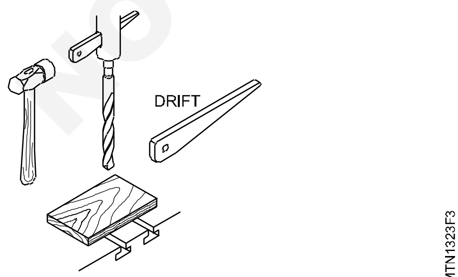


Fig 4



REMOVING A TAPER SHANK DRILL

Fig 3



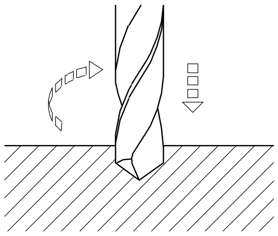
Drill bits

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

Function of drills

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)

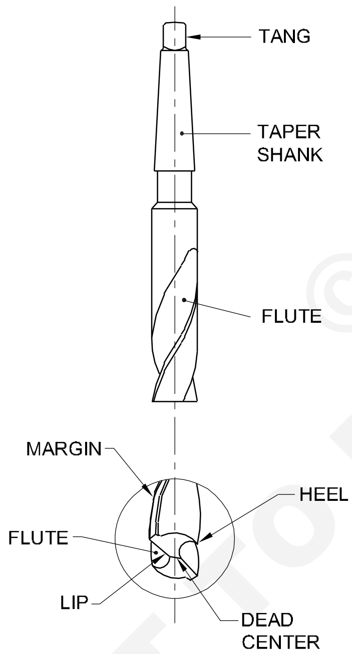
Fig 1



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.

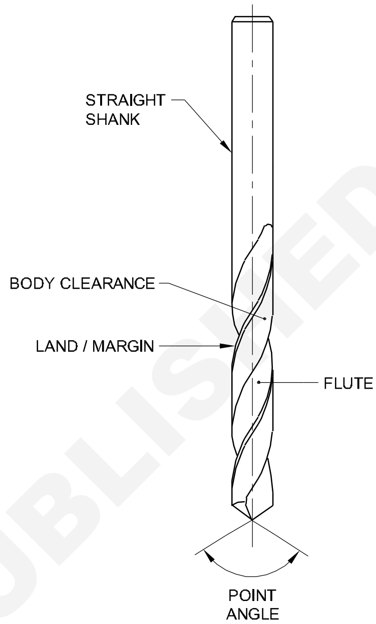
Tang

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.

Fig 3



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 allow these to come out
- the coolant to flow to the cutting edge.

Land/Margin

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

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

Body Clearance

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

Web

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

Hand taps and wrenches

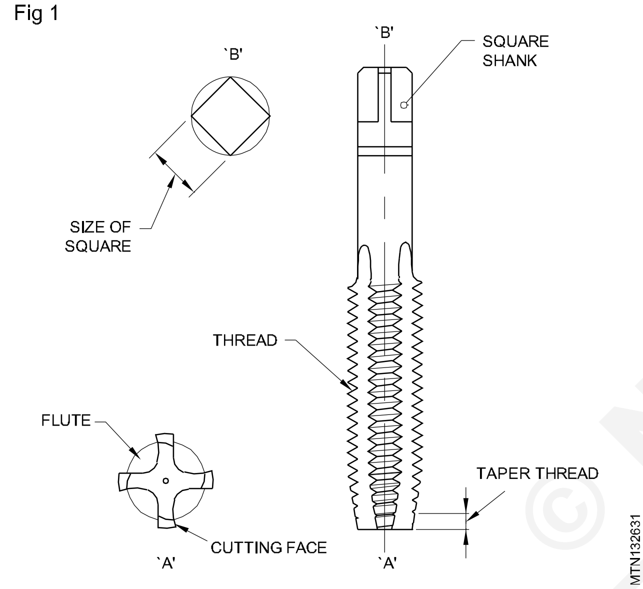
Objectives: At the end of this lesson you shall be able to
- **state the uses of threading hand taps**
- **state the features of hand taps**
- **distinguish between different taps in a set**
- **name the different types of tap wrenches**
- **state the uses of different types of wrenches.**

Use of Hand Taps

Hand taps are used for internal threading of components.

Features (Fig.1)

Fig 1



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

Threads are cut on the surface and are accurately finished.

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

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.

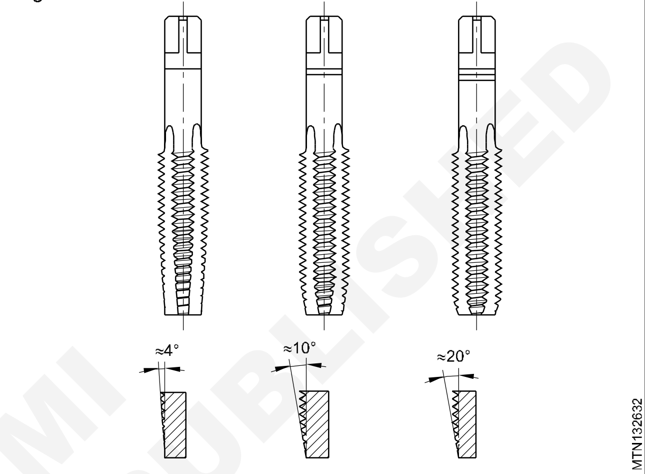
In certain cases the pitch of the thread will also be marked.

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)

Fig 2



These are

- first tap or taper tap
- second tap or intermediate tap
- plug or bottoming tap

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

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

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

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

The taper tap has one ring the intermediate tap has two rings and the bottoming tap has three rings (Fig.3)

Tap Wrenches

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

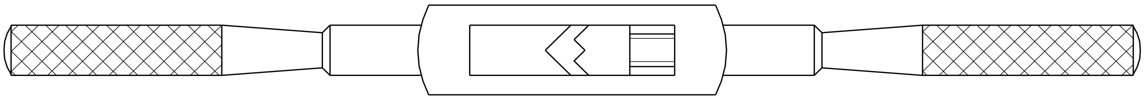
Tap Wrenches are of different types

1. Double ended adjustable wrench
2. T handle tap wrench and
3. Solid type tap wrench.

1. Double ended adjustable wrench

Double ended adjustable tap Wrench or Bar Type Tap Wrench. This is shown in Fig.3.

Fig 3



MTN132633

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.

2. T- Handle tap wrench (Fig 4)

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

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

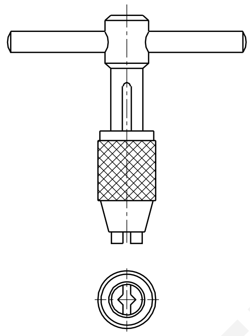
This is not suitable for holding large diameter taps.

3. Solid type tap wrench (Fig 5)

These Wrenches are not adjustable

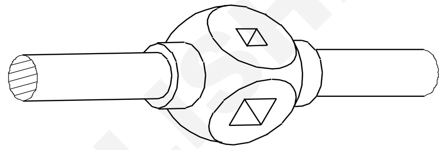
They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches and thus prevents damage to the taps.

Fig 4



MTN132634

Fig 5



MTN132635

Tap Drill Size

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

What is a tap drill Size?

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

Tap Drill Sizes for Different Threads

ISO Metric Thread

Tapping drill size

for M10 x 1.5 thread

Minor diameter = Major diameter – 2 x depth

depth of thread = 0.6134 x pitch of a screw

2 depth of thread = 0.6134 x 2 x pitch

=1.226 x 1.5 mm = 1.839 mm

Minor dia (D1)=10 mm – 1.839 mm

=8.161mm or 8.2 mm

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

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

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

Tap drill size = Major diameter – pitch

= 10 mm - 1.5 mm; = 8.5 mm.

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

ISO Inch (Unified) threads Formula

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

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

Tap drill size = 5/8" – 1/11"

= 0.625" – 0.091" ; = 0.534"

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

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

What will be the tapping size for the following threads?

(a) M 20

(b) UNC 3/8

Refer to chart for determining the pitches of the thread.

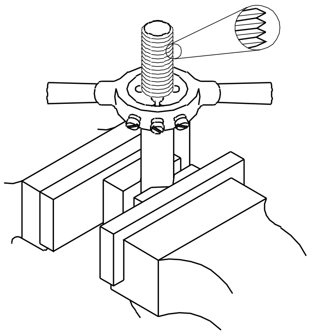
Die and die stock

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

Uses of Dies

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

Fig 1



Types of Dies

The following are the different types of dies.

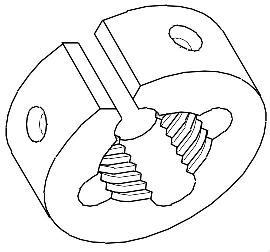
Circular Split Die (Button die)

Half Die

Adjustable Screw Plate Die

Circular Split Die/Button Die (Fig 2)

Fig 2



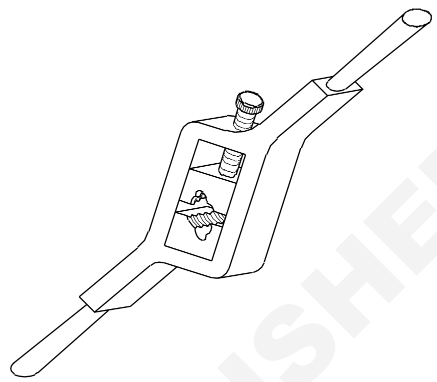
This has a slot cut to permit slight variation in size.

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)

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.

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.

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

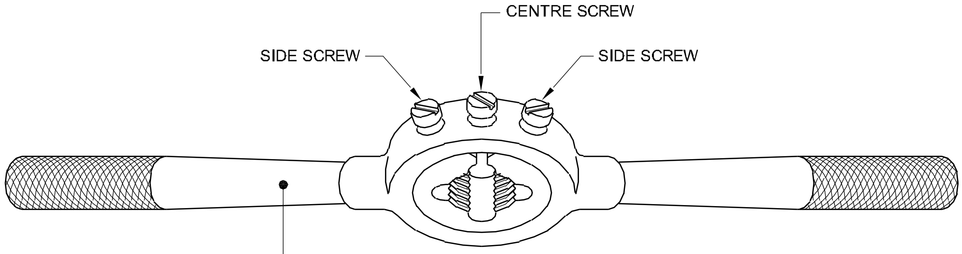
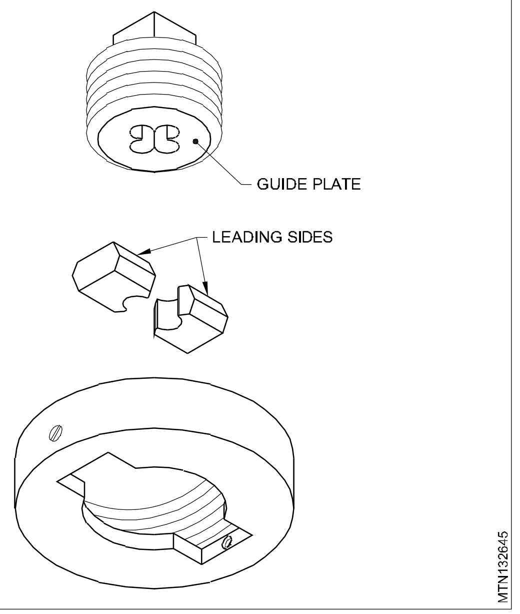


Fig 5



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

Both pieces should have the same serial numbers.

Die Nut (Solid Die) (Fig 7)

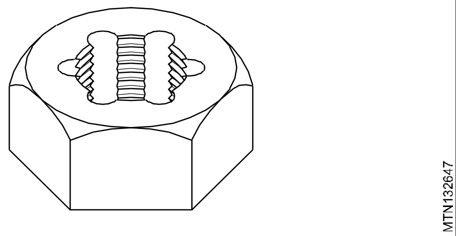
The die nut is used for chasing or reconditioning the damaged threads.

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

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

The die nut is turned with a spanner.

Fig 7



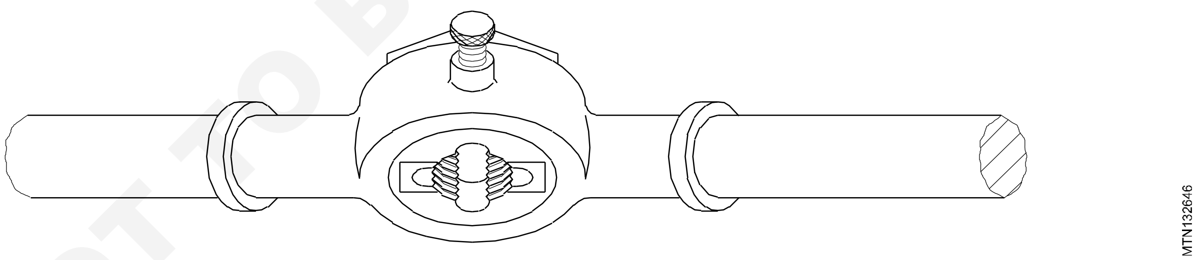
Screw extractor (Fig 8)

Fig 8

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

To use after drilling a hole into the fastness tap the screw retraction into the fastener. Top the screw extractor into the hole using a hammer.

Fig 6



Reamers

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

What is reamer?

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

Advantages of 'reaming'

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

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

Classification of reamers

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

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

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

Fig 1

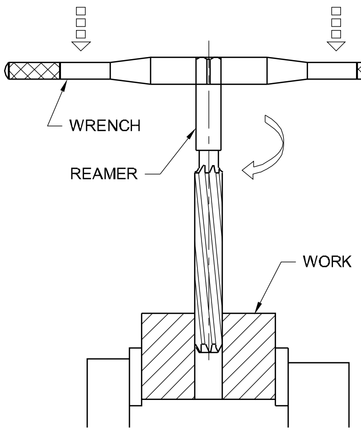
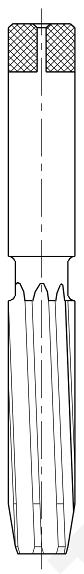
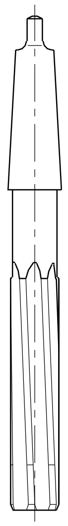


Fig 2



HAND REAMER

Fig 3



MACHINE REAMER

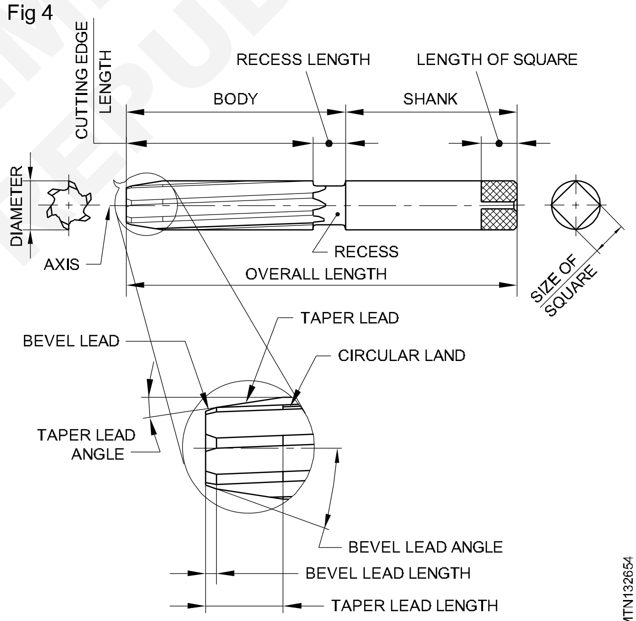
Machine reamers are fitted on spindles of machine tools by means of a floating chuck and are rotated for reaming.

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

Parts of a hand reamer

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

Fig 4



Hole size for reaming

Objective: At the end of this lesson you shall be able to
- **determine the hole size for reaming.**

For reaming with a hand or machine reamer the hole drilled should be smaller than the reamer size.

The drilled hole should have sufficient metal for finishing with the reamer. Excessive metal will impose a strain on the cutting edge of the reamer and damage it.

Calculating drill size for reamer

A method generally practised in workshops is by applying the following formula.

Drill size = Reamed size - (undersize+oversize) of drilled hole.

Finished size

Finished size is the diameter of the reamer.

Undersize

Undersize is the recommended reduction in size for different ranges of drill diameter. (Table 1)

TABLE 1
Undersizes for reaming

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

Oversize of drilled hole

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

For light metals the undersize will be 50% larger.

Example

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

Drill size = Reamer size - (undersize + oversize)

(finished size) = 10mm

Undersize as per table = 0.2 mm

Oversize = 0.05 mm

Finished size = 0.05+0.2 = 0.25mm

Drill size = 10mm - 0.25mm = 9.75 mm

Determing the drill hole sizes for the following reamers.

i) 15mm ii) 44mm

iii) 4mm iV) 19mm

Answer

i) ______________

ii) ______________

iii) ______________

iv) ______________

If the reamed hole is undersize, the cause is that the reamer is worn out.

Always inspect the condition of the reamer before commending reaming.

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

Defects in reaming - Cause and Remedies Reamer hole undersize

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

Always inspect the condition of the reamer before using.

Surface finish rough

The causes may be anyone of the following are combination thereof.

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

While reaming apply a steady and slow feed rate.

Ensure a copious supply of the lubricant.

Do not turn the reamer in the reverse direction.

Lapping

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

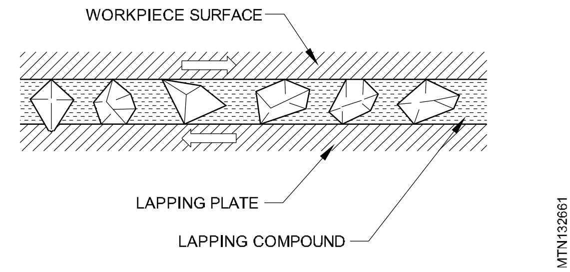
Lapping is a precision finishing operation carried out using line abrasive materials.

Purpose : This process

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

Lapping process: in the lapping process small amounts of material are removed by rubbing the work against a lap charged with a lapping compound. (Fig 1)

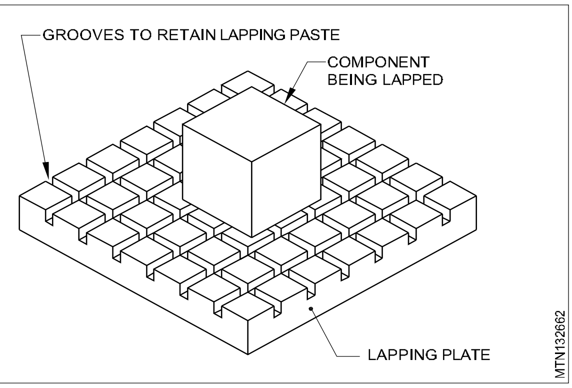
Fig 1



The lapping compound consists of the abrasive particles. Suspended in a base 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.

Fig 2



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 practices.

This is a process by which the abrasive practices 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 workpiece on the plate and move along and across, covering the entire surface areas of the plate. When carrying out fine lapping, the surface should be kept moist with the help of kerosene.

Wet and dry lapping: Lapping can be carried out either wet or dry.

In wet lapping there is surplus oil and abrasives on the surface of the lap. As the workpiece which is being lapped is moved on the lap, there is movement of the abrasive particles also.

In the dry method the lap is first charged by rubbing the abrasives on the surface of the lap. The surplus oil and abrasives are then washed off. The abrasives embedded on the surface of the lap will only be remaining. The embedded abrasives act like a fine oilstone when metal pins to be lapped are moved over the surface with light pressure. However, while lapping, the surface being lapped is kept moistened with kerosene or petrol. Surfaces finished by the dry method will have better finish and appearance. Some prefer to do rough lapping by wet method and finish by dry lapping.

Lap materials and lapping compounds

Objectives: At the end of this lesson you shall be able to
- **state the qualities of different lap materials**
- **name the different types of lap materials**
- **name the different types of abrasive materials used for lapping**
- **distinguished between the application of different lapping abrasives**
- **state the function of lapping vehicles**
- **name the solvents used in lapping.**

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

Laps are usually made of
- close grained iron
- copper
- brass or lead.

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

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

Lead is an in expensive form of lap commonly used for holes. Lead is cast to the required size on steel arbar. These laps can be expanded when they are worn out. Charging the lap is much quicker.

Lapping abrasives and their applications:

Abrasives of different types are used for lapping.

The commonly used abrasives are:

- silicon carbide
- aluminium oxide
- boron carbide and
- 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.

Solvents used in lapping

In addition to the base used in making the lapping compound, solvents like water, kerosene, etc are also used at the time of lapping.

Abrasives of varying grain sizes from 50 to 800 microns are used for lapping, depending on the surface finish required on the component.

Flux

Objectives : At the end of this lesson you shall be able to
- **state the criteria for the selection of fluxes**
- **distinguish between corrosive and non-corrosive fluxes**
- **name the different types of flux and their application.**

Fluxes are non-metallic materials which are used at the time of soldering.

Functions of flux

- Flux removes oxides from the soldering surface.
- It prevents corrosion.
- It helps molten solder to flow easily in the required place.
- It promotes the wet surface.

Selection of flux

The following criteria are important for selecting a flux.

- Working temperature of the solder
- soldering process
- materials to be joined

Classes of flux

Flux can be classified into corrosive flux, and non corrosive flux

Corrosive flux in acid form is corrosive and should be washed immediately after the soldering operation is completed.

Non-corrosive flux is in the form of lump, powder, paste or liquid.

DIFFERENT TYPES OF FLUX

Hydrochloric acid: Concentrated hydrochloric acid is a liquid which fumes when it comes into contact with air. After mixing with water, 2 or 3 times the quantity of the acid, it is used as dilute hydrochloric acid.

Hydrochloric acid combines with zinc forming zinc chloride and acts as a flux. So it cannot be used as a flux for sheet metals other than zinc, iron or galvanised sheets.

Zinc chloride: It is mainly used for soldering copper sheets, brass sheets and tin plates.

As it is extremely corrosive, the flux must be perfectly washed off after soldering.

Ammonium chloride

This is the form of powder or lump. It evaporates when heated.

Ammonium chloride is used as a flux for soldering steel.

A solution of a mixture of hydrogen chloride, zinc chloride and ammonium chloride is used as a flux for stainless steel sheets.

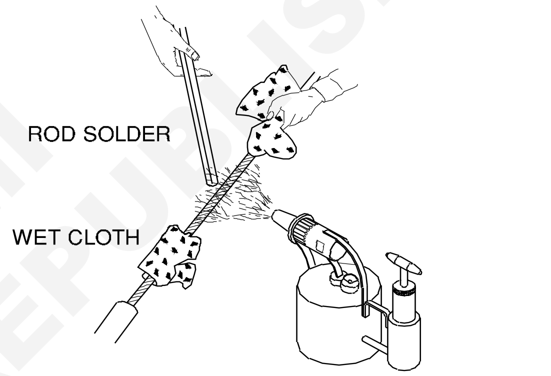
Resin: As resin is not very effective for removing oxidation coating, and, as it is not highly corrosive, it is used as flux for copper and brass. Resin melts at about 80° to 100°C.

Paste: This is a mixture of Zinc chloride, resin, glycerin and others and is available as a paste.

As it is effective for removing oxidation coating, it is used for soldering small handworks and radio wiring.

Soldering with blowlamp

Fig 1



SOLDERING WITH BLOWLAMP

Soldering with a blowlamp is done when the heat capacity of a soldering iron is not sufficient.

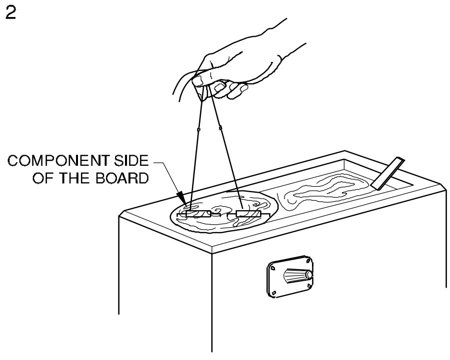
The method, shown in Fig 1, permits rapid heating and is used primarily for larger jobs, such as piping and cable work, vehicle, body repairs and some applications in the building trade.

This requires skillful management of the flame.

Dip soldering:

This method, shown in Fig 2, is used for bulk production and for tinning work similar to component soldering on printed Circuit Boards (PCB). Components to be soldered

Fig 2



DIP SOLDERING

or tinned are dipped into a bath of molten solder, which is heated electrically. The solder is kept in motion by an agitator in order to obtain an even temperature and to keep the surface free from oxides. If no agitator is provided, the surface must be protected or skimmed at regular intervals to remove the oxides.

The temperature can be controlled very accurately.

Machine soldering

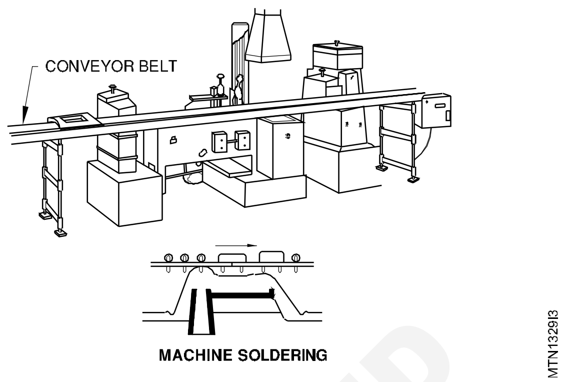
The method, shown in Fig 3, is used for quantity production and is based on the principle, when molten solder is set in rapid motion, the oxide film breaks without setting on the surface. The solder comes into direct contact with the components to be soldered.

Soldering machines are of different designs for wave soldering, cascade soldering and jet soldering.

Equipment for machine soldering is expensive and the cost of production is high.

Accurate temperature control can be arranged.

Fig 3



MACHINE SOLDERING

Brazing Techniques

Objectives : At the end of this lesson you shall be able to
- **explain the brazing technique**
- **Study copper to copper pipe brazing swaged joint**
- **Studies braze copper with MS tube**

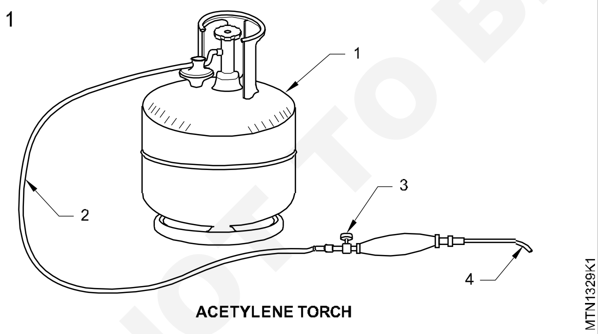
Brazing techniques

Acetylene torch (Fig 1)

> **Danger: Acetylene is very inflammable, Do not allow anyone to smoke while you are brazing)**

- Connect the torch with a flexible hose to the gas regulating valve of the acetylene cylinder; make sure that all of the connections are tight to prevent gas leakage. Check all connections for leaks with soap water before lighting the torch.

Fig 1



ACETYLENE TORCH

- Open the cylinder valve one turn, only. Open the regulating valve fully. Open the torch control valve just enough to give a flow of gas. Light the escaping gas at the tip of the torch.
- Adjust the torch control valve to get the correct flame. The flame should be blue. It should have a sharp bright cone in the middle with pale outer flame. If the flame is yellow more gas is required. open the control valve.
- The size of the torch tip or nozzle determines the size of the inner cone. use a cone size that gives the required amount of heat.

Propane turbo torch (Fig 2): (Danger: Propane is very inflammable. Do not allow anyone to smoke while you are brazing)

- This gives a smaller outside flame. The tip of the inner cone is much hotter than an acetylene flame of the same size. Always work with a smaller flame than acetylene.
- Connect, adjust and use this torch in the same way as acetylene described above, check all connections for gas leaks with soap water before lighting the torch.
- Follow exactly the instruction supplied with the torch.

1 This is the cylinder that holds the gas for brazing

2 Check the connections for leaks at each end of this hose with soap water.

3 Use the torch control valve to control the gas flow.

4 Fit a torch tip which gives the correct flame.

5 This is an acetylene flame suitable for pipe brazing

6 The bright cone is the hottest part of the flame work with the tip of the cone.

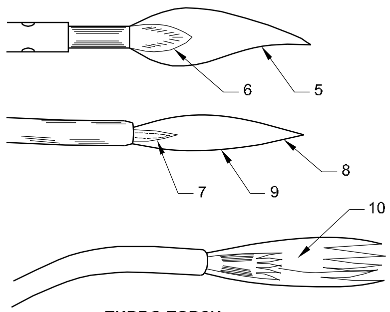
7 The high bright cone is the hottest part of the flame with the tip of the cone

8 This is an acetylene flame suitable for capillary tube brazing required.

9 The other flame should be pale yellow. If it is yellow,

10 This is a propone turbo torch flame. The end tractions will tell you what size of flame of use.

Fig 2



TURBO TORCH

Kerosene blow lamp

- This gives a larger flame than a propane or acetylene torch.
- When lighting, follow carefully the instructions supplied with the torch. Wherever possible light the blow lamp in an open space for safety.

Silver brazing: One of the best method of connection copper pipes after swaging or by the use of coupling, in a leak proof manner is by silver brazing,. By this method the copper pipes can be connected to the compressor, service valves and the other parts also.

Silver brazing can be easily done if the correct procedure is followed.

Clean the inside and outside of the tube end using sand paper of wire brush. Fit the joint closely and support the joint. Apply flux required for the brazing rod. (Flux is used to prevent chemical action during heating the metal. The flux used for soldering refrigeration fittings is made of alcohol and resin.

There are various silver alloys in the market. The rod used to join copper pipes is called copper to copper brazing rod'. These have 35 to 45 percent silver content. This material melts at 1120°F and flows 1145°F

Precautions: Do not apply the solder at the joint if it is not red hot

Any oxy-acetylene torch is excellent heat source for silver brazing. While using blow lamp the joint is to be heated longer time.

To join copper pipe to steel pipe and any pipe to the compressor dome only oxy acetylene torch can be used. This torch can also used for refrigerator cabinet patch work.

While brazing keep away the flame from rubber plastic parts and insulating materials of the refrigerator or AC.

The pipes joined by brazing can be separated by heating it again.

Flux: Flux is a substance which works as an agent help the solder to flow easily. It cleans the surface and prevents oxidation. Melting point of flux is much less than that of solder.

Various types of flux and their uses are given below.

Ammonium chloride NH_4Cl	- For soldering cast iron
Hydrochloric acid HCL	- For soldering G.I sheets
Zinc chloride $ZnCl_2$	- For soldering mild iron sheets
Tallow	- For soldering lead and electrical joints
Resin	- For soldering electrical joints
Phosphoric	- For soldering stainless steel

Braze a copper tube with swaged joint

Fit two pipes to braze. If it is a loose fit the joint will be weak. Insert the end of one pipe into the swage of the other. Apply a small amount of flux to the surfaces to be joined, with the help of blow torch heat the joint. The brazing rod must be melted by the heat. Complete ring of brazing material can be seen at the end of the swage remove the torch and allow the joint to cool.

Braze copper with ms tube: In most tube and fitting connections are made by either soldering or silver brazing. Soldering joints are used for water pipes and drains. silver brazed joint are used for refrigerant pipes and rubbing.

The best methods of making leak proof connection while providing maximum strength is to silver braze the joints. These joints are very strong and will stand up under the most extreme temperature condition.

An oxyacetylene torch is an excellent heat source for silver brazing. The proper silver brazing temperature will be indicated by the colour of green shade.

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

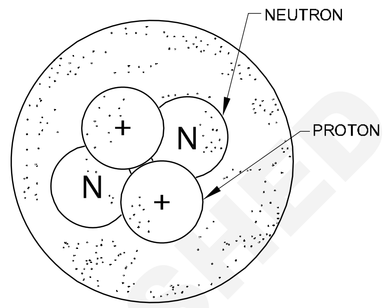
Protons

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.

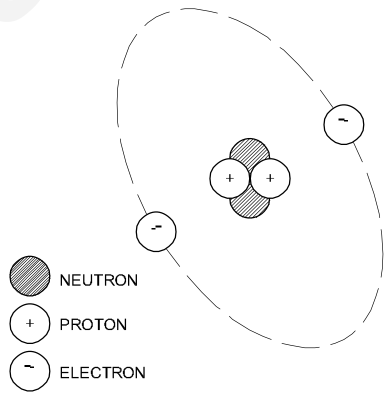
Fig 1



NUCLEUS OF AN ATOM

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 2



Neutron

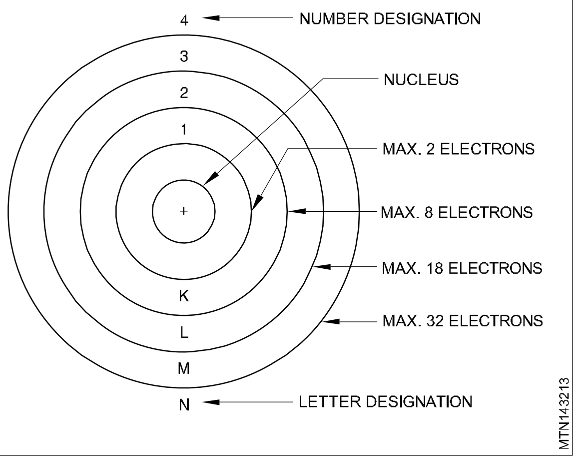
A neutron is actually a particle by itself, and is electrically neutral. Since neurtons are electrically neutral, they are not too important to the electrical nature of atoms.

Energy Shells

In an atom, electrons are 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.

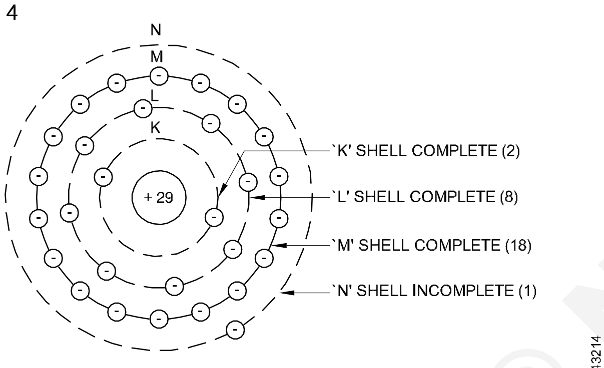
If the total number of electrons for a given atom is known, the placement of electrons in each shell can be easily determined. Each shell layer, beginning with the first, is

Fig 3



filled with the maximum number of electrons in sequence. For example, a copper atom which has 29 electrons would have four sheels with a number of electrons in each shell as shown in Fig 4.

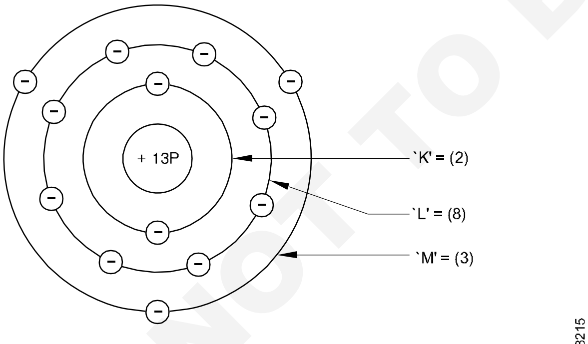
Fig 4



COPPER ATOM

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

Fig 5



ALUMINIUM ATOM

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.

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

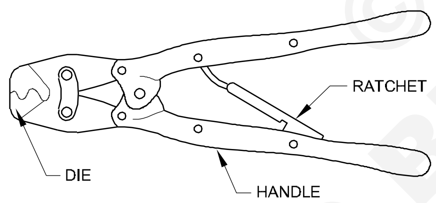
Cables are terminated at electrical appliances, accessories and equipment etc. for providing electrical connections. All terminations must be made to provide good electrical continuity, and made in such a manner as to prevent contact with other metallic parts and other cables.

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.

Different types of 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).

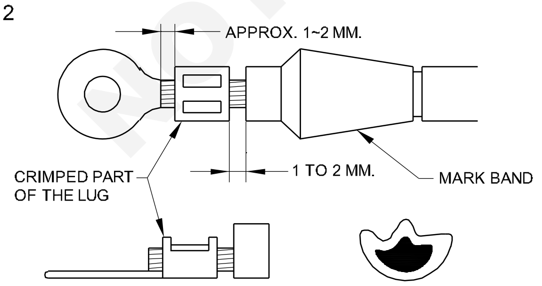
Fig 1



CRIMPING TOOL

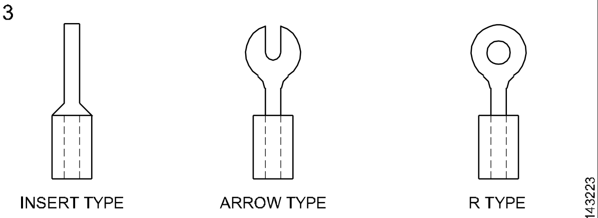
It is important to choose a crimp terminal that matches the conductor diameter and the dimensions of the connecting screw terminal . (Figs 2 and 3)

Fig 2



CRIMP TERMINAL CONNECTION

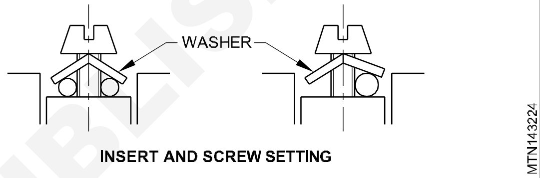
Fig 3



VARIOUS KINDS OF CRIMP TERMINALS

Insert screw setting: The conductor is inserted between the terminal block and the special form of washer (Fig 4), and then the screw is tightened.

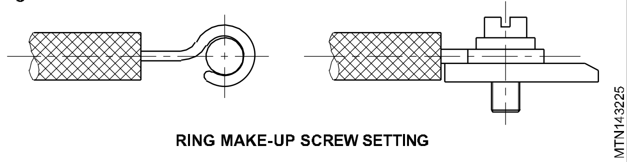
Fig 4



INSERT AND SCREW SETTING

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 5) In the case of a stranded conductor, soldering of the loop is essential to prevent strands getting fray.

Fig 5



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.

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.**

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.

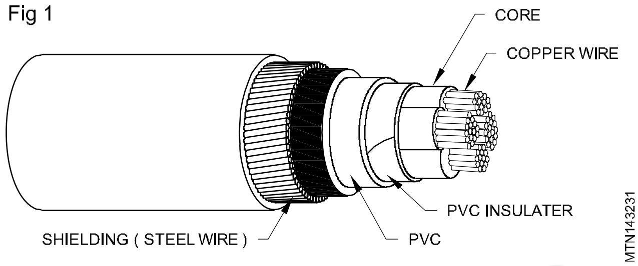
Reasons for earthing

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



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.

Ohm’s Law

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

Electrical terms and definitions EMF and Pd

The force tending to make electrons to move along a conductor is called the potential difference (pd) in the conductor and is expressed in volts. This is also called the electric pressure or the voltage.

The voltage developed by a source such as a battery of a generator is called its electromotive force. (emf)

When one ampere current flows through one ohm resistance the p.d. across the resistance is said to be one “Volt”. Voltmeter is used to measure the voltage of a supply and is connected in parallel to the supply. EMF/Pd is denoted by letter “V”.

Current

The flow of electrons is called current. Its unit is ampere. When one volt is applied across a resistance of one ohm the amount of current passess through the resistance is said to be one “Ampere”. It is denoted by “A”. Smaller units are milliampere and microampere. Ammeter should be connected in series with the load.

Resistance

It is the property of a substance which opposes the flow of electricity. Its unit is ohm. The resistance of a conductor, in which a current of one ampere flows when potential difference of one volt is applied across its terminals, is said to be one ohm.

An ohmmeter is used to measure the resistance of an electric circuit. It is denoted by “Ω” Bigger units are Kilo ohms and Mega ohms.

1 K $\Omega = 10^3$ ohms

1 Mega $\Omega = 10^6$ ohms

Ohmmeter should be connected in parallel with the load and should not be connected when there is a supply.

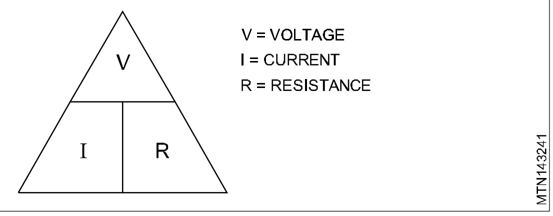
There is a definite relationship between the three electrical quantities of Voltage, Current and Resistance.

Ohm's Law states

`The current is directly proportional to the voltage and inversely proportional to the resistance' when the temperature remains constant.

An aid to remember the Ohm's law relationship is shown in the divided triangle. (Fig 1)

Fig 1



Written as a mathematical expression, Ohm's Law is -

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

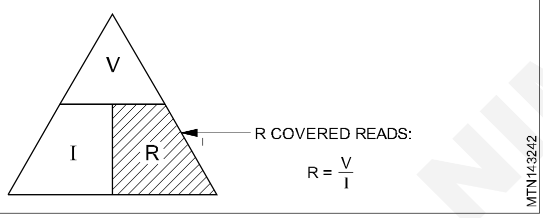
or $I = \dfrac{V}{R}$

Of course, the above equation can be rearranged as:

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

or $R = \dfrac{V}{I}$ (Refer Fig 2)

Fig 2



Example

How much current(I) flows in the circuit shown in Fig.3

Given

Voltage(V) = 1.5 volts

Resistance(R) = 1 k ohm

= 1000 ohms.

Find

Current(I)

Formula

$$I = \frac{V}{R}$$

Solution

$$I = \frac{1.5\ \text{V}}{1000\ \text{ohms}} = 0.0015\ \text{amp}$$

Answer

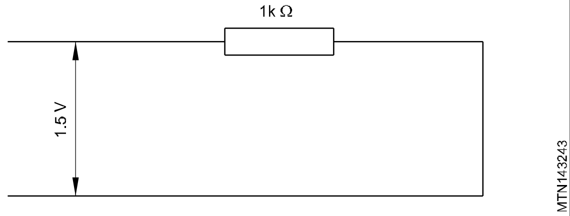
The current in the circuit is 0.0015 A

or

the current in the circuit is 1.5 milliampere (mA).

(1000 milliamps = 1 ampere)

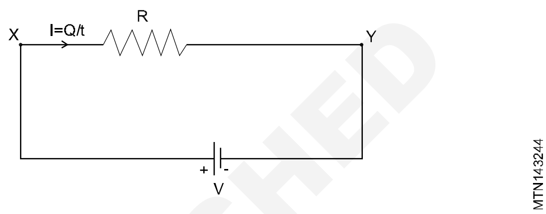
Fig 3



Electric Circuit (closed circuit, open circuit and short circuit)

An electric circuit is the path in which the electric current flows. Fig. 4 shows a simple circuit.

Fig 4



B is the source of electric energy (a cell) L is the lamp, the load or appliance to use the electric energy, S is the switch to control the circuit, i.e. to make the circuit on or off, F is the fuse to protect the circuit from faults, B, S and F have terminals marked 1, 2, 3, ... Connecting wires connect them systematically. Electric current starts from terminal 1, goes to terminal 2 through the connecting wire. When S 'ON' it passes to 3 and through F and L it returns to the terminal 8 of the source. Thus the current's path is completed. A circuit like this is called a closed circuit. If the switch is off or the connecting wires are cut or disconnected, it becomes an open circuit. Current cannot pass in an open circuit. If an extra wire connects terminals 5 and 7, the current will find an easier path. This forms a short circuit. In this case, the current does not pass through the load. The current may be very high. The fuse protects the circuit in such cases.

Identification of A C and D C Meters

AC and DC meters can be identified as follows

1) By the symbol available on the dial / scale.

a) Direct current

b) Alternating current

2) By seeing the graduation on the dial / scale

a) If the graduation of dial is uniform throughout, it is a D C meter.

b) If the graduation of dial is cramped at the beginning and at the end, it is an A.C. meter

3) By seeing the terminals

a) In the d C meter the terminals are marked with + and– The positive (+) terminal is Red in colour and the negative (–) terminal is Black in colour.

b) In the A.C. meter there is no marking on the terminals and no difference in colour.

Pire wheel

(i) current:

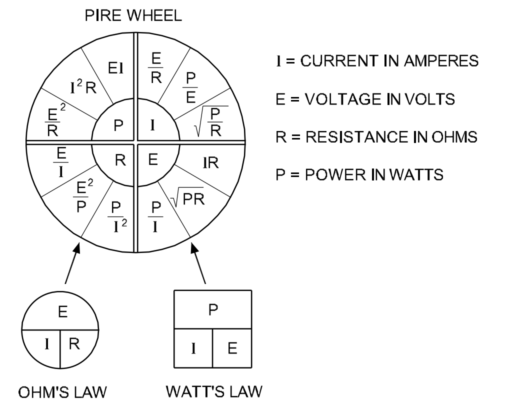
$I = V / R$

$= P / V$

$= \sqrt{P / R}$

The formulae (or equations) to solve for unknown voltage, current, resistance or power can be obtained by combining Ohm's law and Power law. This is shown in Fig.5

Fig 5



Electrical measuring instruments and electrical circuits

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

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

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

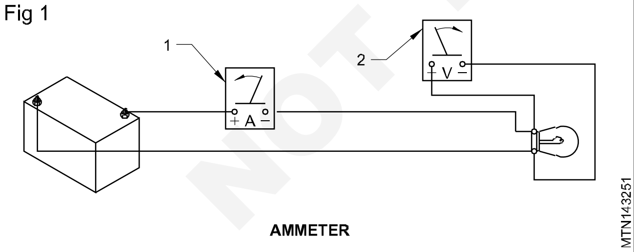
– Ammeter

– Voltmeter

– Ohmmeter

Ammeter (Fig 1)

Fig 1



AMMETER

The ammeter (1) is fitted on the vehicle panel board/ dashboard.

It is connected in series in the circuit as shown in the fig.1.

Uses of ammeter

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

This is connected in series with the load.

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

Care

Do not connect an ammeter in parallel in the circuit.

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

Use DC meter for automobile charging system.

Select and use an ammeter as per the required range.

Voltmeter

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

Uses of a voltmeter

To measure the voltage at any point of circuit.
To measure the voltage drop in the circuit.
To check the condition of the battery.

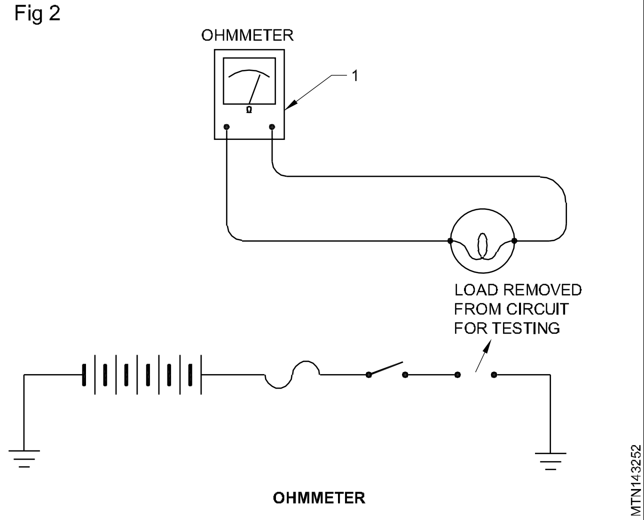
Care

Select the voltmeter as per the required range.

Do not connect the voltmeter in series in the circuit.

Ohmmeter (Fig 2)

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 :

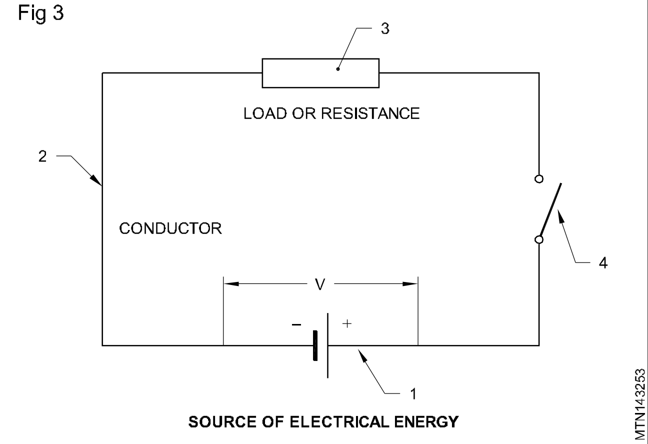
– a voltage source (1)

– connecting wires (conductors) (2)

– a load (lamp or motor) (3)

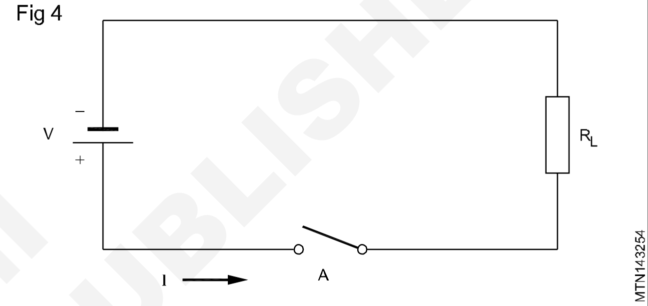
– switch (4).

Fig 3



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

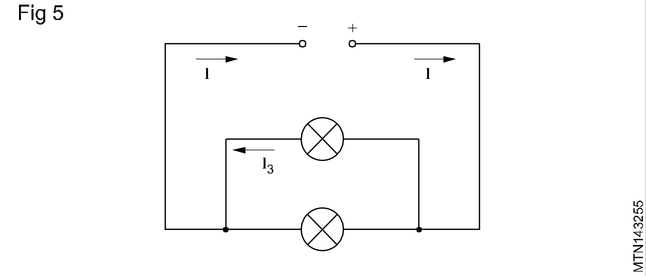
Fig 4



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 ohmic value of resistance it is grouped as low, medium and high resistance.

Low resistance

Range : 1 Ohm and below.
Uses : Armature winding, ammeter.

Medium resistance

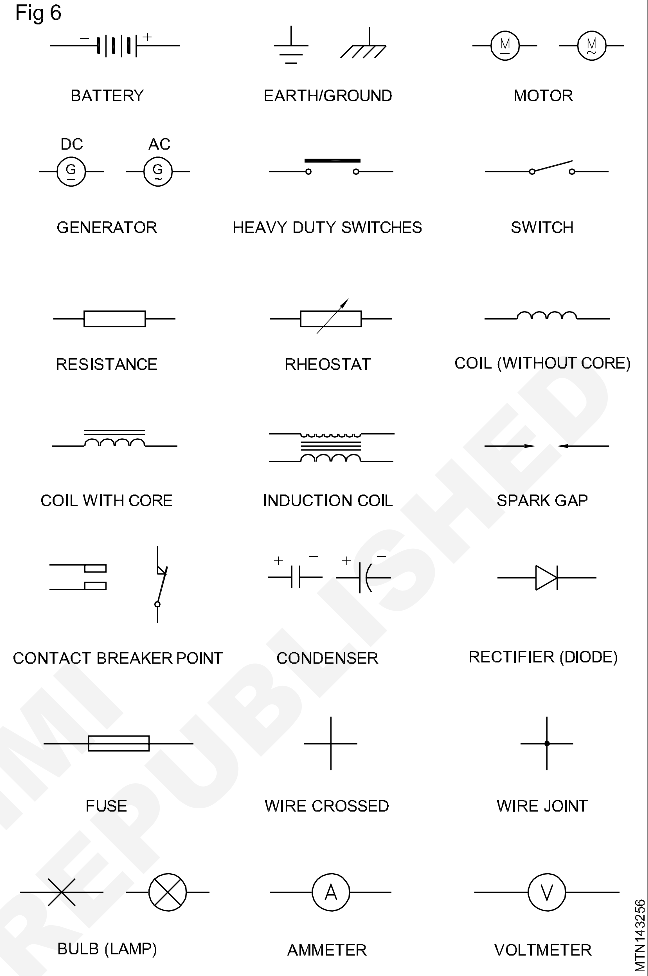
Range : Above 1 Ohm up to 1,00,000 Ohm.
Uses : Bulbs, heaters, relay starters.

High resistance

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

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

Fig 6



Multimeter

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

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

There are two major types of multimeters

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.

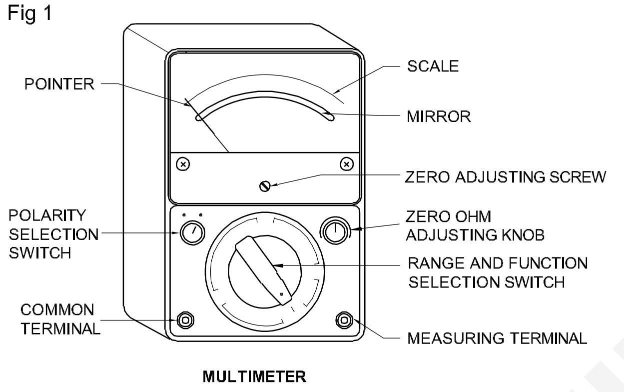
There are several types of multimeters available in the market, manufactured by various manufactures. Each model differs from the others by the extra facilities available. It is a versatile tool for all automobile. With proper usage and care, it could give service for many years.

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

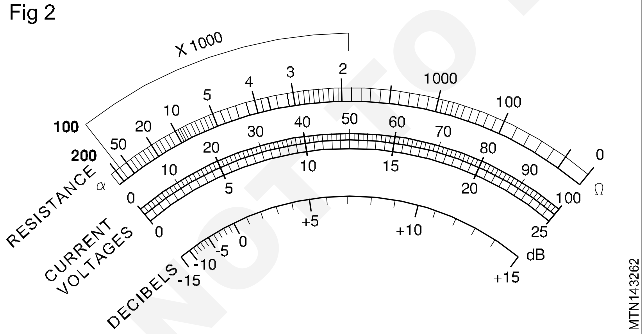
Scale of multimeter

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.

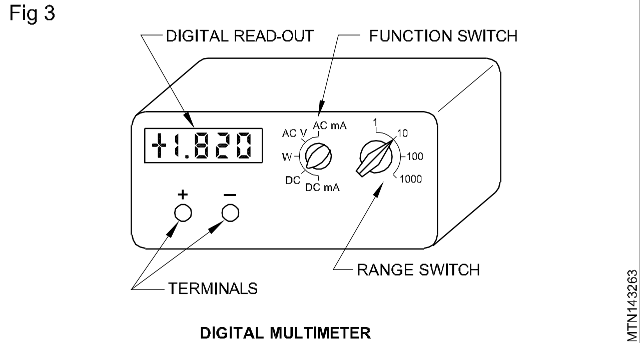
Multiple range

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 isalways 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.

Fig 3



DIGITAL MULTIMETER

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.

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.

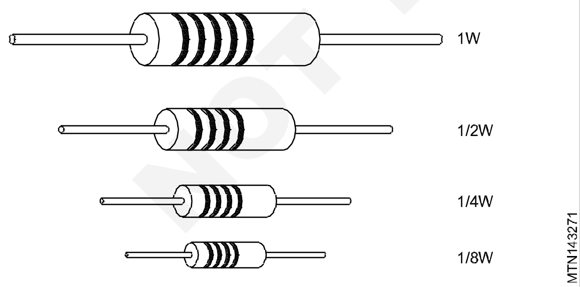
FIXED VALUE RESISTORS
- Carbon composition resistors
- Wire-wound resistors
- Film resistors
  - Carbon - film resistors
  - Metal film resistors
  - Metal oxide film resistors
  - Cermet film resistors
  - Integrated resistors
- Printed resistors

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)

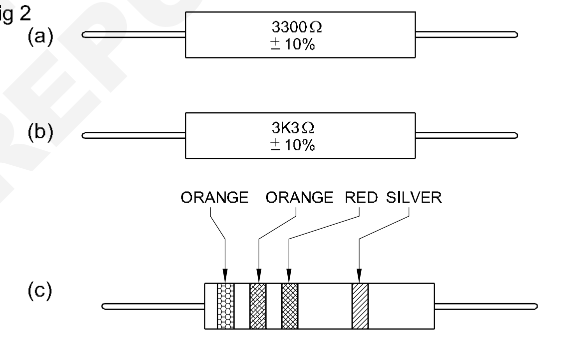
For using resistors in circuits, depending upon the type of circuit in which it is to be used, a particular type, value and wattage of resistor is to be chosen. Hence before using a resistor in any circuit, it is absolutely necessary to identify the resistor's type, value and power rating.

Fig 1



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.

Fig 2



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.

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

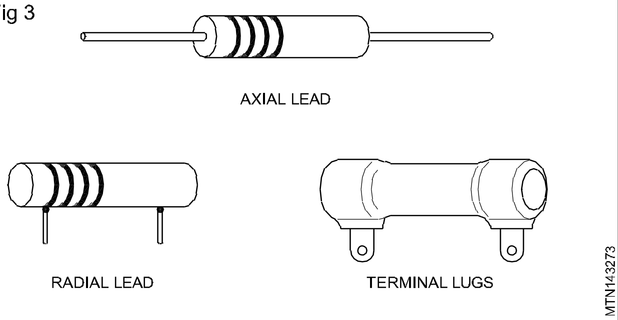


TABLE 1

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

Fuse

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

Introduction

A fuse is a protective device. It is a weakest portion in the electrical circuit.

An electric current heats the wire when the current passes through it. The amount of heat depends upon the current and resistance in the wire.

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

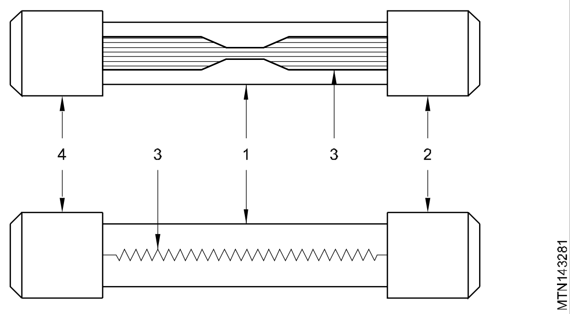
The heating effect in the circuit is limited by the fuse. If this limit is not controlled, the circuit an accessories will be overloaded causing severe damage to them.

Purpose of fuse (Fig 1)

A fuse opens the circuit by blowing out when current (overload) flows in the circuit to prevent severe damage to the accessories.

The flow of excess current in a circuit may be caused by a short circuit.

Fig 1



Construction

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

The fuse is assembled in a fuse carrier of glass or ceramic material.

Nowadays fuse elements assembled in glass tubes, called cartridges, are widely used in automobiles.

It consists of a glass tube (1) with metal end caps (2) & (4).

A soft fine wire or strip (3) carries the current from one cap to another (4).

The conductor (3) is designed to carry a specific maximum current.

Working

The current flows through the conductor (3) between two metal caps (2) & (4) and then to the equipment.

If the current value exceeds the limit prescribed on the fuse, the fuse element (3) melts and opens the circuit and prevents the equipment from damage.

Identification of blown fuse

If you look at the burnt fuse and if the element is broken the fuse is burnt due to overloading.

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

Circuits protected with fuse

- Headlight circuit
- Tall - light circuit
- Number -plate circuit
- Panel lamp circuit
- Interior lamp circuit
- Side indicator circuit
- Horn circuit
- Wiper circuit
- Dashboard / panel instruments circuit
- Header and air conditioner
- Charging circuit
- Radio
- Cigarette lighter
- Reverselamp

Circuits without fuse

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

Fuse rating and colour

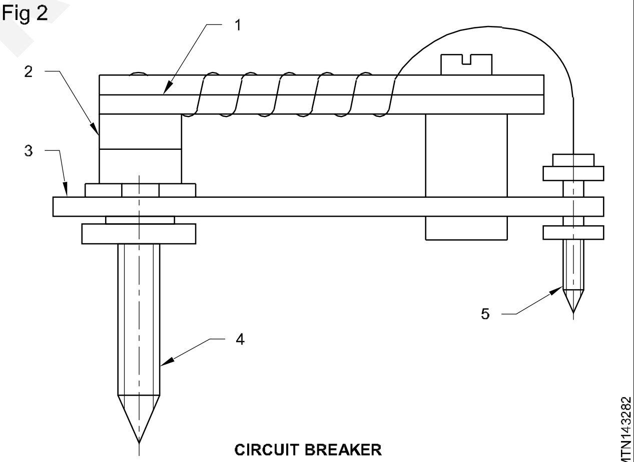
Rating	Colour
3 Amp	Violet
5 Amp	Tan
10 Amp	Red
20 Amp	Yellow
25 Amp	White
30 Amp	Light green

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 will light and then go out. Thus giving an indication of a faulty circuit. The circuit breakers are made in ratings up to 50 amps.

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

Fig 2



CIRCUIT BREAKER

Capacitors

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

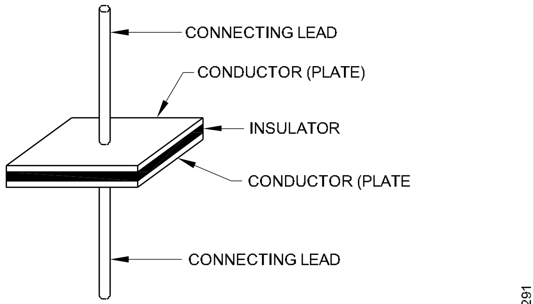
Capacitors

A device designed to posses capacitance is called a capacitor.

Construction

A capacitor is an electrical device consisting of two parallel conductive plates, separated by an insulating material called the dielectric. Connecting leads are attached to the parallel plates. (Fig 1)

Fig 1



SIMPLE CAPACITOR. THE PLATES OF A CAPACITOR ARE ALWAYS INSULATED FROM EACH OTHER

Function

In a capacitor the electric charge is stored in the form of an electrostatic field between the two conductors or plates, due to the ability of dielectric material to distort and store energy while it is charged and keep that charge for a long period or till it is discharged through a resistor or wire. The unit of charge is coulomb and it is denoted by the letter `C'.

Capacitance

The ability to store energy in the form of electric charge is called capacitance. The symbol used to represent capacitance is C.

Unit of capacitance

The base unit of capacitance is farad. The abbreviation for farad is F. One farad is that amount of capacitance which stores 1 coulomb of charge when the capacitor is charged to 1 V. In other words, a farad is a coulomb per volt (C/V).

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

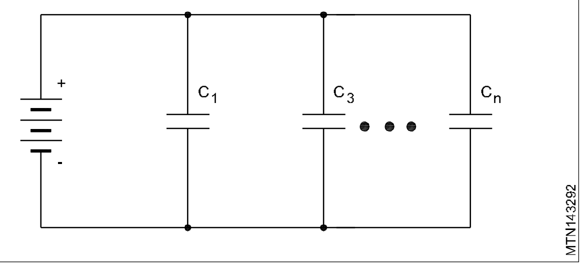
Capacitors are widely used as parts of electrical circuits in many common electrical devices. Ex. Ignition circuit.

Parallel Capacitors

Capacitors connected in parallel will **add** their capacitance together.

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

Fig 2



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

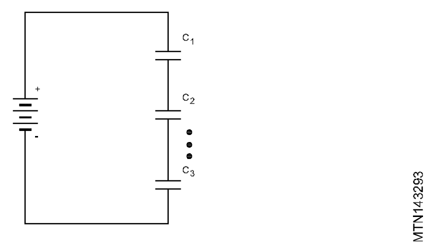
Capacitors connected in series will have a lower total capacitance than any single one in the circuit.

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

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



Tracing of auto electrical components in a circuit

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

Description of automobile cables

The cable consists of multi - strand copper conductor covered with good quality PVC insulation.

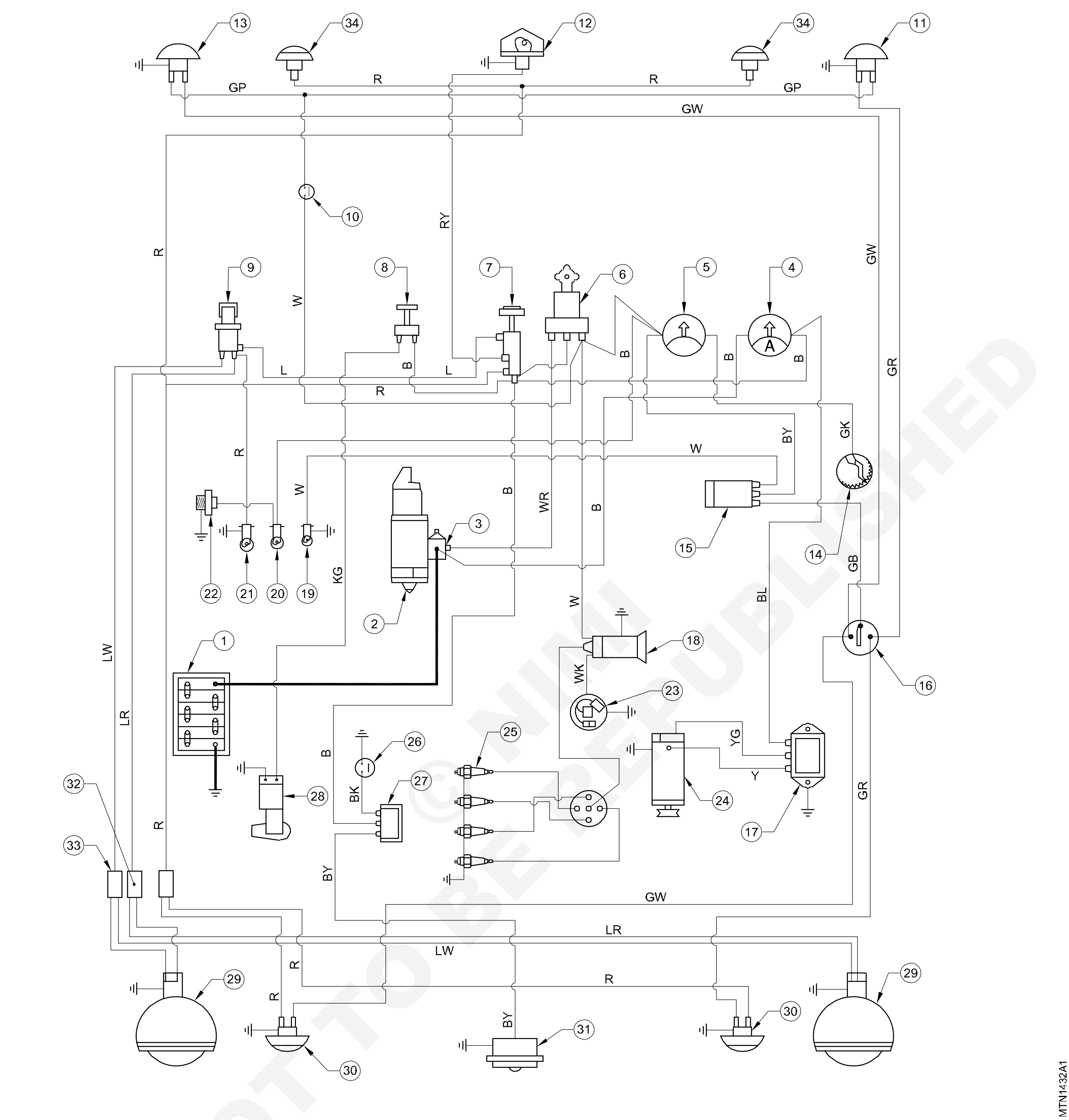
The current to the various electrical accessories is carried through cables.

The various cables used in wiring are :

- Starting system cable
- General purpose cable
- High tension cable

The specification of the cable refers to the number of stands and diameter of each strand. Eg. 25/012 indicates, the cable consists of 25 strands of 0.012” gauge diameter of each strand.

Fig 1



The size of the cable depends upon the current rating of the accessories connected in that circuit. A thick cable can carry more current and is used in the starting system.

Colour code in cables and wirings

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

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

The automobile manufactures use cables of different colours and usually follow the Lucas colour code system. It consists of basic colours (main colours) and combination of colours to identity individual circuits. (Refer 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 conductors are used to enable the circuit to be completed, i.e., feed wire, switch wire and return wire. In vehicles, the metal chassis is used for return wire (ground return), in some case the switch is incorporated in the unit. In some units, the switch is placed in the return side of the unit instead of on the feed side. Certain accessory circuits are fed through the ignition switch and certain auxiliary lighting circuits through the side and tail lamp switch.

Main feed colour

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

1 **Brown -** Battery circuit interior light, horn, control box, ammeter, ignition switch.
2 **Yellow -** Generator circuit - generator terminals to control box terminals and ignition warning light.
3 **White -** Ignition circuit - all units which are wired through the ignition switch and which are essential for the starting and running of the vehicle and which are not fused, i.e., electric control pump, starting motor, solenoid switch, etc.
4 **Green -** Fused auxiliary circuits which are feed through the ignition switch, i.e., stop lamps, fuse gauge, direction indicators, windshield wiper, etc.
5 **Light green -** Flasher unit to flasher indicator waving light.
6 **Blue -** Headlamp circuit fed from terminal on lighting switch. Included in this circuit are fog lamps, panel lights, door lights, etc., which are only required when the side lamps are switched on.
7 **Black -** All ground wired. If a unit do not internally grounded or is mounted on an insulated portion of the vehicle, a cable must be connected from the body of the unit to a good ground point on the chassis.

Cable sizes

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

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

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

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

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

Circuit tracing

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

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

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

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

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

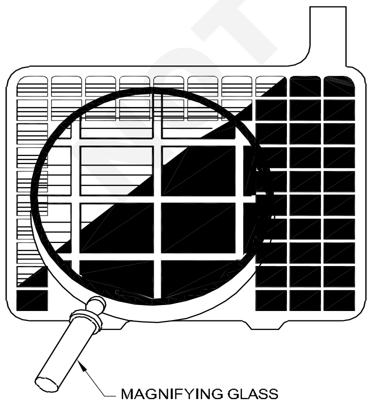
– Silver oxide cell

– 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.

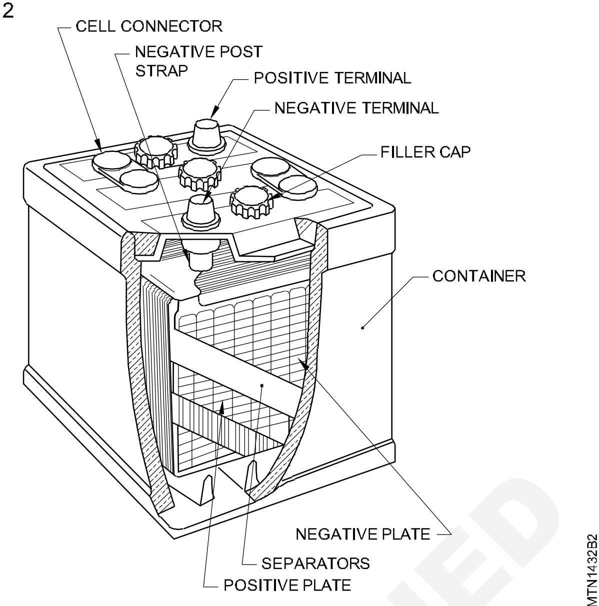
Lead acid battery (Figs1&2)**:** This battery is an electrochemical device for converting electrical energy into chemical energy and vice versa. The main purpose of the battery is to store electrical energy in the form of chemical energy. It provides supply of current for operating various electrical 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



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

Fig 2



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

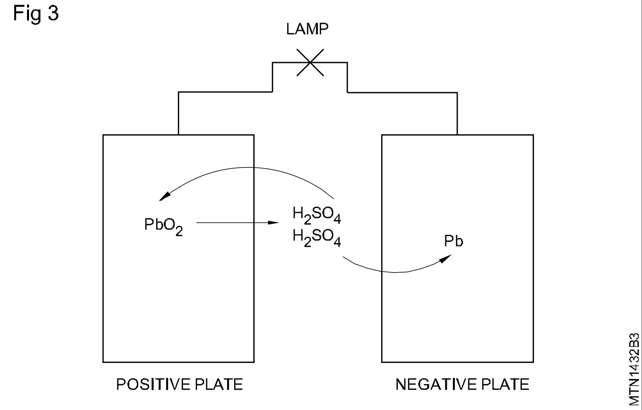
Each a group of plates is held together by a post strap, to which individual plates are welded. The post strap is extended up to the cell cover to provide battery terminals. The positive and negative plates are arranged alternatively, and in between the plates, separators are used to prevent contact of the positive and negative plates. Separators are made of specially treated wood, hard rubber, resin, integrated fibre or in combination with rubber or mats of glass fibres. The container in which the plates are placed is made of hard rubber which is not affected by the electrolyte. A solution of sulphuric acid and distilled water is added until the level of the liquid in the container is about 1/4" to 3/8" above the top of the plates. A filler cap with air vents is provided to allow gases to escape out.

Chemical Reactions

Discharging (Fig.3)**:** During discharging, the sulphuric acid is broken into two parts, hydrogen (H_2) and sulphate (SO_4). The hydrogen is liberated at the lead peroxide plates (PbO_2) reducing them to lead oxide (PbO) which combines with parts of the sulphuric acid to form lead sulphate ($PbSO_4$) and water (H_2O). The SO_4 is liberated at the spongy lead plate (Pb) and combines with them to form lead sulphate ($PbSO_4$). During this process the electrolyte becomes less concentrated due to absorption of the sulphate by the lead plates.

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

Fig 3

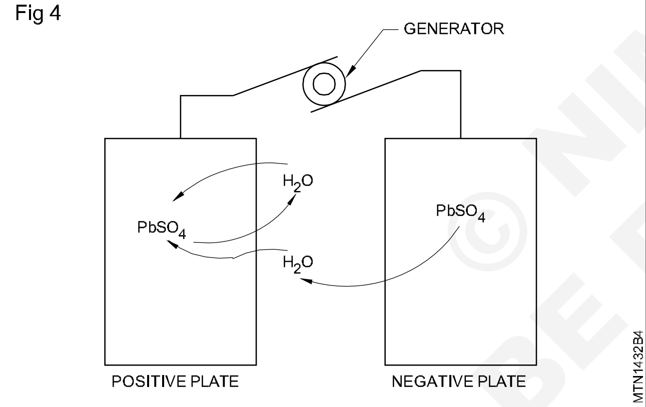


Charging (Fig.4)

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

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

Fig 4



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

Check and top up electrolyte level every week. Electrolyte should be 10 mm to 15 mm above the plates.

Check the specific gravity of the battery with a hydrometer. (Fig 5) If the specific gravity falls below 1.180 then add a few drops of sulphuric acid.

Sp. gravity readings and the state of charge of the battery are as follows.

Sl.No.	Specific	State of charge of the battery
1	1.260 - 1.280	Fully charged
2	1.230 - 1.260	3/4 charged
3	1.200 - 1.230	1/2 charged
4	1.170 - 1.200	1/4 charged
5	1.140 - 1.170	About run down
6	1.110 - 1.140	Discharged

Check the voltage across the cell terminals of each cell by using a cell tester. Cell voltage is 2 to 2.3 volts per cell for fully charged condition.

If the voltage of each cell is less than specified, then the battery should be recharged.

While charging do not overcharge the battery.

Keep the battery terminals always tight and clean.

To prevent formation of corrosion on the terminals smear petroleum jelly on it.

Voltage check of battery: With the help of a voltmeter the voltage of battery is tested. This will commonly vary from 12-13V

Battery selection (Fig 6)**:** Most cars in current production are equipped with a 12V battery. When a manufacturer

Fig 5

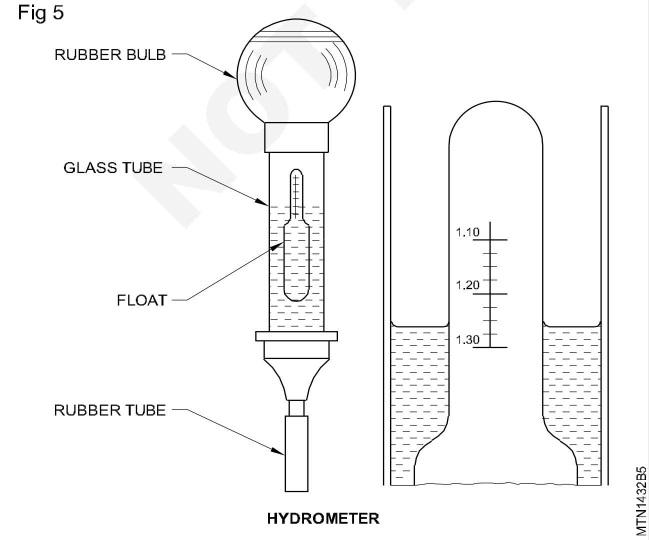
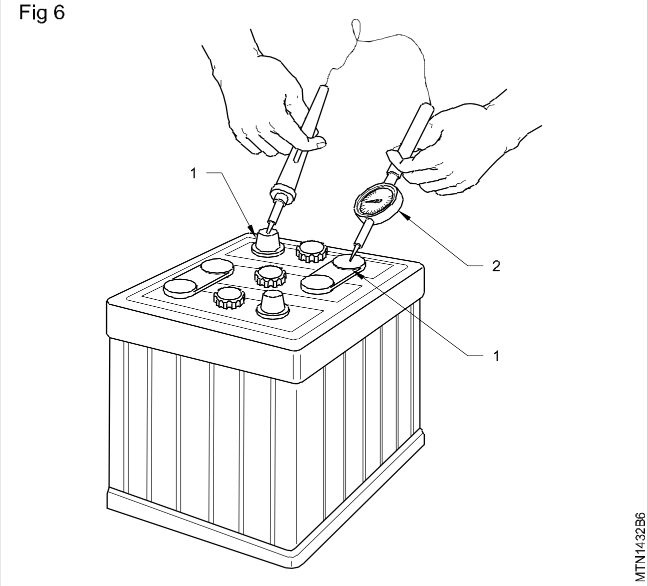


Fig 6



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.

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^{o}F.

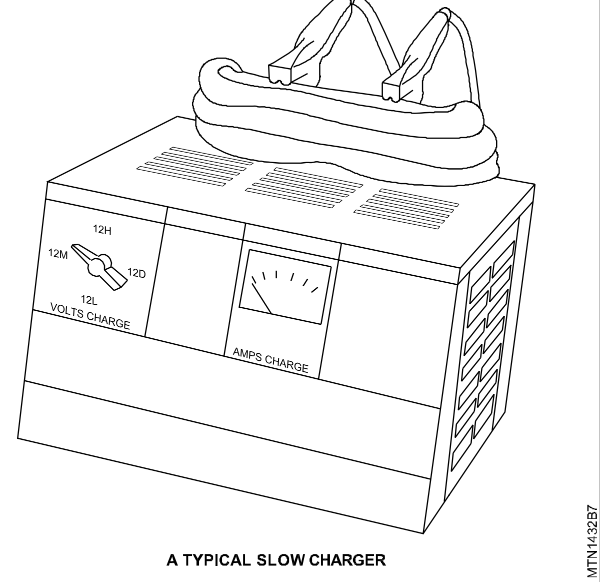
2 Violent gassing or spewing of electrolyte occurs.

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.

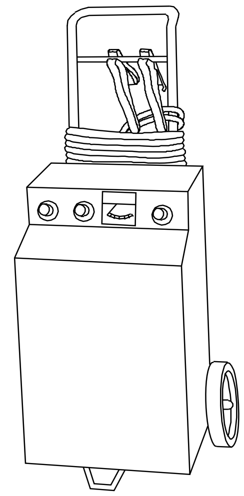
Fast charging (Fig 8)**:** Fast charging will not fully recharge a battery, it will restore the charge sufficiently to allow the battery to be used.

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.

Features of sealed maintenance free battery

- No need for checking electrolyte level and tapping throughtout the life.
- Seal construction ensures no leakage of electrolyte from terminal or casing.

Fig 8



A TYPICAL FAST CHARGER

Benefits

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

Solenoid & relay

Objectives: At the end of this lesson you shall be able to
- **define a relay**
- **classify relays according to the operating force and function**
- **explain the function of current sensing relay & Voltage sensing relay**
- **state solenoid and its application**
- **describe a solenoid switch and its function.**

Relay: A relay is a device which opens or closes an auxiliary circuit under predetermined conditions in the main circuit.

Relays are extensively used in electronics, electrical engineering and many other fields.

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

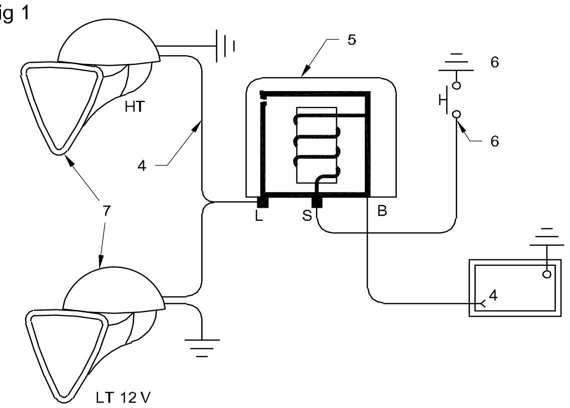
Classification of relays

Relays are also classified according to their main operating force as stated under

- Electromagnetic relays
- Thermal relays

Electromagnetic relay: A relay switch assembly is a combination of movable and fixed low - resistance contacts that open or close a circuit. The fixed contacts are mounted on springs or brackets, which have some flexibility. The movable contacts are mounted on a spring or a hinged arm that is moved by the electromagnet in the relay as shown in Fig 1.

Fig 1



The other types of relays coming under this group are as follows.

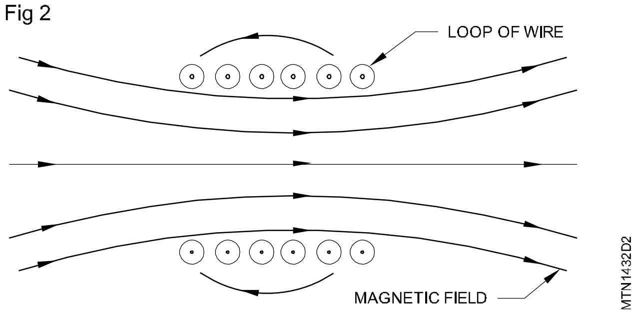
Current sensing relay: A current sensing relay functions whenever the current the coil reaches an upper limit. The difference between the current specified for pick up (must operate) and non - pick up (must not operate) is usually closely controlled. The difference in current may also be closely controlled 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

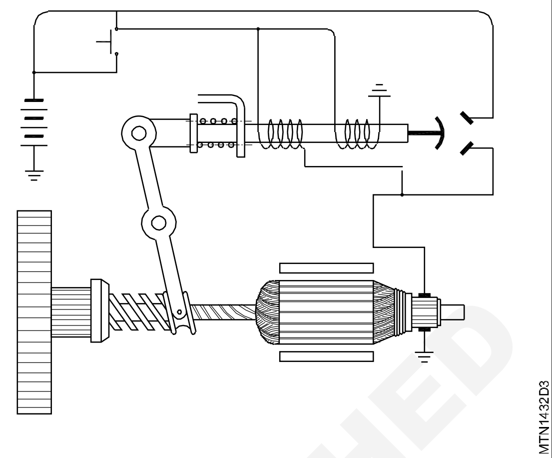


Application

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.

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 semi-conductor 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.

Fig 1

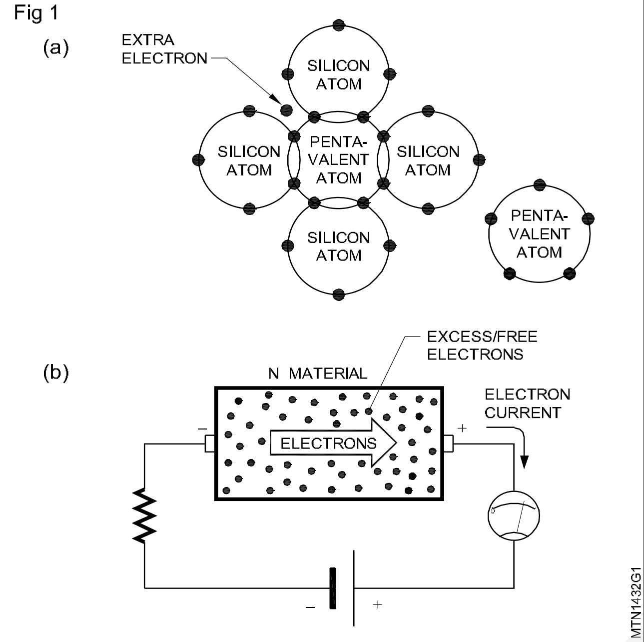
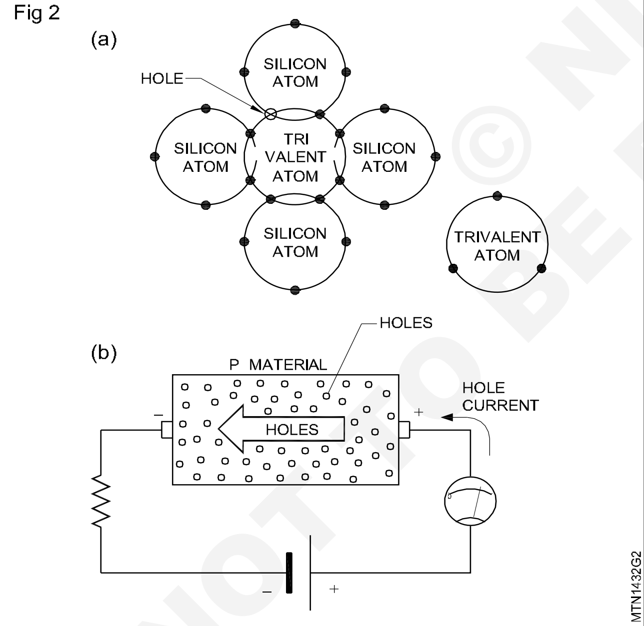


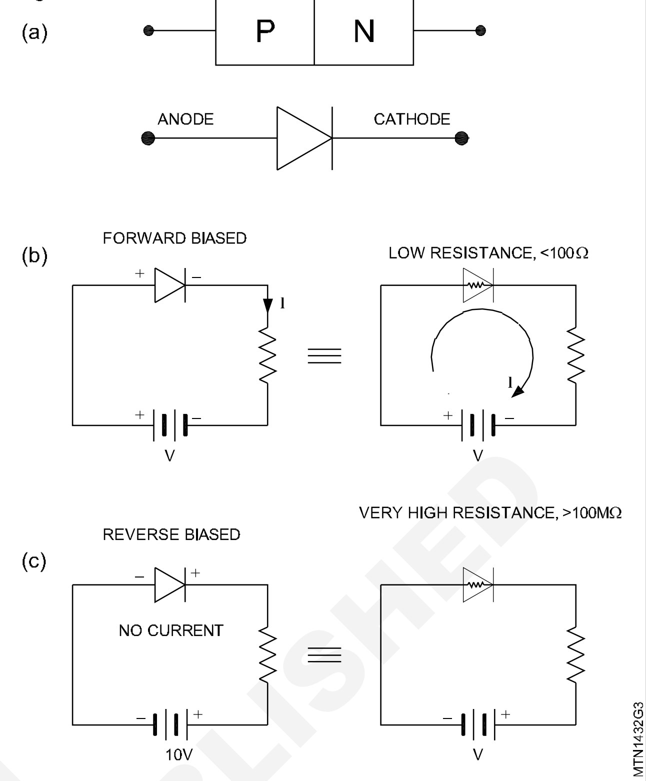
Fig 2



P-N junction

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

Fig 3



Types of diodes

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

Classification of Diodes

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

- **low power diodes**

  can handle power of the order of several milli watts only

- **medium power diodes**

  can handle power of the order of several watts only

- **high power diodes**

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

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

- **Signal diodes**

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

- **Switching diodes**

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

- **Rectifier diodes**

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

Polarity marking on the diodes

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

Type number or diode code number

Unlike resistors, capacitors or inductors, the diodes do not have any value that can be printed or coded on its body. The other reason for this is, there are almost innumerable types of diodes with varied current handling and other specifications. Hence, instead of printing its specifications on its body, all diodes will have a type number printed on their body. This type number carries a set of specifications which can be found out by referring to a diode data manual. Diode data manuals give data of several thousands of diodes from different manufacturers. Some of the popular type numbers of diodes are

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

Transistors and classification

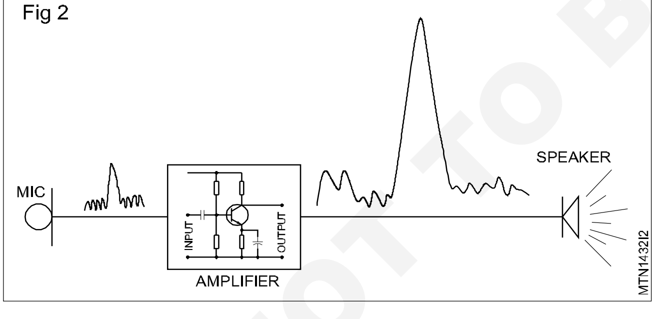
Objectives: At the end of this lesson you shall be able to
- **state the two main uses of transistors**
- **list the advantages of transistors over vacuum tubes**
- **list the important classifications of transistors**
- **state the use of a transistor data book**
- **state about thyristor and characteristics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

Introduction to Transistors

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

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

Fig 2



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.

Fig 1

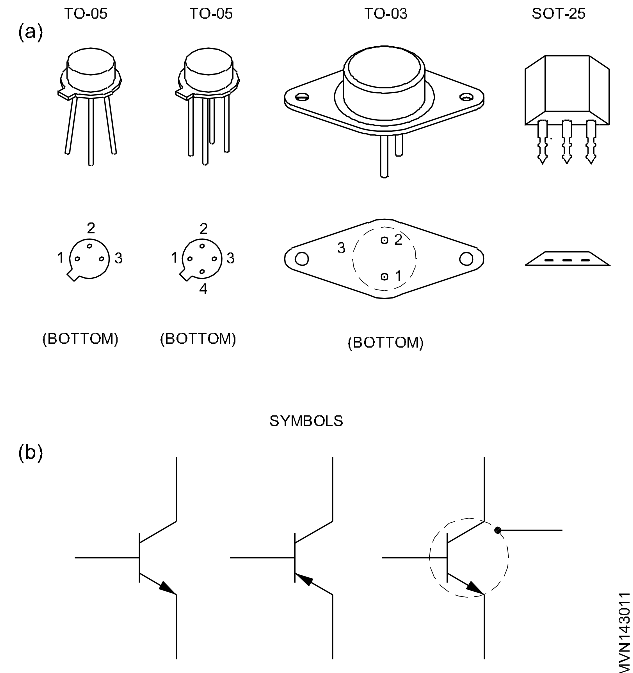


Fig 3

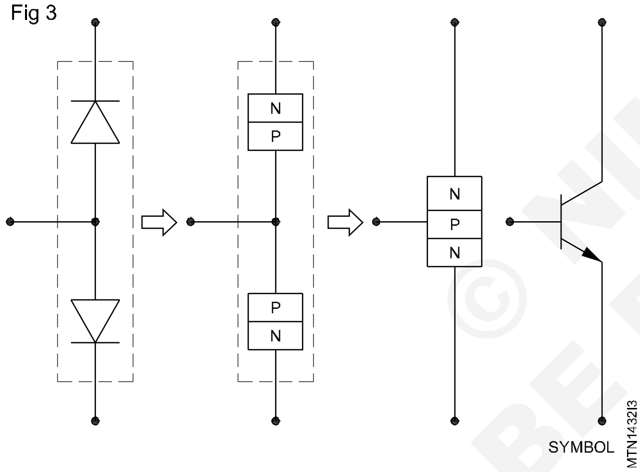
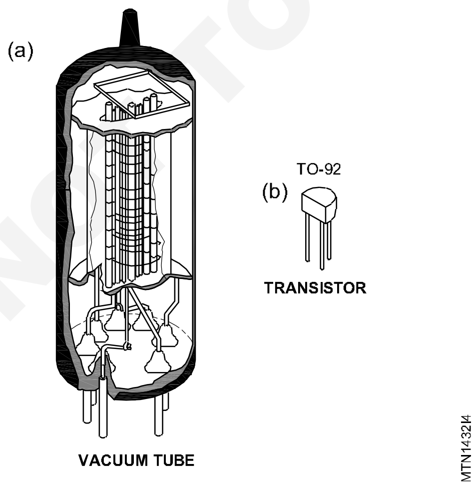


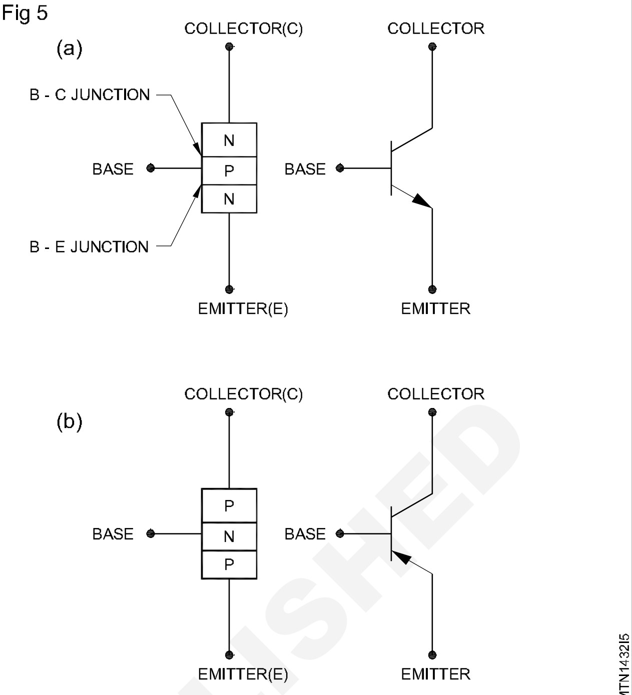
Fig 4



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.

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).

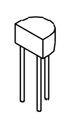
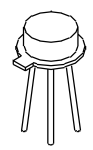
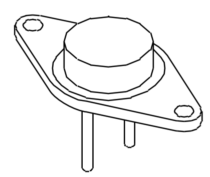
Low power transistors (less than 2 watts)	**Medium power transistors** (2 to 10 watts)	**High power transistors** (more than 10 watts)
		

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.,

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.

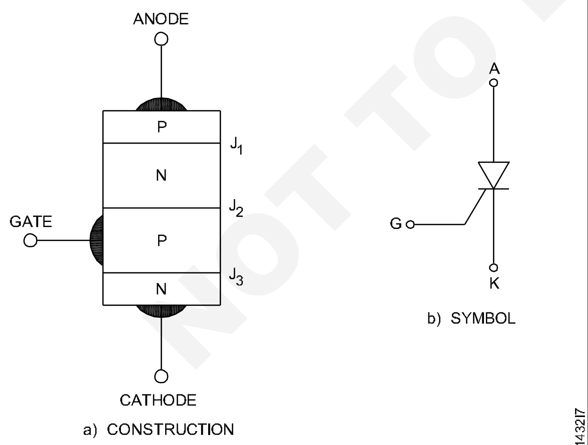
Thyristor and the characteristics of SCR

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

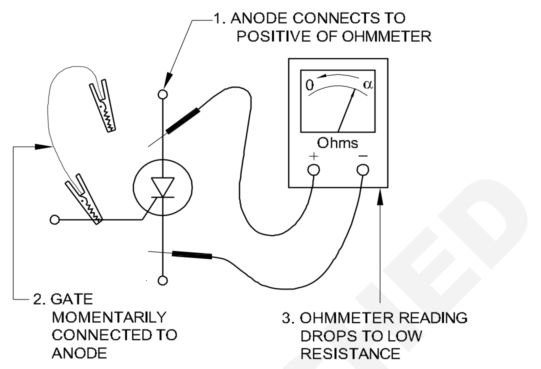
Fig 7



SILICON CONTROLLED RECTIFIER

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 8



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.

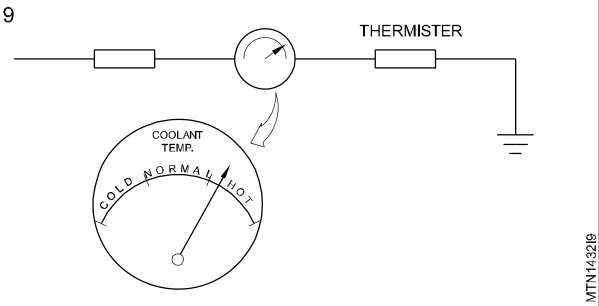
Thermistor: It is also semiconductor device used in most vehicles today. They are named because they are actually a temperature sensitive resistor. It is made of powdered nickel, cobalt, copper, iron and manganese which has been fused together at a higher temperature. The electrical resistance of a thermistor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

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



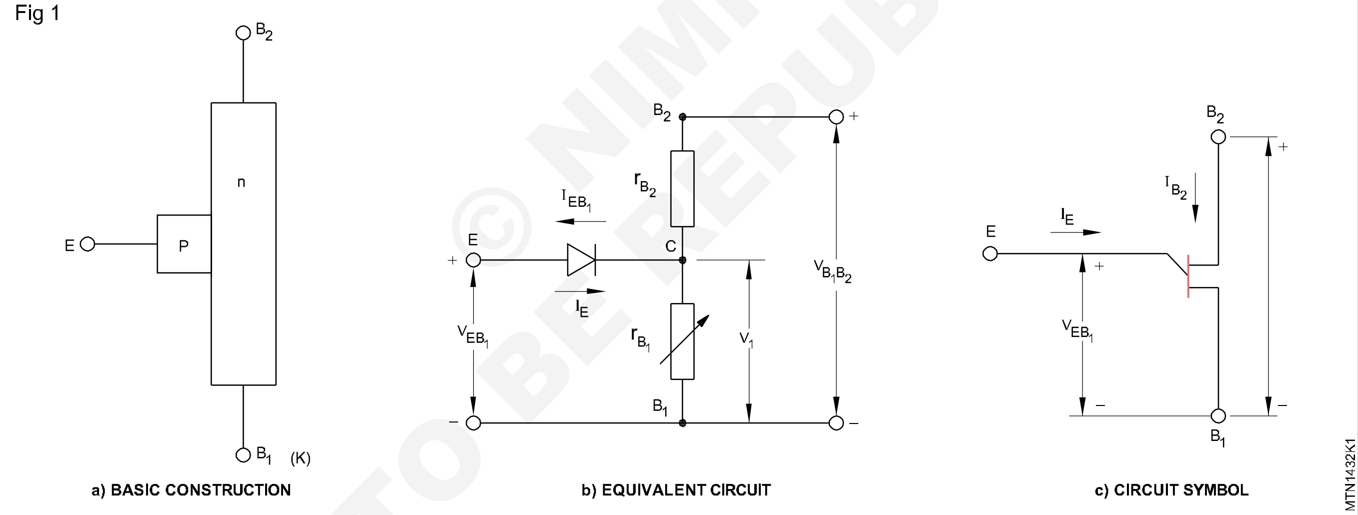
Uni-Junction Transistor (UJT)

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



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.

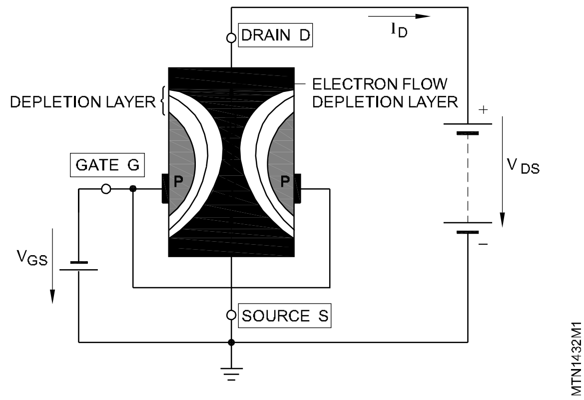
FET is a voltage controlled device.

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.

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

Fig 1

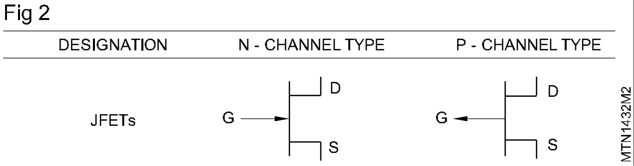


Unlike in bipolar transistors in which the main current is both by electrons and holes. In contrast in FETs depending on the type(P or N type) the main current in either by electrons and holes and never both. for this reason FETs are also known as Unipolar transistors or unipolar device.

Junction Field effect Transistor (JFET)

It is a three terminal device and looks similar to a bi-polar transistor. The standard circuit symbols of N-channel and P-channel type FETs are shown in Fig.2.

Fig 2



Construction

As shown in Fig 3a, a n-channel JFET has a narrow bar of n-type. To this,two p-type junctions are diffused on opposite sides of its middle part fig 3a.These diffused junctions form two PN diodes or gates. The N-type semiconductor area between these junctions/gates is called the channel. The diffused P regions on opposite sides of the channel are integrally connected and a single lead is brought out which is called gate lead or terminal.Direct electrical connections are made at the two ends of the bar.One of which is called source terminal,S and the other drain terminal, D.

A p-channel FET will be very similar to the n-channel FET in construction except that it uses P-type bar and two N-type junctions as shown in Fig 3b.

FET notation listed below are essential and worth memorizing.

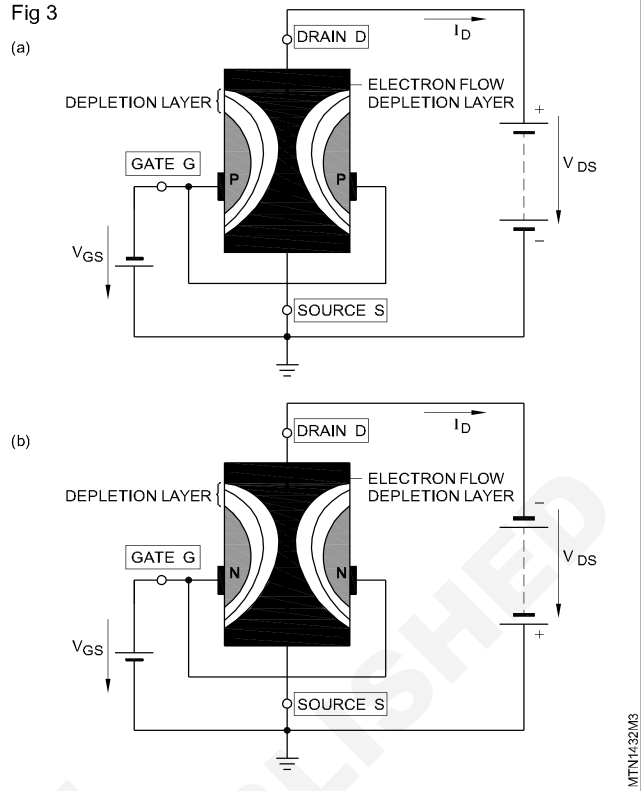
1 **Source terminal:** It is the terminal through which majority carriers enter the bar (N or P bar depending upon the type of FET).

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).

Fig 3



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.

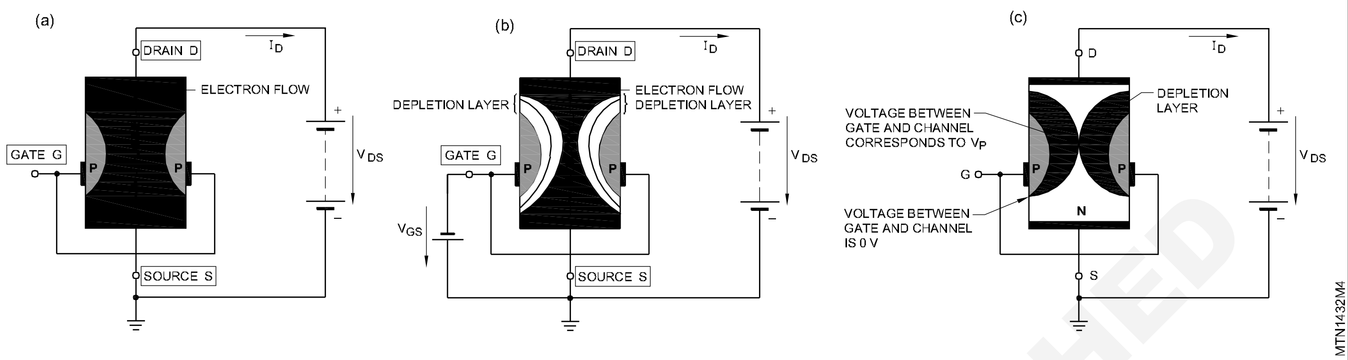
This depletion region decreases the width of the channel causing the drain current to decrease.

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 refferred as a voltage controlled devices.

P channel JFET operates in the same way as explained above except that bias voltages are reversed and the majority carrier of channel are holes.

Fig 4



Metal Oxide Field Effect Transistor (MOSFET)

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

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

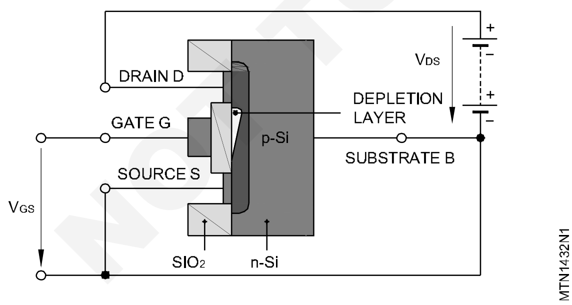
Type of MOSFET

Depletion-type MOSFET

Construction and mode of operation

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

Fig 1



Here, two highly doped n-zones are diffused into p-doped silicon plate, which is referred to as the substrate, and are provided with junction-free drain and source connections. Between the two zones there is a thin weakly n-doped channel, which produces an electrical connection between the source and drain without an external field-action. This channel is covered by an insulting layer of silicon dioxide (SIO_2), to which a metal electrode is applied as the gate connection.

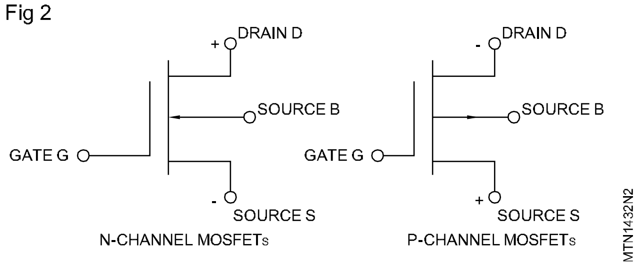
If a voltage U_{DS} is applied between source and drain, at U_{GS} =)V an electron current flows from the source electrode via the n-channel to the drain electrode. If, however, a negative voltage is applied to control electrode G, the electrons present in the n-channel are forced out of the vicinity of the gate electrode, so that a zone depleted of charge carriers is produced there. This causes a constriction of the n-channel and consequently also a reduction of its conductivity. If the gate voltage becomes more negative, the conductivity of the channel is reduced, as is consequently also the drain current I. Another peculiarity of depletion type MOSFET s is that they can also be controlled with a positive gate-voltage. charge carries are then drawn out of the P- doped substrate into then-channel and its conductivity is increased even further, compared with the conductivity at U_{GS}- OV

Designations and circuit symbols

The same designations are used for the connections of MOSFETs as they are for JFETs, I,e. source, drain and gate. MOSFETs, however, have another electrode, which is referred to as the substrate connection. Together, which is referred to as the substrate connection, Together with the semiconductor material of the channel, this 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.

Fig 2



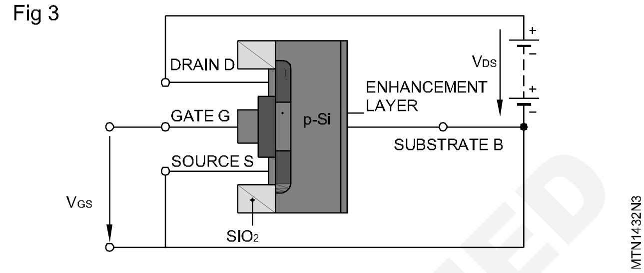
N- Channel MOSFETs are operated with a positive drain-source Voltage. They have a considerably greater practical significance than p-channel MOSFETs, which require a negative drain-source voltage for their operation.

Enhancement-type MOSFET

Construction and mode of operation

Enhancement-type MOSFETs have a similar technological construction to the depletion types. Without the external action of a field. However no conducting channel exists between the drain connection and the source connection, so that at U_{GS}=)V, no drain current can flow, Fig 3. shows the construction of an enhancement-type n-channel MOSFET.

Fig 3

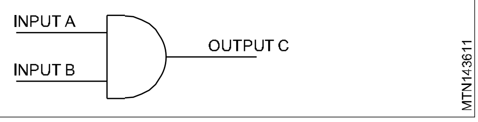


Basic logic gates

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

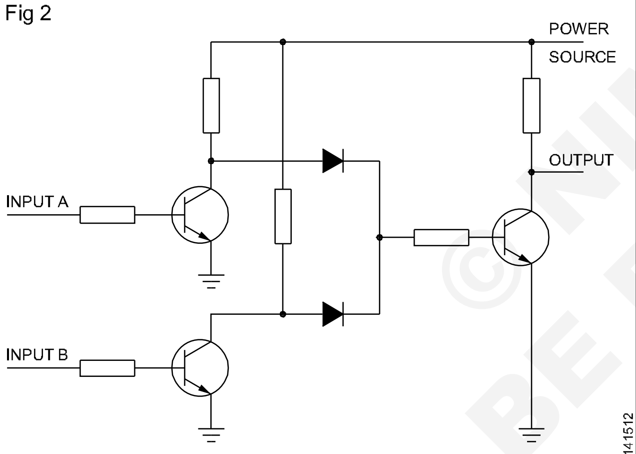
Logic circuits (Fig 1)**:** Digital ICs are made up of many different elements. Most important of these are transistors. This transistor circuits are called logic circuits or digital circuits and are made up of combinations of different types of so-called gates. These gates have the special ability to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

Fig 1



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

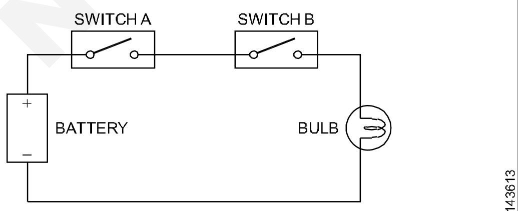
Fig 2



SEMICONDUCTOR CIRCUIT THAT CORRESPONDS TO AN "AND" GATE

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

Fig 3



SIMPLE MECHANICAL CIRCUIT THAT CORRESPONDS TO AN "AND" GATE

Similarly, in an actual AND gate, there will be an "on" signal (often represented as the number 1) at the output terminal (C) only if there is a voltage at both input terminals (A and B). If either A or B is zero (off) or if both are zero, C will also be zero. These combination can be shown in a truth table.

AND - gate truth table

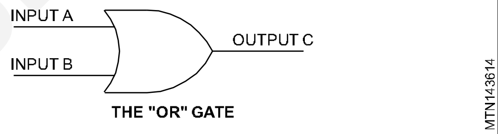
Inputs		Output
A	**B**	**C**
0	0	0
0	1	0
1	0	0
1	1	1

The "OR" Gate (Fig 4, 5 & 6)

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

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

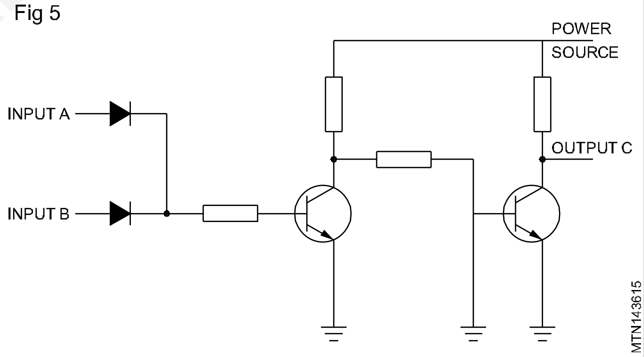
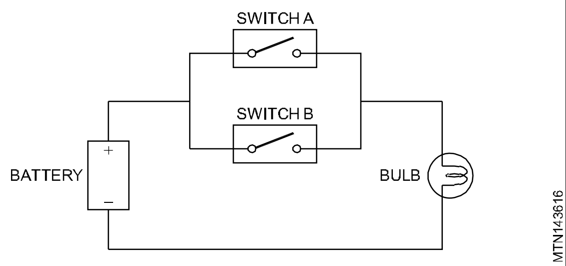


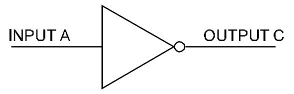
Fig 6



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).

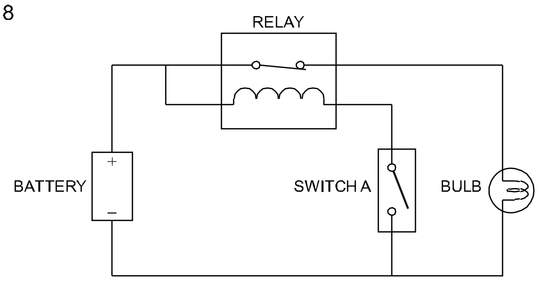
In the mechanical NOT circuit, the light bulb doesnot go on if switch A is closed. When switch A is opened the relay closes and the bulb is turned on.

Fig 7



"NOT" GATE

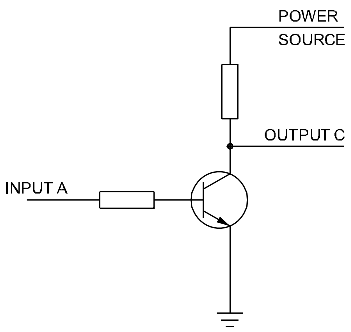
Fig 8



SIMPLE MECHANICAL CIRCUIT THAT CORRESPONDS TO "NOT" GATE

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)

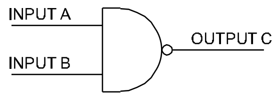
Fig 9



SEMICONDUCTOR CIRCUIT THAT CORRESPONDS TO "NOT" GATE

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

Fig 10



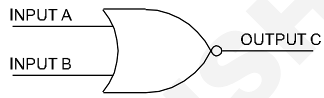
"NAND" GATE

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

Tools and equipment used in oxy-acetylene gas welding

Objectives : At the end of this exercise you shall be able to
- **compare the features of oxygen and acetylene regulators**
- **state the features of hose - pipes used in gas welding**
- **distinguish between the hose connections for oxygen and acetylene regulators and blowpipes**
- **state the features of a blowpipe and their functions**
- **state edge preparation.**

Gas welding principle

Gas welding is a most important type of welding process. it is done by burning of fuel gases with help of oxygen which form a concentrated flame of high temperature. This flame directly strikes the weld area and melt the weld surface and filler materials. The melted part of welding plates diffused one another and create a weld joint after cooling. This welding method can be used to join most of common metals used in daily life.

Oxy - acetylene gas welding: The essential requirement for a beginner dealing with oxy - acetylene gas welding is to identify the tools and equipment required and know their uses.

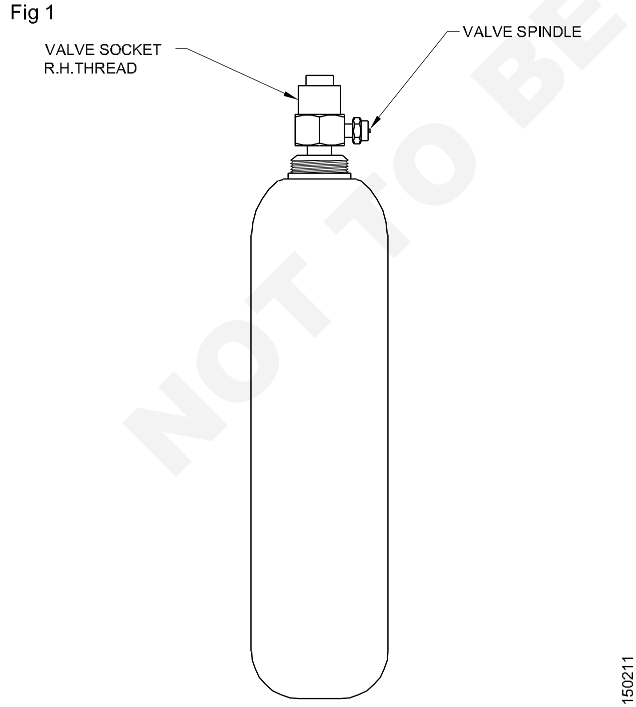
Oxygen gas cylinders (Fig. 1)

oxygen gas cylinder is black colour pointed steel bottle and it has a storing capacity of 7m^3 gas.

The valve socket has right hand threads.

The cylinder is used to store oxygen gas with a pressure of 120 to 150 kg/cm^2

Fig 1

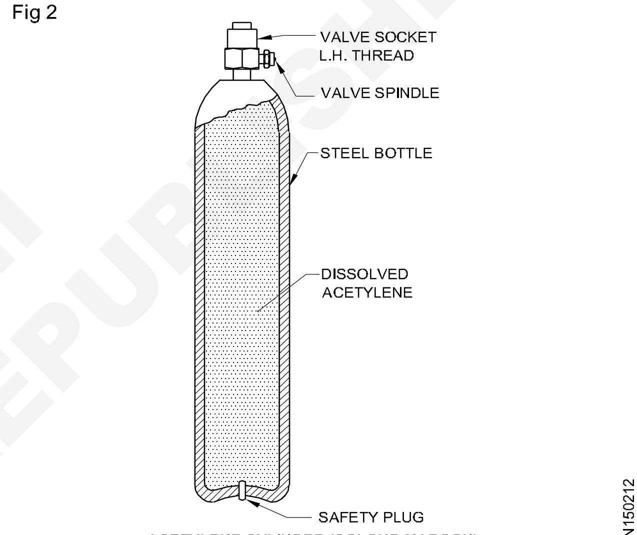


OXYGEN CYLINDER (COLOUR BLACK)

Dissolved acetylene cylinders (Fig. 2)

This is painted maroon and has a storing capacity of 6m^3. The valve socket has left hand threads. It is used to store acetylene gas in a dissolved state with a pressure of 15-16kg/cm^2.

Fig 2

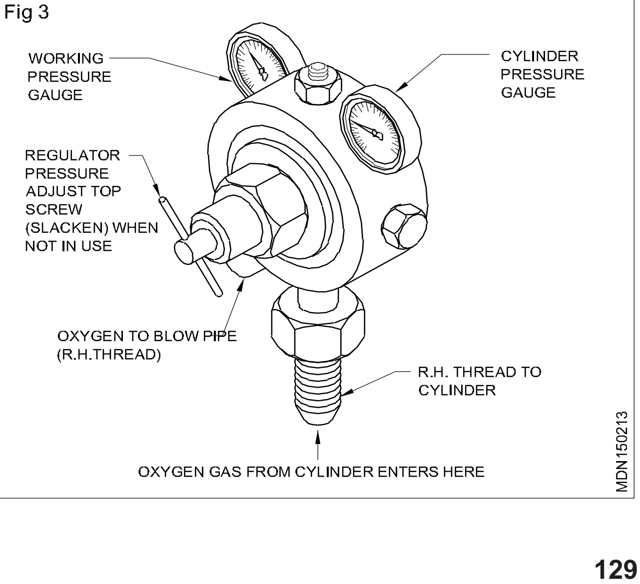


ACETYLENE CYLINDER (COLOUR MAROON)

Pressure regulators for oxygen

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

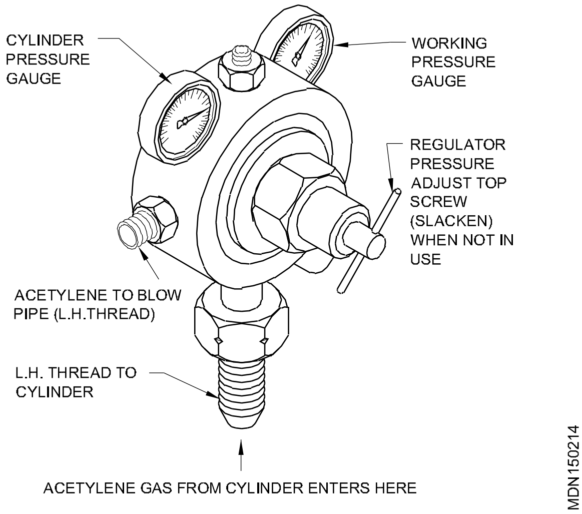
Fig 3



Pressure regulators for acetylene

This is to reduce and control the acetylene cylinder gas pressure to a suitable working pressure at a constant rate of flow for the blowpipe. This regulator has left hand screw threads. (Fig 4)

Fig 4

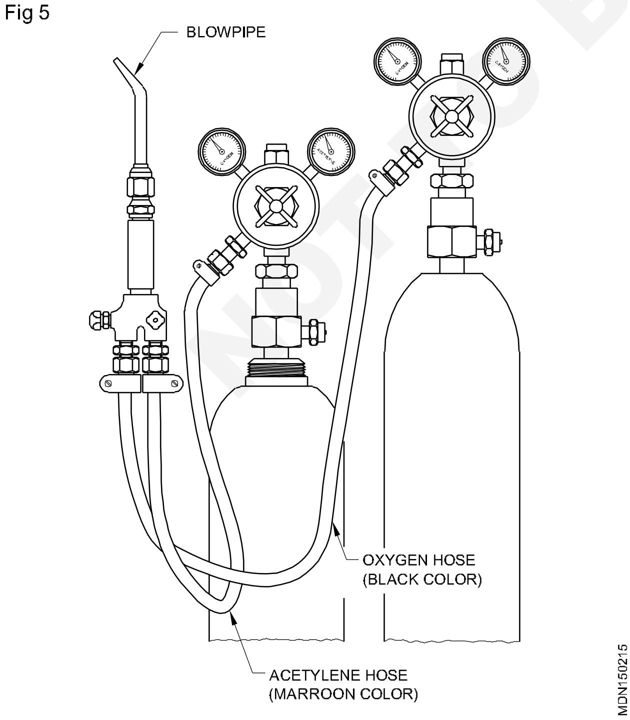


Both oxygen and acetylene regulators have a cylinder pressure gauge to indicate the cylinder gas pressure and a working pressure gauge to indicate the working pressure required for the blowpipe. (Figs 3 & 4)

Rubber hoses

The hose carries the gases from the gas regulators to the blowpipe. The hoses are made of strong canvas rubber and it having good flexibility. The hose pipe for the oxygen line is black in colour while that for the acetylene line is maroon colour. (Fig 5)

Fig 5

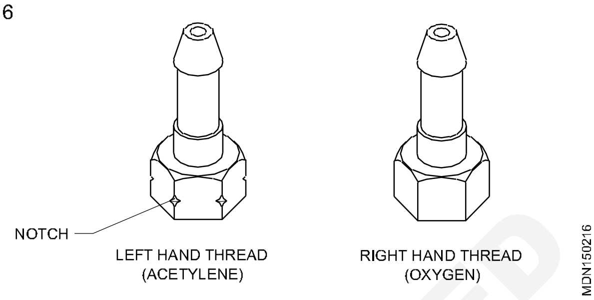


Hose pipe connections for regulators

This is a connecting union used to connect rubber hose pipes with the regulators.

Oxygen connection has right hand threads while the acetylene connection has left hand threads. (Fig 6). The nut used for the acetylene rubber hose connections will have a notch at its corners.

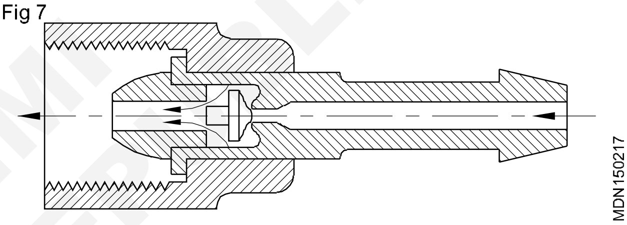
Fig 6



Hose pipe connections for blowpipes

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

Fig 7



It is used to connect the rubber hose pipe with the blowpipe.

The oxygen connection has right hand threads while the acetylene one has left hand threads.

Blowpipe set with nozzle (Fig 8)

This is a device with a handle and inlet connection for acetylene (left hand threads) and oxygen (right hand threads). It has control valves for acetylene and oxygen gas flow, a gas mizing chamber, and a neck - pipe with a nozzle.

Fig 8

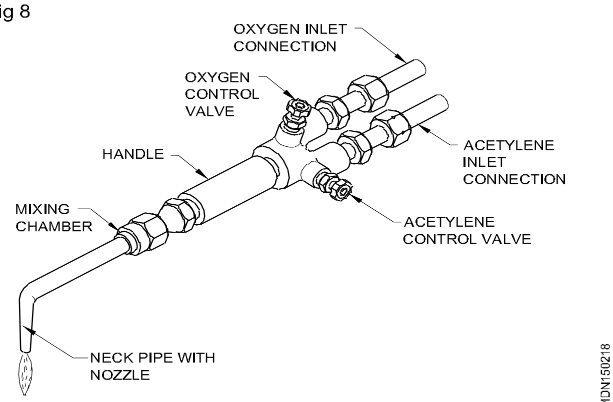
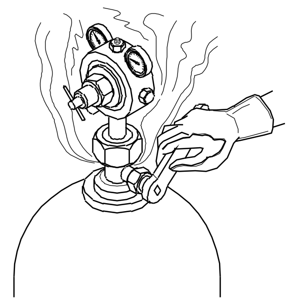


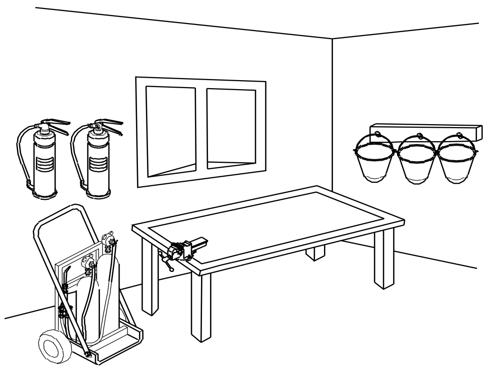
Fig 9



MDN150219

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

Fig 10



MDN15021A

Keep the work area free from any form of fire.

Safety gas cylinders

Do not roll gas cylinders or use them as roller.

Use a trolley to the carry the cylinders.

Close the cylinder valves (Fig 9) when it is not in use or empty.

Keep full and empty cylinders separately.

Always open the cylinder valves slowly, not more than one and a half turn.

Use the correct cylinder keys to open the cylinders.

Do not remove the cylinder keys from the cylinders while welding. It will help to close the cylinders quickly in the case of a back-fire or flash-back.

Always use the cylinders in an upright position for easy handling and safety.

Always check the cylinder valves to clean the valve sockets before attaching regulators. (Fig 11)

Safety for rubber hose pipes (Fig 12)

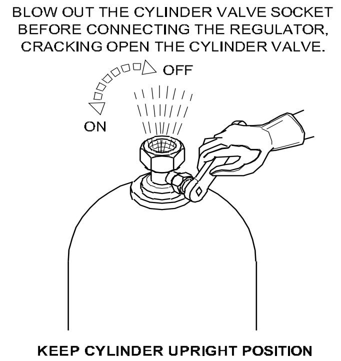
Inspect the rubber hose pipes periodically and replace the damaged ones.

Do not use old bits of hose pipes / tubes.

Do not replace the hose pipes for acetylene with the ones used for oxygen.

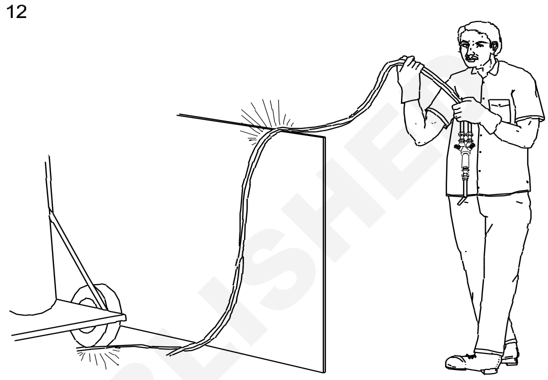
Always use a black hose pipes for oxygen and maroon hosepipes for acetylene.

Fig 11



MDN15021B

Fig 12



MDN15021C

Safety for regulators (Fig 11)

Prevent hammer blows to the gas cylinders and ensure that water, dust and oil do not settle on the cylinders.

Right hand threaded connection for oxygen and left hand threaded connection for acetylene.

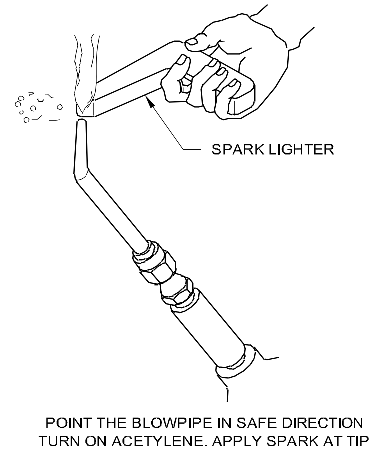
Safety for blowpipes

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

When flame snaps out and backfires, quickly shut off the both valves in blowpipe (oxygen first) then acetylene and their dip in water.

While igniting the flame, point the blowpipe nozzle in a safe direction. (Fig 13)

Fig 13



MDN15021D

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

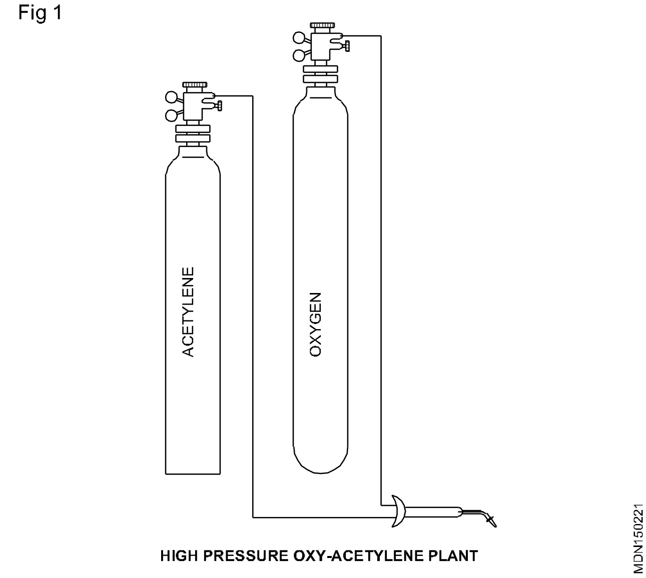
Systems of oxy-acetylene welding

Objectives : At the end of this lesson you shall be able to
- **distinguish between high pressure and low pressure acetylene plants**
- **distinguish the features of low pressure and high pressure blowpipes.**

Oxy-acetylene plants can be either high pressure or low pressure.

A high pressure plant utilizes acetylene under high pressure, upto 1 kg/cm^2. (Fig 1)

Fig 1



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

A low pressure plant utilizes acetylene under low pressure (0.017 kg/cm^2) produced by an acetylene generator only. (Fig 2)

High pressure and low pressure plants utilize oxygen gas in compressed high pressure cylinders only.

The high or low pressure systems used in oxy-acetylene welding refer only to the acetylene pressure.

Distinguishing features of blowpipes

For low pressure systems, a specially designed injector type blowpipe is required. This can be used for high pressure also. (Fig 3)

In a high pressure system, a mixer type high pressure blowpipe is used, this is not suitable for the low pressure system. (Fig 3)

Fig 2

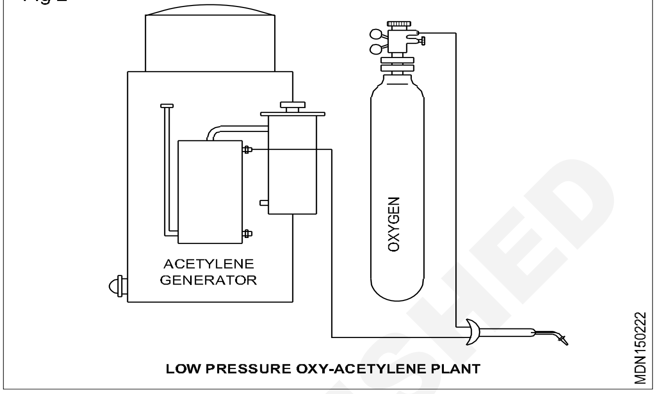
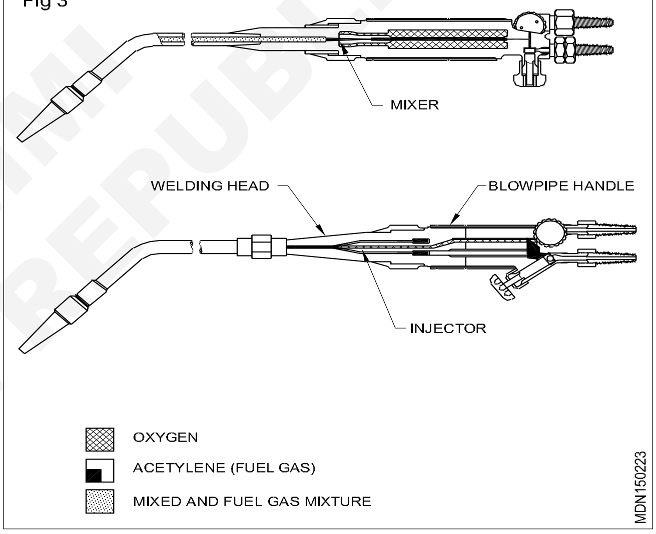


Fig 3



Edge preparation

Objectives: At the end of this lesson you shall be able to
- **state the necessity of edge preparation**
- **describe the edge preparation for butt and fillet welds.**

Necessity of edge preparation: Joints are prepared to weld metals. The preparation of edges are also necessary prior to welding in order to obtain the required strength to the joint. The following factors are to be taken into consideration for the edge preparation.

– The welding process like SMAW, oxy-acetylene welds, Co_2, electro-slag etc.

– The type of metal to be jointed, (i.e.) mild steel, stainless steel, aluminium, cast iron etc.

– The thickness of metal to be joined.

– The type of weld (groove and fillet weld)

– Economic factors

The square butt weld is the most economical to use, since this weld requires no chamferring, provided satisfactory strength is attained. The joints have to be bevelled when the parts to be welded are thick so that the root of the joints have to be made accessible for welding in order to obtain the required strength.

In the interest of economy, bevel butt welds should be selected with minimum root opening and groove angles such that the amount of weld metal to be deposited is the smallest. "J" and "U" butt joints may be used to further minimise weld metal when the savings are sufficient to justify the more difficult and costly chamferring operations. The "J" joint is usually used in fillet welds.

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

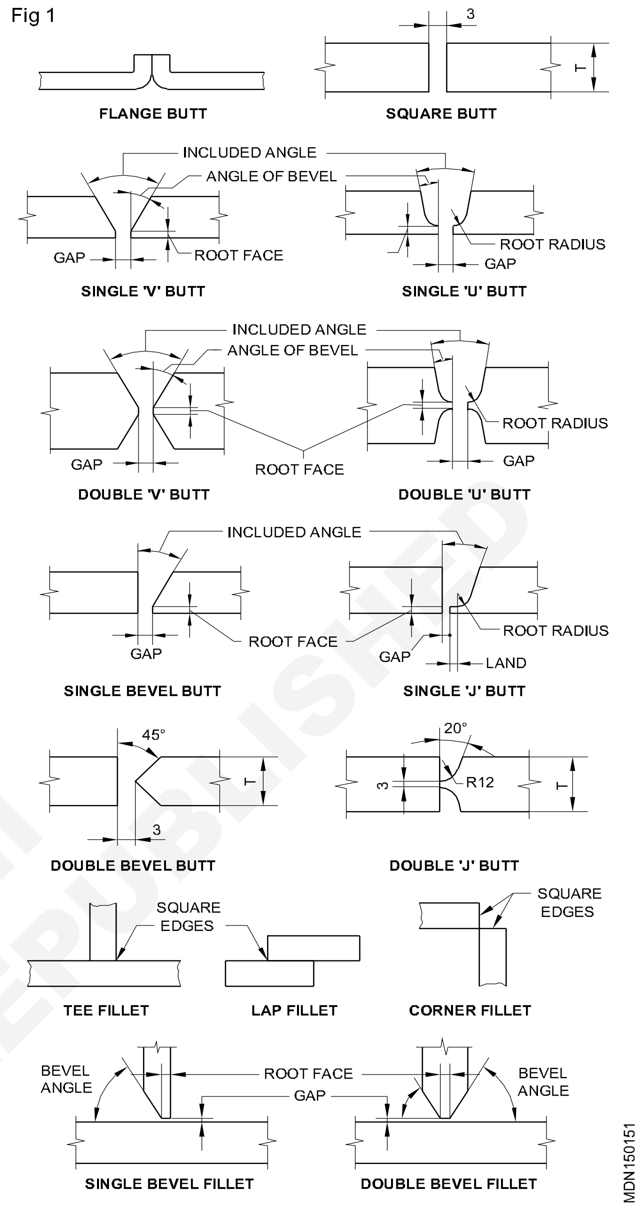
Method of edge preparation: The joining edges may be prepared for welding by any one of the methods mentioned below.

– Flame cutting
– Machine tool cutting
– Machine grinding or hand grinding
– Filing, chipping

Types of edge preparation and setup

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

Fig 1



Pascal's Law - pressure viscosity

Objectives: At the end of this lesson you shall be able to
- **state Pascal's Law**
- **understand the concept of force multiplication**
- **state many functions of hydraulic fluids**
- **define the term viscosity.**

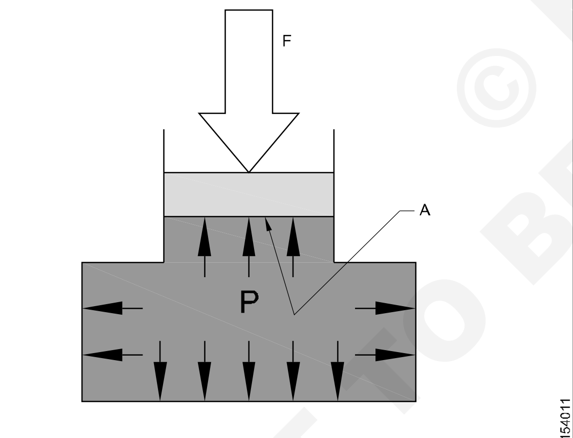
Pascal's law (Blase Pascal, 1623-1662)

Pascal's law is the central law for the development of a number of machines, such as hydraulic brakes, hydraulic jacks, etc. The law states that 'pressure exerted on a fluid is transmitted equally in all directions, acting with equal force on equal areas'. The following sections explain how a pressure is developed in a hydraulic system with the application of a force through a pump mechanism and how a force is developed with the application of the pressure through an actuator mechanism.

Hydraulic Pressure

Pressure is the result of the resistance offered to compression when an incompressible oil medium is squeezed by the application of a force. This pressure is transmitted equally throughout the medium in all directions, according to the Pascal's law.

Fig 1



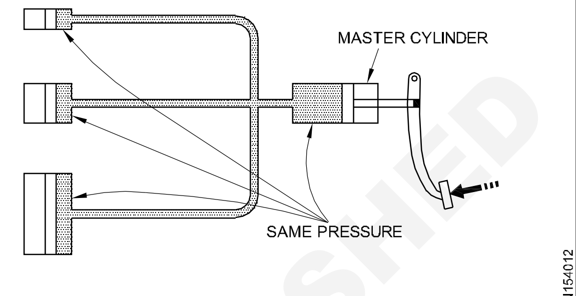
DEVELOPMENT OF PRESSURE

Figure 1 shows a cylinder chamber with a definite volume of oil and a piston. A force (F) is applied to the oil through the piston. When the oil is pushed, its pressure (P) increases in direct proportion to the applied force and inverse proportion to the piston area (A). Pressure can, therefore, be defined as the force acting per unit area. That is,

$$P = \frac{F}{A}$$

A typical Application of Pascal's Law: A feature of hydraulic theory can be seen in the illustration in Figure 2. which demonstrates the pressure in the master cylinder

Fig 2



AN APPLICATION OF PASCAL'S LAW

is transmitted equally to all wheel cylinders as per the Pascal's Law.

Units of Pressure: There are many units of pressure, such as Pascal (Pa), bar, pounds per square inch (psi), Kg/cm^2, etc., used in industrial world. Some of the most important units of pressure are highlighted below:

1 Pascal	= 1 N/m^2
1 bar	= 100000 Pa = 10^5 Pa (100 kPa)
1 bar	= 14.5 psi
1 bar	= 1.02 kgf/cm^2
1 kgf/ cm^2	= 0.981 bar

Hydraulic Force

When a pressure (P) is applied onto the area (A) of a cylinder piston, a force (F) is developed. The amount of force developed is equal to the area times the applied pressure. That is,

$$F = P \times A$$

Example 1: What will be the pressure required to lift 75000 N using a hydraulic cylinder with an effective area of 0.0103 m^2?

Force, F	= 75000 N
Area, F	= 0.0103 m^2
Pressure, P	= F/A
	= 75000/0.0103 Pa
	= 7281553 Pa = 72.8 bar

Exercise 1: Calculate the approximate force, a hydraulic cylinder can apply, if it has a diameter of 5.1 cm and is connected to a 200 bar circuit.

Force multiplication

Figure 3 shows an arrangement of two cylinders with piston areas A_1 and A_2 ($A_2 > A_1$) respectively. These two cylinders are interconnected by a pipeline. Oil is enclosed in the cylinder chambers and in the pipeline. When the plunger piston A_1 is applied with a force F_1, a pressure (say P1) is developed in the oil, which acts equally in all directions through the oil. It means that the same pressure (P1) acts on the ram piston A_2. This causes the development of a force (say F_2). The governing equations for the forces developed in the cylinders are as follows:

$$F_1 = P \times A_1$$

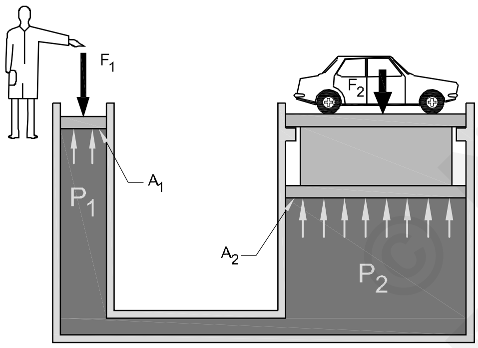
$$F_2 = P \times A_2$$

Therefore,

$$F_2 = F_1 \times (A_2 / A_1)$$

We can see that by controlling the area ratio (A2/ A1) a larger output force can be obtained from a smaller input force. This principle is also used in many hydraulic machines. For example, a hydraulic jack used to lift cars at service stations, brakes in vehicles, etc., use the force multiplier principle for power amplification.

Fig 3



ILLUSTRATING THE CONCEPT OF FORCE MULTIPLICATION

MTN154013

Example 2

To understand the idea of force multiplication, consider figure 1.1, where applied force, F1= 25 N, cross sectional area of plunger, A1 = 10 cm2, ram piston area A2 = 100 cm2. What will be the force F2 required to lift the car placed on the ram platform?

Solution:

Pressure $P_1 = F_1 / A_1 = 25/10 = 2.5 \text{ n.cm}^2$

$P_1 = P_2 = 2.5 \text{ n.cm}^2$

Therefore, $F_2 = A_2 \, P_2$

$= 100 \times 2.5$ N

$= 250$ N

Exercises 2: A hydraulic car lift used in a service station has an input pump piston and an output plunger to support a loading platform. The pump piston has a radius of 0.012 m and the loading piston has a radius of 0.15 m. The total weight of the car and the plunger is 25000 N. If the bottom surfaces of the piston and plunger are at the same level, what input force is required to lift the car and output plunger? What pressure produces this force? [Ans: 160 N, 3.536 bar]

Oil flow

A hydraulic system, with a pump pushing oil continuously through a pipeline, produces a oil flow between any two points in the pipeline as long as there is a pressure difference between these two points.

Flow rate

Flow rate of oil is a measure of the volume of the oil passing a point per unit of time. It is usually measured in m^3 per minute or in other units.

Hydraulic oil

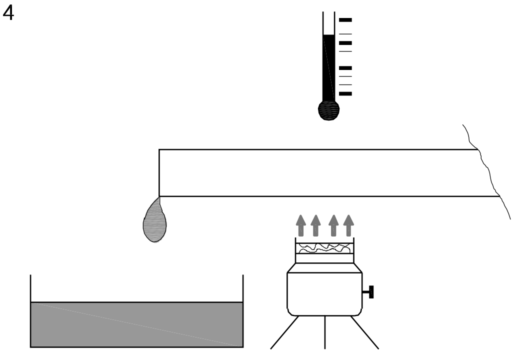
Hydraulic oil is the lifeblood of any hydraulic system. Its primary function is to transmit power from one part of the system to the other part. Apart from this function, it has to lubricate the internal moving parts of system components, seal clearance between the moving parts, and act as a heat transfer medium, as it flows through the system. Oil is usually composed of base stock ad many additives. Mineral-based oils (i.e., petroleum-based oils) are used in a majority of applications. The purpose of using additives in oil is to improve the performance of the oil for a give application. Oil's resistance to flow, expressed in terms of its viscosity, is an important parameter that must be considered.

Hydraulic oils are susceptible to the problem of contamination as they are generally used in harsh environments. Presence of particulates, water, air, and their reaction products in hydraulic oil can adversely affect the performance of these systems. Therefore, the most important requirement of any hydraulic system is to maintain its oil medium in a clean state. Hydraulic filters are used to remove solid contaminants in hydraulic oil.

Viscosity (Fig.4)

Viscosity is a measure of a liquid's resistance to flow. Thicker oil has more resistance to flow and possesses a higher viscosity. Viscosity is affected by temperature. Oil viscosity decreases as the temperature of oil increases.

Fig 4



ILLUSTRATING THE EFFECT OF TEMPERATURE ON VISCOSITY

MTN154014

A property, that describes the difficulty with which oil moves under the force of gravity, is called kinematic viscosity. It is measured in terms of stokes.

Stoke (St): This is the CGS unit of kinematic viscosity, equivalent to square centimeter per second (cm^2/s.) The more customary unit of kinematic viscosity is the centistokes (cSt). One cSt is one one-hundredth of a stoke. The relations amongst various units of kinematic viscosity are summarized below:

* 1 stoke = 1 cm^2/s

* 1 cSt = 0.01 Stoke

* 1 cSt = 1 mm^2/s

Hydraulic system

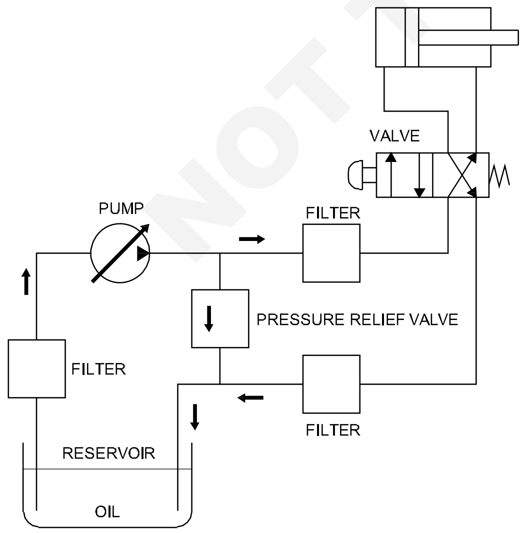
Objectives: At the end of this lesson you shall be able to
- **appreciate a typical hydraulic system**
- **define the components of a hydraulic power pack**
- **explain the working of a hydraulic pump.**

A Typical Hydraulic System

A typical hydraulic system is shown in the schematic diagram of Figure 1. The system is a closed system and comprises a power pack, control valves, and actuators. The hydraulic power pack consists of a hydraulic pump coupled to engine, a reservoir filled with oil, and a pressure relief valve (PRV). The pump pushes the oil into the closed system. It develops a high pressure, when the pump flow encounters some opposition. Therefore, the mechanical energy provided by the prime mover of the pump is converted into hydraulic energy. This energy is transmitted to hydraulic actuators through the oil medium. Hydraulic actuators, such as cylinders, are used to convert the hydrostatic energy back to mechanical energy. Hydraulic valves are used to control the direction and the speed of the actuators. The pressure relief valve is used to limit the pressure in the system.

All system components are interconnected through fluid conductors, such as pipes, tubing and/or hoses, for the leak-free transmission of the hydraulic power. The pressurized oil media must be positively confined in the system, through the use of effective seals, for the efficient utilization of the power. Contaminants should not be allowed to accumulate in the system. Filters are used to remove contaminants in the oil medium.

Fig 1

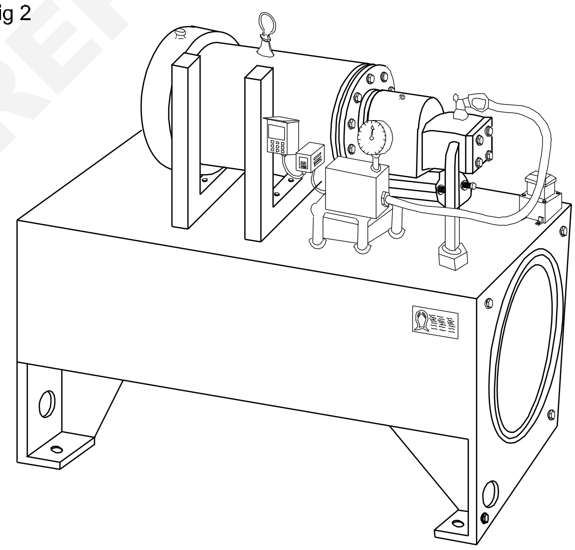


REPRESENTATIONS OF A TYPICAL HYDRAULIC SYSTEM

Reservoir (Fig 2)

A hydraulic power pack, employed in a hydraulic system, transforms the power conveyed by its prime mover into hydraulic power, at pressures and flow rates as required for all system actuators. It is usually a compact and portable assembly that contains components necessary to store and condition a given quantity of oil, and to push a part of the oil into the system. The essential components are reservoir (tank), pump, relief valve, pressure gauge etc. A reservoir is essentially a container that stores a sufficient quantity of oil required for the system. A well-designed reservoir in a hydraulic system allows most of the foreign matter to drop out of the oil and assists in dissipating heat from the oil.

Fig 2



HYDRAULIC POWER PACK

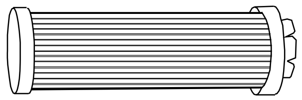
Oil Filter (Fig 3)

Impurities can be introduced into a system as a result of mechanical wear, and external environmental influences. For this reason filters are installed in the hydraulic circuit to remove dirt particles from the hydraulic oil. The reliability of the system also depends on cleanliness of oil.

Pressure Relief Valve (Fig 4)

A pressure relief valve (PRV) is used in a hydraulic system to limit the maximum working pressure of the system to a safe value in order to protect operating personnel against injury and system components against any damage.

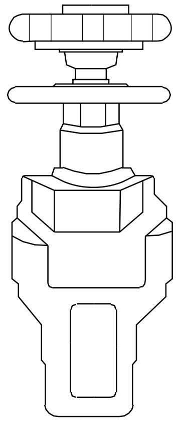
Fig 3



HYDRAULIC FILTER ELEMENT

MTN154023

Fig 4



PRESSURE RELIEF VALVE

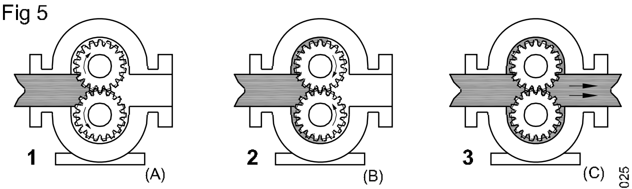
MTN154024

External gear pump (Fig 5)

Figure 5 illustrates the operation of an external gear pump with the help of its schematic diagrams in three critical positions. It basically consists of two close-meshing identical gears, enclosed in a close-fitting housing. Oil chambers are formed in the space enclosed by the gear teeth, pump housing, and side plates. Each of the gears is mounted on a shaft supported on bearings in the end covers. One of the gears - called the drive gear - is coupled to a prime mover through its drive shaft. The second gear is driven, as it meshes with the driver gear.

The gears rotate in opposite directions when driven by the prime mover, and mesh at a point in the housing between the inlet and outlet ports. When the gears rotate in the housing, the diverging teeth create an expanding volume at the inlet side of the pump. This creates a partial vacuum at the inlet chamber of the pump, which draws oil into the chamber from the system reservoir [Figure 5(a)]. The oil then travels around the periphery of the rotating gears as two streams [Figure 5(b)]. Since the pump has a positive internal seal against leakage, the oil is positively ejected out of its delivery port [Figure 5(c)]. Therefore, when run by the prime mover, the intermeshing gears displace a fixed volume of oil from the suction side to discharge side in one revolution of the drive shaft and crate a flow.

Fig 5



SCHEMATIC DIAGRAMS ILLUSTRATING THE OPERATION OF AN EXTERNAL GEAR PUMP

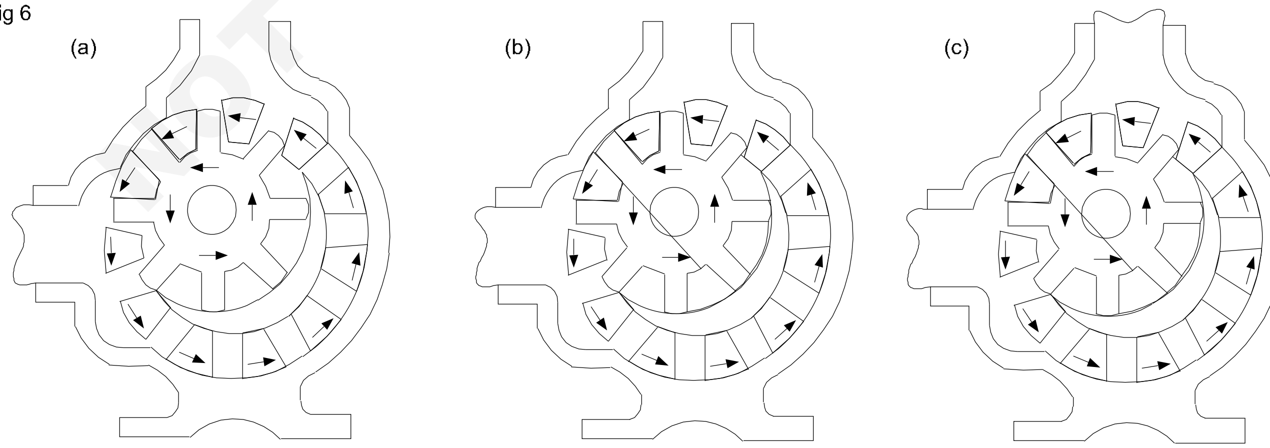
MTN154025

Internal gear pump

Figure 6 illustrates the operation of an internal gear pump with the help of its schematic diagrams in three critical positions. This pump consists of an outer rotor gear, an inner spur gear, and a crescent-shaped spacer, all enclosed in a housing. The inner gear with less number of teeth operates inside the rotor gear. The gears are set eccentric to each other. The stationary crescent spacer is machined into the space between these gears and separates them. The spacer divides the oil stream, and acts as a seal between the suction and discharge ports.

Any one of the gears can be driven through a shaft supported on bearings. Both the gears rotate in the same direction, when power is applied to the drive shaft. The rotation of gears causes the teeth to un-mesh near the inlet port and consequently a partial vacuum is created at the inlet chamber of the pump, which draws oil into the chamber from the system reservoir [Figure 6(a)]. Oil trapped between the inner and outer gear teeth on both sides of the spacer is carried from the inlet port to the delivery port, as the gears rotate [Figure 6(b & c)]. Since the pump has a positive internal seal against any leakage, the oil is positively ejected out of the delivery port.

Fig 6



SCHEMATIC DIAGRAM ILLUSTRATING THE OPERATION OF AN INTERNAL GEAR PUMP

MTN154026

Hydraulic actuators, DC valves, non return valves and another valves

Objectives: At the end of this lesson you shall be able to
- **explain different types of hydraulic actuators**
- **explain the symbol and working of hydraulic DC valves**
- **explain the symbol and working of non-return valve**
- **explain the symbol and working of an adjustable type throttle valve.**

Hydraulic Actuators

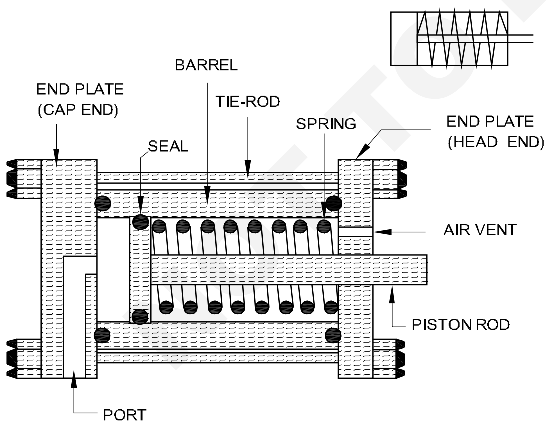
A linear actuator, is used in hydraulic system, it converts hydraulic power into a controllable linear force or motion.

Single-acting Hydraulic Cylinders

A single-acting cylinder is designed to exert force hydraulically in one direction - either on its extension stroke or on its retraction stroke. It utilizes some other force to complete the motion in the other direction. It can be seen that the single-acting cylinder is capable of performing work only in one direction of its motion and hence the name single-acting cylinder.

The cross-sectional view of a single-acting cylinder is shown in Figure 1. It consists of a barrel, a piston-and-rod assembly, a spring, end-caps, a set of seals, and a port. Oil chamber is formed in the cylinder with the barrel, piston, and the piston-side end-cap. The piston-and-rod assembly is a tight-fit inside the barrel and is biased by the spring. The port is integrated into its cap-end to permit or to relieve the system oil. Application of a hydraulic pressure through the port moves the piston-and-rod assembly in one direction to provide the working stroke. The piston-and-rod assembly moves in the opposite direction, either by a spring force or by gravity, or even by exerting an external force. In a cylinder with a spring-assisted retraction, the spring is designed not to carry any load, but, to retract the piston-and-rod assembly with sufficient speed.Figure 1 A schematic diagram showing the cross-sectional view of a single-acting cylinder.

Fig 1

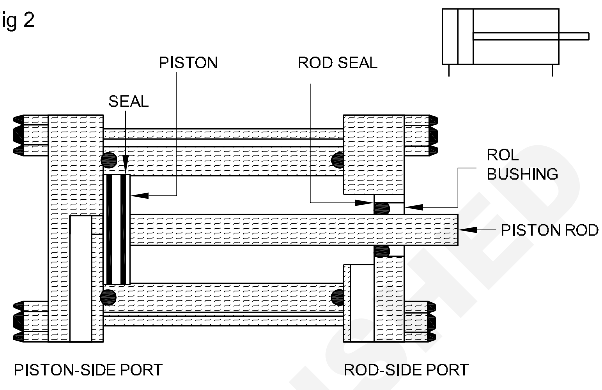


Double-acting hydraulic cylinders

Double-acting hydraulic cylinders, like single-acting cylinders, are also linear actuators. A double-acting cylinder can perform work in both directions of its motion, and hence the name double-acting cylinder.

Cross-sectional view of a double-acting cylinder (Fig.2)

Fig 2



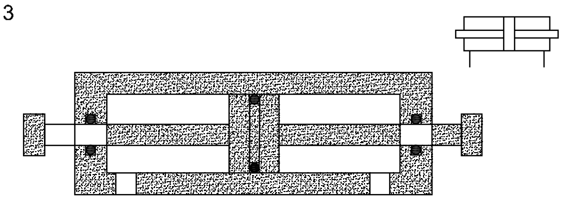
A cross-sectional view of a double-acting hydraulic cylinder is given in Figure 2. It consists of a barrel, a piston-and-rod assembly, end-caps, a set of seals, and two ports. The double-acting cylinder has oil ports on both ends, namely piston-side port and piston-rod-side port. Application of a hydraulic pressure through the piston side port extends the cylinder, provided that the pressure from the piston-rod side is relieved. In the same way, application of a hydraulic pressure through the piston-rod side port retracts the cylinder, provided that the pressure from the piston side is relieved.

Double Rod-end Hydraulic Cylinders

A double rod-end cylinder has piston-rods extending out of the cylinder at both ends, as shown in Figure 3. It has equal areas on both sides of the piston.

A double rod-end hydraulic cylinder (Fig.3)

Fig 3



2/2-way directional control (DC) hydraulic valve

Simplified sketches of a 2/2 - DC (way) valve are shown in Figure 4. The valve consists of housing with a sliding spool, a compression spring. The spool is designed to slide in a close-fitting bore of the valve body. The groove between lands on the spool provides leak-free flow paths between the ports. The operation of the valve is explained with the help of the two views of the valve in its normal and actuated positions. Figure 4: Cross-sectional views of a 2/2-DC hydraulic valve in its normal and actuated positions.

Fig 4

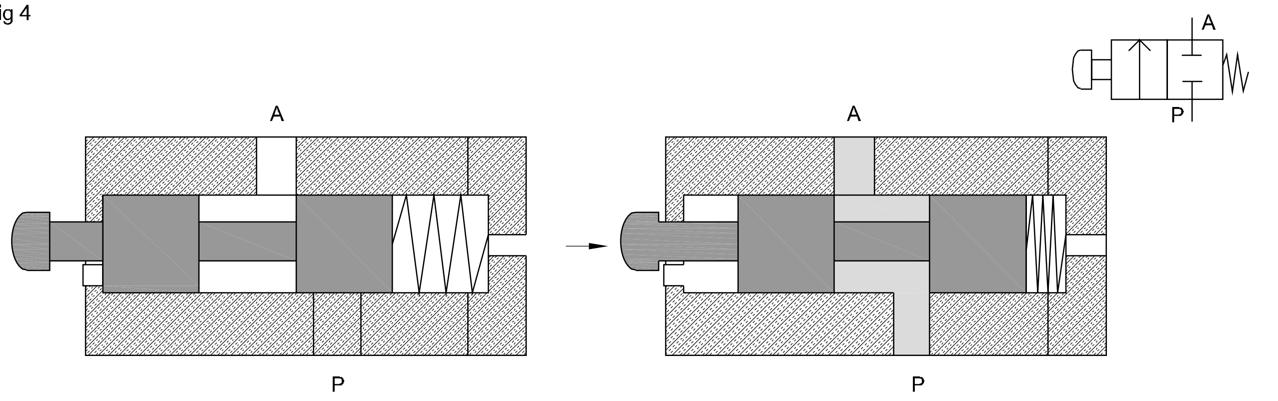


Fig 4(a) Normal position

Fig 4 (b) Actuated position

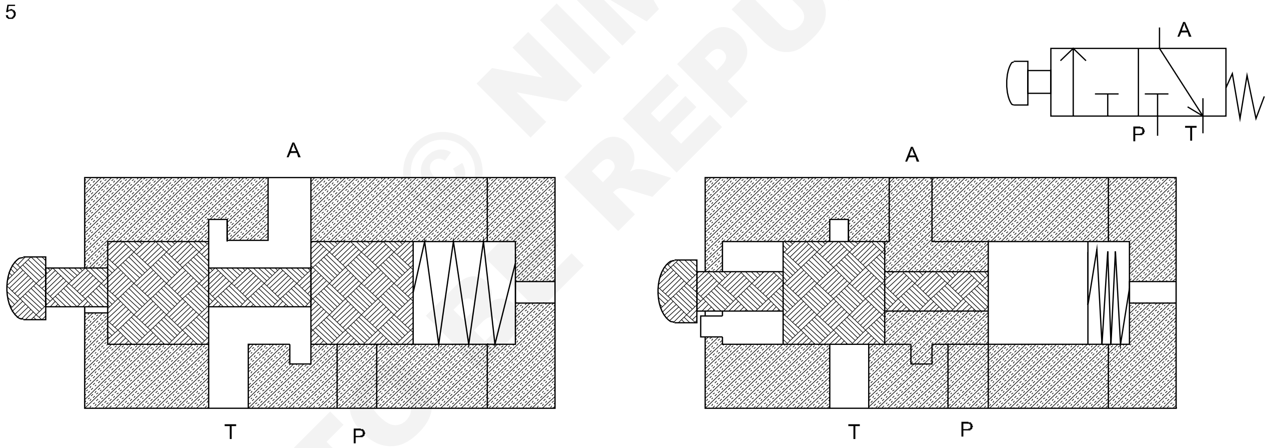
Fig.4 Cross-sectional views of a 2/2 - DC hydraulic valve in its normal and actuated positions

In the normal position of the valve, as shown in Figure 4(a), both the pressure port P and the working port A are blocked. In the actuated position of the valve, as shown in Figure 4(b), the working port A is open to the pressure port P. Once the actuating force is removed, the compression spring brings the spool back to its normal position.

3/2-Directional Control (DC) hydraulic valve

A 3/2-DC (way) valve has three ports and two switching positions. The cross-sectional views of a spool type 3/2-DC valve in its normal position as well as actuated position are shown in the simplified sketches of Figure 5. The pressure port is blocked in the normal position of the valve, as shown in Figure 5(a). In the actuated position of the valve, as shown in Figure 5(b), the working port A is open to the pressure port P and closed to the tank port T. The 3/2-way valves can be used to control single-acting hydraulic cylinders.

Fig 5



(a)Normal Position

(b)Actuated Position

Figure 5: Cross-sectional views of a spool type 3/2-DC hydraulic valve (NC type) in its normal and actuated positions

Example 1: A single-acting hydraulic cylinder is to clamp a component when a push-button valve is pressed. As long as the push-button is pressed, the cylinder is to remain in the clamped position. If the push-button is released, the cylinder is to retract to its home position. Develop a hydraulic circuit to implement the control task using a fixed-displacement pump and a 3/2-Dc valve.

Solution

Two positions of the hydraulic circuit, for implementing the control task given in Example 1, in the normal and actuated positions of the DV valve, are shown in Figure 6. The power supply unit consists of a hydraulic pump driven by an electrical motor, a reservoir and an integral pressure relief valve. The pump can be set by using a separate pressure relief valve (PRV), as shown.

Fig 6

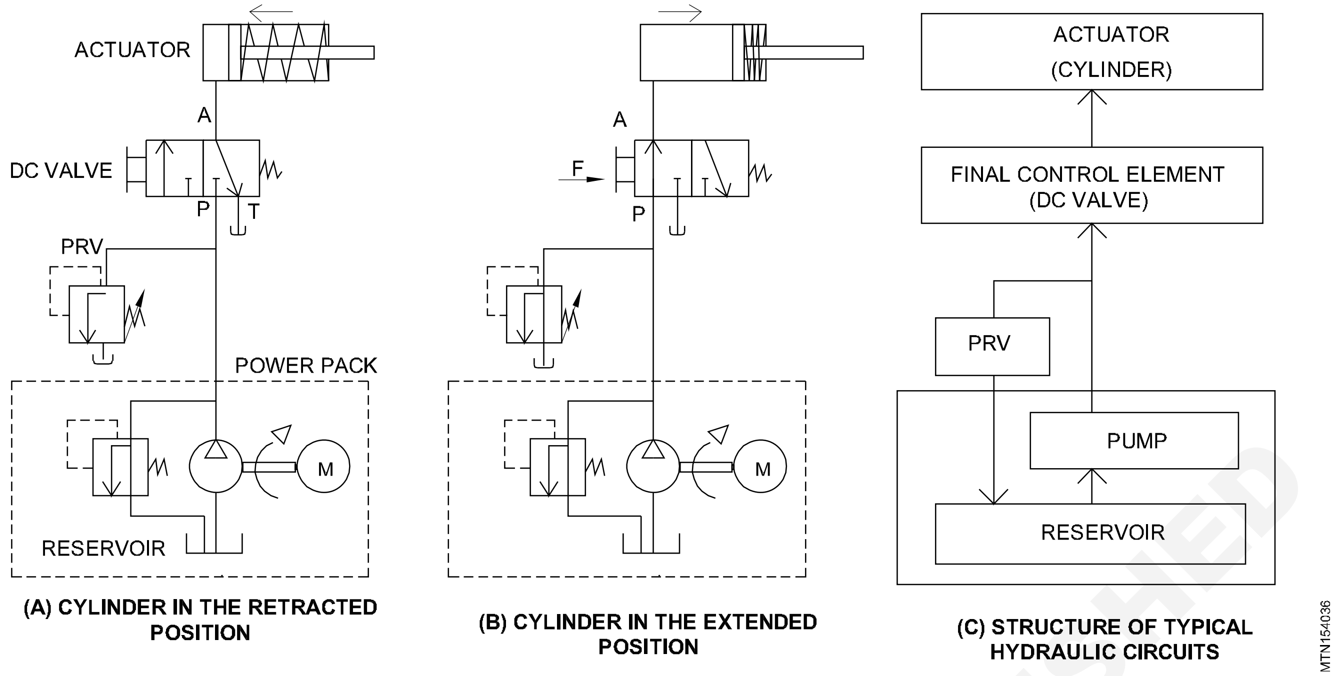


Figure 6: Two positions of the hydraulic circuit for the direct control of a single-acting cylinder, and a typical structure of hydraulic circuits

The single acting cylinder can be controlled by using a manually actuated 3/2 DC valve as shown in the figure. In the actuated position of the valve, as shown in the figure 6(b), the valve allows the flow the pump to the cylinder. The cylinder then extends to its forward direction. When system pressure reaches the setting of the relief valve, pump flow is bypassed over the relief valve against the full system pressure. This maximum pressure limiting action of the relief valve serves to protect the system against over-pressurisation. In the normal position of the 3/2 - DC valve a shown in Fig. 6(a), the valve blocks the flow from the pump to the cylinder. The cylinder then retracts to its home position. A typical structure of hydraulic circuits is given in the block diagram of figure 6(c).

4/2 Directional control (DC) hydraulic valve

A 4/2 - DC (way) valve has four ports and two switching positions. Simplified cross-sectional views of a manually actuated 4/2 DC valve with spool design, in its normal and actuated positions, are shown in Fig.7. In the normal position of the valve, as shown in Fig.7(a), paths from the pressure port P to the working port B and from the working port A to the tank port T are open. When the valve is actuated, paths from the pressure port P to the working port A and from the working port B to the tank port T are open, as shown in Fig. 7(b). This valve can be used as the main valve to drive a double - acting hydraulic cylinder or a bi-directional hydraulic motor.

Example 2 A double -acting hydraulic cylinder is to extend and clamp a work - piece when a push - button valve is pressed. As long as the push - button is actuated, the cylinder is to remain in the clamped position. If the push button is released, the cylinder is to retract. Develop a hydraulic control circuit to implement the control task. A fixed -displacement hydraulic pump is used as the power source.

Solution

Two positions of the hydraulic circuit for the control task in Example 2 in the normal and actuated positions of the double -acting hydraulic cylinder are shown in Fig. 8. The double - acting cylinder can be controlled by using a manually-actuated 4/2 DC valve. The power supply unit consists of hydraulic pump driven by an electrical motor, a reservoir, and an integral pressure relief valve. The pump delivers pressurized oil to the circuit with constant displacement.

When the valve is actuate as shown in the Fig. 8(b) the system oil flow is directed to the piston side port of the cylinder, and the cylinder extends in the normal position of the valve as shown in the fig. 2(a) the oil flow is directed to the piston - rod side port of the cylinder and the cylinder retracts to its home position. The maximum / operating pressure (say 100 bar) in the system can be set by using a separate pressure relief valve (PRV) as shown.

Fig 7

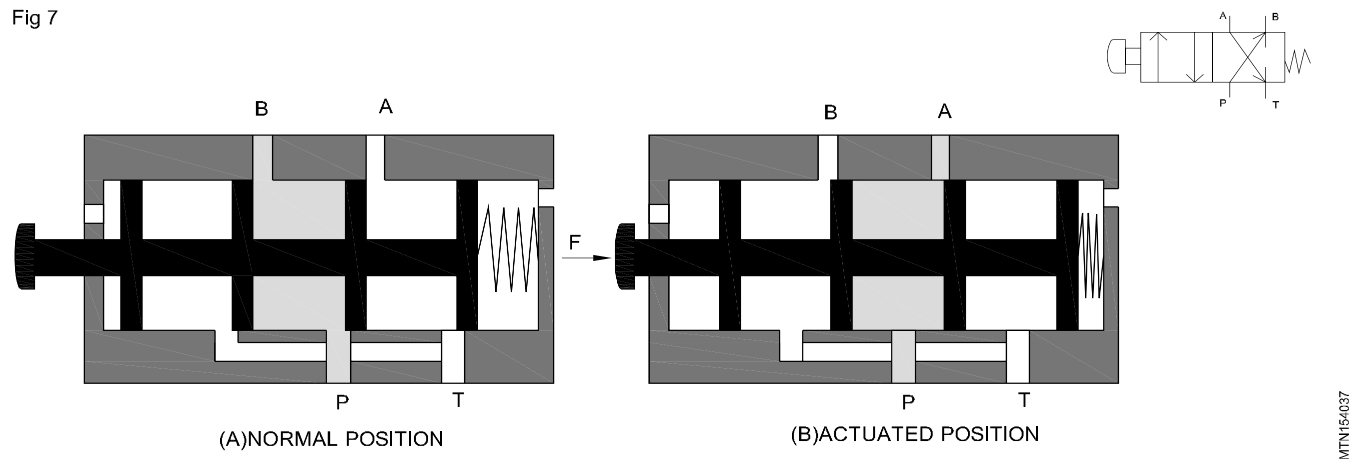


Figure 7: Cross sectional views of a manually actuated 4/2 DC hydraulic valve in its normal and actuated position

Fig 8

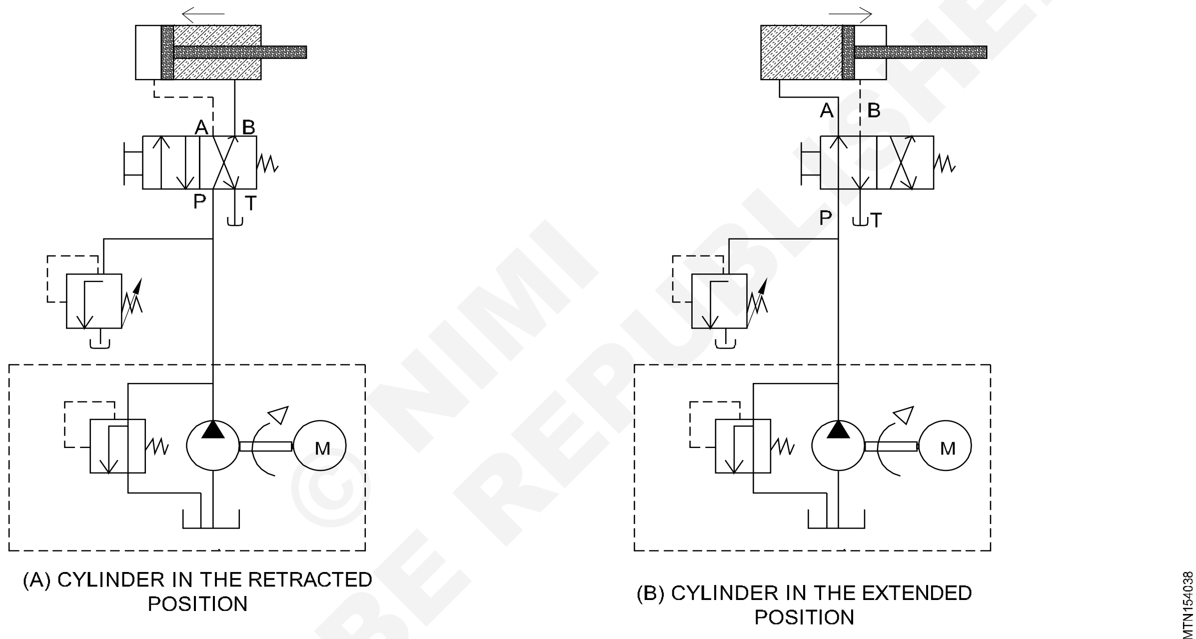


Figure 8: Two positions of the circuit for the control of a double - acting hydraulic cylinder

Non-return Hydraulic Valve

A non-return valve (NRV) is the simplest type of directional control valve used in a hydraulic circuit. The valve preferentially permits flow through it in one direction and blocks the flow in the reverse direction. The basic NRV is the so-called check valve. A hydraulic check valve consists of a valve body and a spring-biased ball poppet or cone poppet, apart from inlet/outlet ports. The spring holds the poppet against the valve seat. Cross-sectional views of these two types of hydraulic check valves are shown in Figure 9.

When the system pressure at the port A is high enough to overcome the spring force, the poppet is pushed off its seat allowing the system oil to flow freely through the valve from the port A the port B with a low-pressure drop across it. The flow through the valve is blocked when the intended flow direction is from the port B to the part A, by poppet reseating.

Fig 9

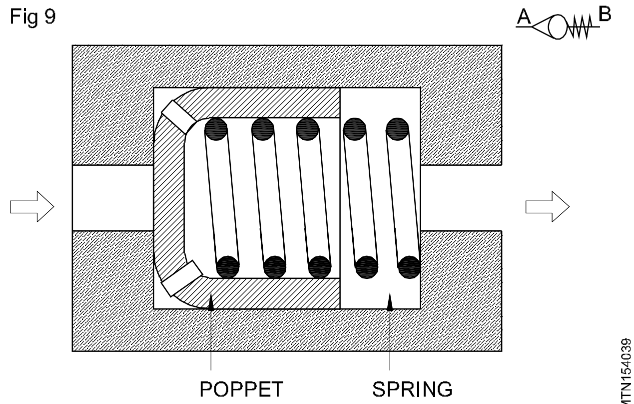


Figure 9: Cross-sectional views of a check valve

Flow Control (Throttle) Valve

A throttle valve is a device with a restriction that offers a resistance to the system oil flowing through it. The throttle valve regulates the flow rate of the system oil. According to the type of restriction, throttle valves are of two types.

They are: (1) Fixed type and (2) Adjustable type. In a fixed type throttle valve, the restriction is fixed, whereas in an adjustable type throttle valve, the area of the restriction can be varied. These types of throttle valves are further explained in the following sections.

An adjustable throttle valve consists of an orifice whose cross-section can be controlled by an externally adjustable needle-shaped plunger. Oil flow passing through the controlled cross-section can be regulated precisely by the pointed needle. The cross-sectional view of the adjustable throttle valve is given in Figure 10.

Fig 10

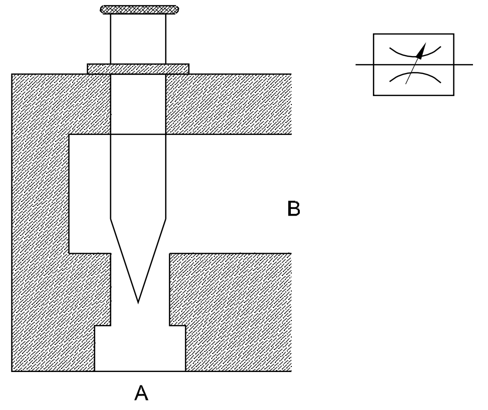


Figure 10: A cross-sectional view of an adjustable type throttle valve

History and developments in automobile industry

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

Auto industry - History, leading manufacturing

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

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

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

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

2000-2010, almost every major car company established manufacturing facilities in our 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 is the largest three wheeler and two wheeler market in the world and second largest tractor manufacture in the world , fifth largest commercial vehicle manufacture in the world and second largest producer of motorcycle in the world after china.

In Indian some Industries are manufacturing the vehicle parts and assembling.

Example: TATA, Hindustan Motor and ashok leyland etc.

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

Example: Ford, Hyundai, Audi etc.

Development in automobile industry: Due to the recent developments in electronics and computers lots of changes have come in the automobile also a mini computer named ECM electronic control module takes the control of

Engine control, transmission control, Brake and steering system controls, Safety controls, and infotainments.

More no of sensors and transducers are employed in all systems to send information to their corresponding electronic control units to achieve precise control on all activities.

Due to this precise controls we could achieve,

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

Gasoline Direct Injection (GDI)

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

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

Electric vehicle (EV)

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

The electric cars available in India are

Mahindra e2oplus

Mahindra e-Verito.

Tata Tigor Electric

Mahindra e-KUV 100

Tata Tiago Electric.

Fuel cells

The fuel cell is 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 fuel 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 & high ways

Objectives: At the end of this lesson you shall be able to
- **state the function of ministry of road transport & highways**
- **state the function of NATRIP**
- **state the function of ARAI**

Ministry of road Transport & Highways: This is an apex organization under the central Government, is entrusted with the task of formulating and administering, in consultation with other central Ministries/Departments, State Governments/UT Administrations, organisations and individuals, policies for Road transport, National highways and transport research with a view to increasing the mobility and efficiency of the road transport system in the country. The ministry has two wings: Roads wing and Transport wing.

Roads wing: Deals with development and maintenance of National Highway in the country

Main Responsibilities

- Planning development and maintenance of national Highways in the country
- Extends technical and financial support to state Governments for the development of state roads and the roads of inter-state connectivity and economic importance.
- Evolves standard specifications for roads and bridges in the country.
- Serves as a repository of technical knowledge on roads and bridges.

Transport wing

Deals with matter relating to Road transport

Main Responsibilities

- Motor vehicle legislation
- Administration of the Motor Vehicles Act, 1988
- Taxation of motor vehicles.
- Compulsory insurance of motor vehicles.
- Administration of the Road transport corporations Act, 1950.
- And promotion of transport co-operatives in the field of motor transport
- Evolves road safety standards in the form of a national policy on road safety and by preparing and implementing the Annual road safety plan.
- Collects, compiles and analyses road accident statistics and takes steps for developing a road safety culture in the country by involving the members of public and organizing various awareness campaigns.
- Provides grants-in-aid to non-governmental Organisations in accordance with the laid down guidelines.

Classification of vehicle

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

Classification of vehicles

Based on central motor vehicle act

- Motor cycle
- Invalid carriage
- Three wheelers
- Light motor vehicle
- Medium passenger vehicle
- Medium goods vehicle
- Heavy passenger 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

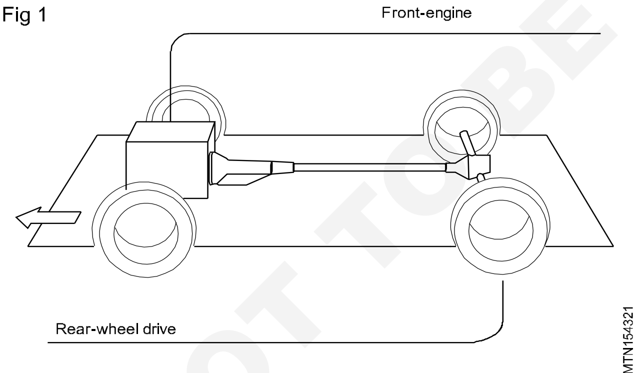
Based on body

- 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

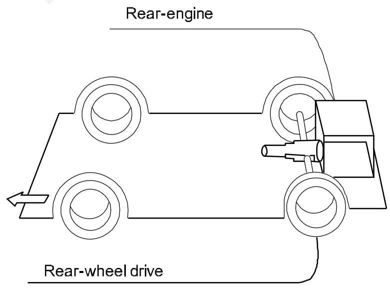
Front engine rear wheel drive (Sumo, Omni, Ambassador, etc.) (Fig 1)

Fig 1



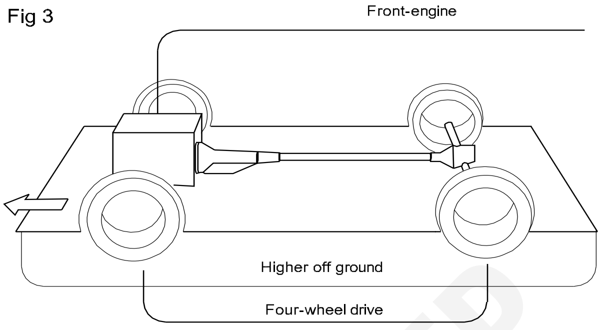
Rear engine rear wheel drive (Tata Nano, Bajaj auto, Valvo bus etc) (Fig 2)

Fig 2



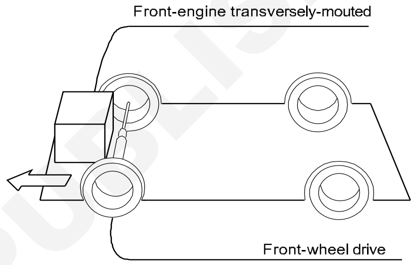
Four wheel/ All wheel drive (Jeep, Scorpio, Gypsy etc.) (Fig 3)

Fig 3



Front engine front wheel drive (Alto, Ertiga, santro, Tiago etc.) (Fig 4)

Fig 4



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

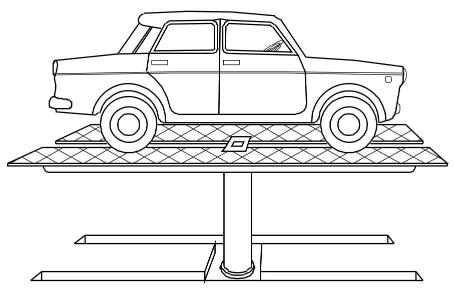
Objectives: At the end of this lesson you shall be able to
- **state the function of vehicle hoists**
- **state the function of engine hoists**
- **sate the function of jacks**
- **state the function of axes stand.**

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

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

Single post hydraulic car hoist (Fig 1): It is facilitate the servicing and repair works conveniently. It is constructed for dependable, trouble free performance and ensuring smooth and safe operation. The post is made of high grade steel. The car hoists are specially designed for resistant to wear and damage during water wash. Single post type is suitable for vehicle up to 6 tones.

Fig 1



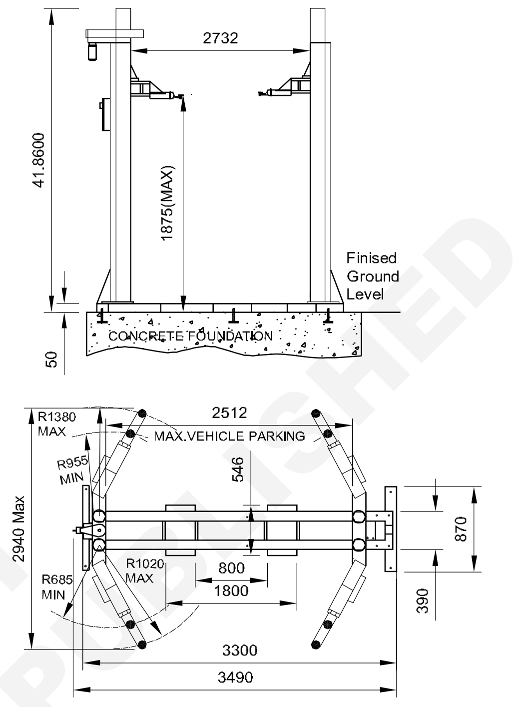
HYDRAULIC CAR HOIST

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

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

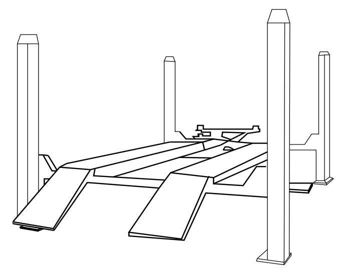
Engine hoist (Fig 4): The engine hoist helps to lift an engine from a car/truck. The hydraulic pressure converts power to a mechanical advantage and lifts the engine from the car with less effort. When using a block and tackles for lifting an engine, use a lifting plate attached to the intake manifold or use a chain bolted at each end of the block so on. They are operated by moving the handle up and down. The other type of portable floor jack is the pneumatic jack which uses compressed air to lift a car or truck. It is mostly used in production side.

Fig 2



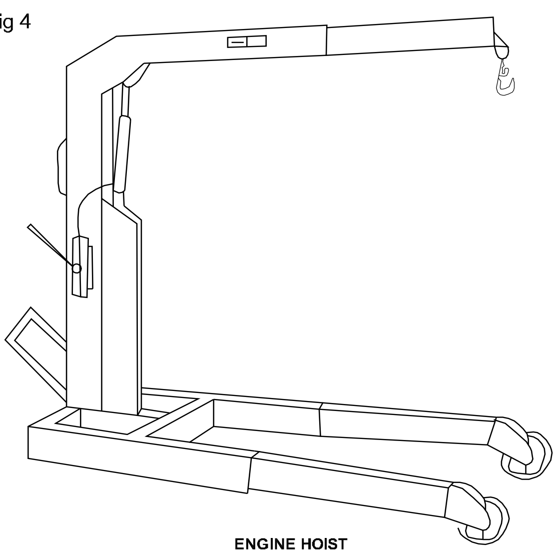
TWO POST HOIST

Fig 3



FOUR POST HOIST

Fig 4



ENGINE HOIST

Never work under a car without safety stands or jack stands

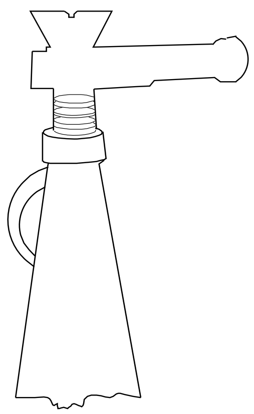
On roads mostly mechanical jacks are used to lift the car/vehicle for small jobs. These jacks work under the principle of screw and nut.

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

Types of jacks

- Light weight screw jack (Fig 5)

Fig 5

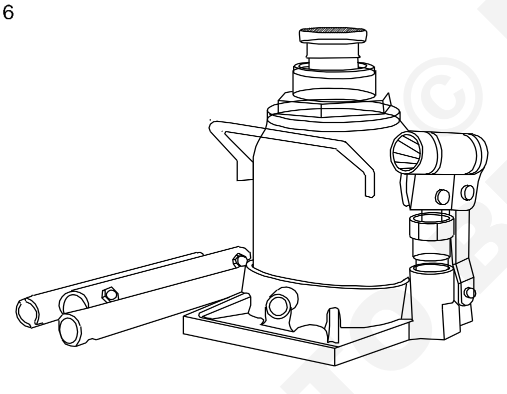


MANUAL TYPE LIFITING JACK

MTN154335

- Heavy duty bottle type hydraulic jack (Fig 6)

Fig 6

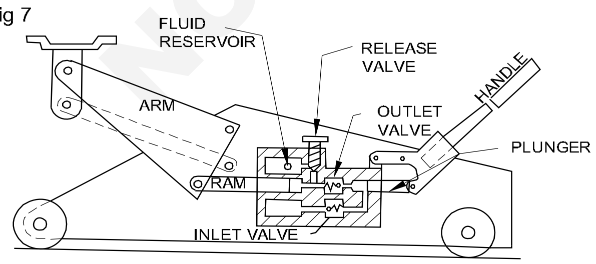


HEAVY DUTY BOTTEL TYPE LIFITING JACK

MTN154336

- Trolley types hydraulic jack (Fig 7)

Fig 7



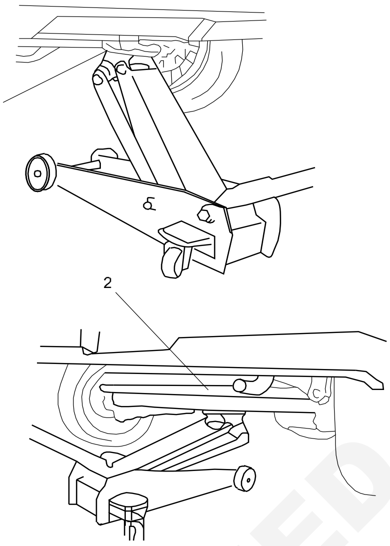
TROLLEY TYPE JACK

MTN154337

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).

Fig 8



FLOOR JACK

MTN154338

Caution: Never apply jack against suspension parts (i.e., stabilizer, etc.) front bumper or vehicle floor, Otherwise it may get deformed.

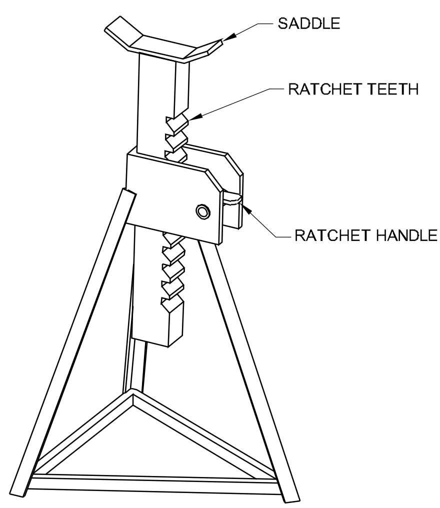
Warning: If the vehicle to be jacked up only at the front or rear end, be sure to block the wheels on ground in order to ensure safety.

After the vehicle is jacked up , be sure to support it on stands. It is extremely dangerous to do any work on the vehicle raised on jack alone.

Axle stand (Fig 9)**:** It is always injure safety before starting the work under the lifted vehicle, Jack support is not enough, it could be dangerous. Always use axle stands for safety work. Different size of stands are used depend upon the vehicle load.

To perform service with either front or rear vehicle end jacked up, be sure to place safety stands (1) under body so that body is securely supported. And the check to ensure that body does not slide on safety stands and the vehicle is held stable for safety.

Fig 9



TYPICAL ADJUSTABLE JACK STAND

MTN154339

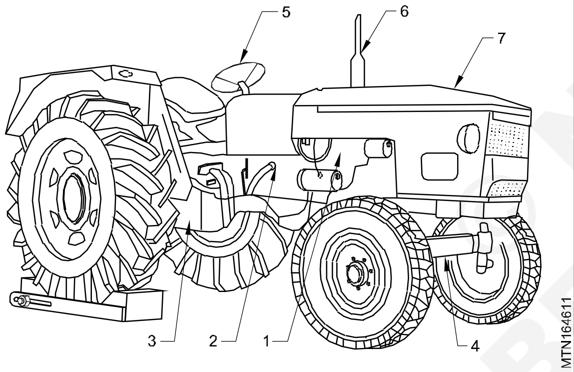
Study of tractor and dozers

Objectives: At the end of this lesson you shall be able to
- **development in tractor industry**
- **describe a tractor & its major parts**
- **describe tractor specification.**

Tractor & its major parts

A tractor is an engineering vehicle specifically designed to deliver a high tractive effort (or torque) at slow speeds, for the purposes of hauling a trailer or machinery used in agriculture or construction. Most commonly, the term is used to describe a farm vehicle that provides the power and traction to mechanize agricultural tasks, especially (and originally) tillage, but nowadays a great variety of tasks. Agriculture implements may be towed behind or mounted on the tractor, and the tractor may also provide a source of power if the implement is mechanized. Major parts of a tractor Engine (1), Transmission (2), Rear axle (3), Front axle (4), Steering (5), Silencer (6) and Bonnet (7) are shown in Fig 1.

Fig 1



Farm tractor design, power and transmission

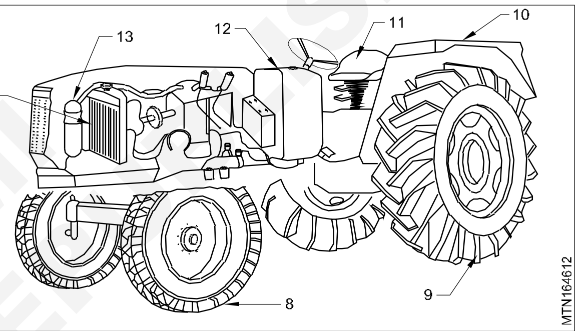
Tractor configuration

Tractor can be generally classified by number of axles or wheels, with main categories of two wheel tractors (single-axle tractors) and four-wheel tractors (two-axle tractors) more axles are possible but uncommon. Among four-wheel tractors (two-axle tractors), most are two-wheel drive (usually at the rear); but many are two wheel drive with front wheel assist, four-wheel drive (often with articulated steering), or track tractors (with steel or rubber tracks)

The classic farm tractor is a simple open vehicle, with two very large driving wheels on an axle below and slightly behind a single seat (the seat and steering wheel consequently are in the centre), and the engine in front of the driver, with two steerable wheels below the engine compartment. This basic design has remained unchanged for a number of years, but enclosed cabs are fitted on almost all modern models, for reasons of operator safety and comfort. These were usually maneuvered through the use of turning brake pedals and separate track clutches operated by levers rather than a steering wheel.

Four-wheel drive tractors began to appear in the 1960s. Some four-wheel drive tractors have the standard "two large, two small" configuration typical of smaller tractors, while some have four large, powered wheels. The larger tractors are typically an articulated, centre-hinged design steered by hydraulic cylinders that move the forward power unit while the trailing unit is not steered separately. Wheel (8), Rear wheels (9), Mud guard (10), Driver's seat (11), Fuel tank (12), Air cleaner (13) and Radiator (14) as shown in Fig 2.

Fig 2



In the early 21st century, articulated or nonarticulated, steerable multitrack tractors have largely supplanted the caterpillar type for farm use. Larger types of modern farm tractors include articulated four-wheel or eight-wheel drive units with one or two power units which are hinged in the middle and steered by hydraulic clutches or pumps. A relatively recent development is the replacement of wheels or steel crawler-type tracks with flexible, steel-reinforced rubber tracks, usually powered by hydrostatic or completely hydraulic driving mechanisms. The configuration of these tractors bears little resemblance to the classic farm tractor design.

Engine and fuels

The predecessors of modern tractors, traction engines, used steam engines for power.

Petrol

Since the turn of the 20th century, internal combustion engines have the power source of choice. Between 1900 and 1960 petrol was the predominant fuel, with kerosene and ethanol being common alternatives. Generally, one engine could burn any of those, although cold starting was easiest on gasoline. Often, a small auxiliary fuel tank was available to hold petrol for cold starting and warm-up, while the main fuel tank held whatever fuel was most convenient or least expensive for the particular farmer.

Diesel

Dieselisation gained momentum starting in the 1960s and modern farm tractors usually employ diesel engines, which range in power output from 18 to 575 horsepower (15 to 480 kW). Size and output are dependent on application, with smaller tractors used for lawn moving, landscaping, orchard work, and truck farming, and larger tractors for vast fields of wheat, maize, soy, and other bulk crops.

LPG and Biodiesel are other fuels used for tractors

Transmission

Most older farm tractors use a manual transmission with several gear ratios, typically there to six, sometimes multiplied into two or three ranges. This arrangement provides a set of discrete ratios that, combined with the varying of the throttle, allow final-drive speeds from less than one up to about 25 miles per hour (40 km/h), with the lower speeds used for working the land and the highest speed used on the road.

Slow, controllable speeds are necessary for most of the operations performed with a tractor. They help give the farmer a larger degree of control in certain situations, such as field work. However, when travelling on public roads, the slow operating speeds can cause problems, such as long queues or tailbacks, which can delay or annoy motorists in cars and trucks. These motorists are responsible for being duly careful around farm tractors and sharing the road with them, but many shirk this responsibility, so various ways to minimize the interaction or minimize the speed differential are employed where feasible.

Older tractors usually have unsynchronized transmission designs, which often require the operator stop the tractor to shift between gears. This mode of use is inherently unsuited to some of the work tractors do, and has been circumvented in various ways over the years. For existing unsynchronized tractors, the methods of circumvention are double clutching or power-shifting, both of which require the operator to rely on skill to speed-match the gears while shifting, and are undesirable from a risk-mitigation standpoint because of what can go wrong if the operator makes a mistake-transmission damage is possible, and loss of vehicle control can occur if the tractor is towing a heavy load either uphill or downhill - something that tractors often do. Therefore, operator's manuals for most of these tractors state one must always stop the tractor before shifting, and they do not even mention the alternatives. As already said, that mode of use is inherently unsuited to some of the work tractors do, so better options were pursued for newer tractor designs.

Hitches and power applications

The power produced by the engine must be transmitted to the implement or equipment to do the actual work intended for the equipment. This may be accomplished via a drawbar or hitch system if the implement is to be towed or otherwise pulled through the tractive power of the engine, or via a pulley or power takeoff system if the implement is stationary, or a combination of the two.

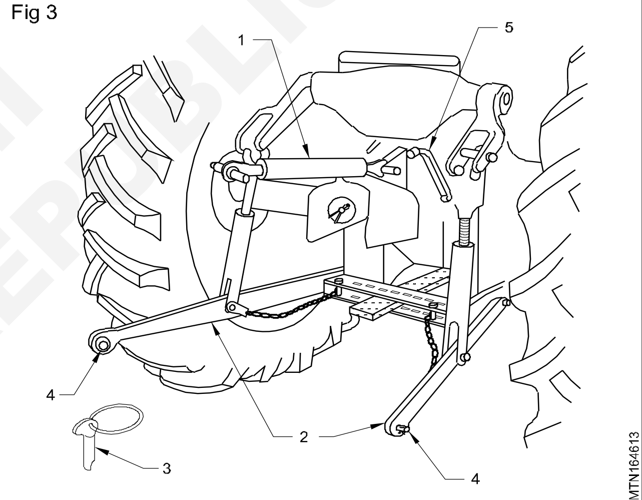
Drawbars

The drawbar is simply a steel bar attached to the tractor to which the hitch of the implement was attached with a pin or by a loop and clevis. The implement could be readily attached and removed, allowing the tractor to be used for other purpose on a daily basis. If the tractor was equipped with a swinging drawbar, then it could be set the center or offset from center to allow the tractor to run outside the path of the implement.

Three-point hitches and quick hitches

The drawbar system was virtually the exclusive method of attaching implements. Equipment attached to the three-point hitch can be raised or lowered hydraulically with a control lever. The equipment attached to the three-point hitch is usually completely supported by the tractor. Another way to attach an implement is via a quick hitch, which is attached to the three-point hitch. This enables a single person to attach an implement quicker and put the person in less danger when attaching the implement. The hitches and power application are shown separately in Fig 3.

Fig 3



A modern three-point hitch

Power take-off systems and hydraulics

In addition to towing an implement or supplying tractive power through the wheels, most tractors have a means to transfer power to another machine such as a baler, swather, or mower. Unless it functions solely by pulling it through or over the ground, a towed implement needs its own power source (such as a baler or combine with a separate engine) or else a means of transmitting power from the tractor to the mechanical operations of the equipment.

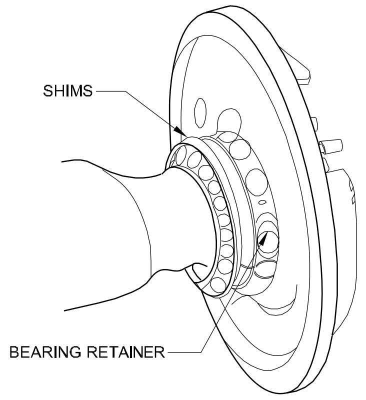
Early tractors used belts or cables wrapped around the flywheel or a separate belt pulley to power stationary equipment, such as a threshing machine, buzz saw, silage blower, or stationary baler. In most cases, it was not practical for the tractor and equipment to move with a flexible belt or cable between them, so this system required the tractor to remain in one location, with the work brought to the equipment, or the tractor to be relocated at each turn and the power set-up reapplied (as in cable-drawn plowing systems used in early steam tractor operations)

A PTO shaft connected to a tractor

Modern tractors use a power take-off (PTO) shaft to provide rotary power to machinery that may be stationary or pulled. The PTO shaft generally is at the rear of the tractor, and can be connected to an implement that is either towed by a drawbar or a three-point hitch. This eliminates the need for a separate, implement-mounted power source, which is almost never seen in modern farm equipment.

Modern tractors can also provide external hydraulic fluid and electrical power to the equipment they are towing, either by hoses or wires.

Fig 4



LOCATION OF AXIE SHAFT BEARING SHIMS

Specification of a tractor such specification can be seen in the website of tractor manufactures in india

Details	Sample-1	Sample-2	Sample-3
Engine	Diesel-Turbo charged	Diesel-DI	Diesel DI
Horse Power	58	42	30
Cylinders	3	3	2
Cubic capacity	2700 cc	2500 cc	1670 cc
F I P type	Rotary	In-line	In-line
Clutch type	Duel	Duel dry	single
Transmission			
Type	Constant mesh-TM side shift	Partial constant mesh(PCM)	Sliding mesh
No of speeds	8F+2R	8 Forward+ 2 Reverse	6F+2R
Front Tyre	7.50x16	6.00x16	5.50x16
Rear Tyre	16.90x28	13.6x28	12.4x24
Maximum road speed	35.8 kmph	29.5 kmph	22.4kmph
PTO			
Type	GSPTO	Live,6 splined shaft	Live,shiftable 2speed
Speed	540rpm@1790Erpm	540 rpm@1500 Erpm	540&1000 rpm@1500Erpm
Hydraulics			
Lifting capacity-lower link in horizontal position	1700 kgf	1700 kgf	1100kgf
3 point linkage & control Steering	3 point link,Draft,posn resp	3 point linkage,Draft	3 point linkage,Draft,
Type-Manual/power	Power steering	Manual,Recirculating worm ball & nut type	Manual,Recirculating worm ball and nut type
Brake Type	Multidisc oil immersed	Multidisc oil immersed	Mechanical,intl-expandible
Electrical, Battery capacity	12V,80Amp-hr	12V,75Amp-hr	12v,65Amp-hr
Dimensions & weights			
Overall length x width x height	3745x1878x2316mm	3435x1710x2220mm	2800x1420x1380mm
Minimum ground clearance	420mm	340-345 mm	280mm
Turning circle with brakes	3145mm	1880-1920 mm	
Total weight	2255kgs	1995 kgs	1400kgs
Filling Capacity	60 lts	45 litres	25 lts
Additional features	SpaceD platform,Diff lock HD ft axle,mobile charger	none	none

Starting and stopping of tractor

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.

– Hand cranking

– Electric Motor cranking

– Compressed air cranking

– Gasoline engine starting

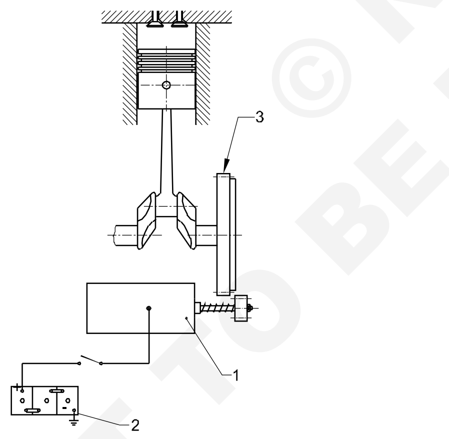
Hand cranking: Usually small diesel engines & power generator are being started using crank handle or rope.

For rope special pulley is provided at front or rear of crankshaft.

Wind rope before pulling by hand.

Electric motor cranking (Fig 1)**:** In this system a starter motor (1) is used to rotate flywheel of the engine. A battery (2) is used to supply power to the starter motor through starting switch.

Fig 1



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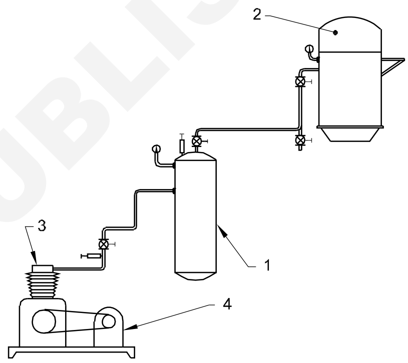
Compressed air cranking (Fig 2)**:** In this method compressed air from the reservoir (1) is admitted through an starting valve in the engine cylinder head when the piston is at the top dead centre at the beginning of the power stroke at a pressure capable of cranking the engine (2). When the engine 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 in reservoir. air compressor (3) is driven by the engine or electric motor (4).

Fig 2



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Gasoline engine starting: Small gasoline is used to crank heavy duty multi cylinder diesel engines which needs more cranking efforts for starting or where battery is not provided. The starting gasoline is cranked by handle/ rope or electric motor.

Stopping the engine gasoline engines are stopped by ignition switch and diesel engines are stopped by cutting the fuel supply after reducing the engine speed to the minimum level by stop lever.

Types of engine

Objectives: At the end of this lesson you shall be able to
- **state the various types of internal combustion engines.**

Engines: In a tractor the engine develops power to propel the tractor. It converts heat energy of the fuel into mechanical energy. Various types of engines are used in present day tractors.

Types of heat engines

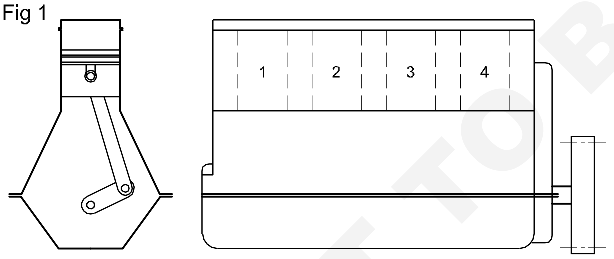
1 External combustion
- Steam engine

2 Internal combustion
- Spark ignition
  - Reciprocating
    - Four stroke
    - Two stroke
  - Rotary engine
- Compression ignition
  - Two stroke
  - Four stroke

Types of engines as per cylinder arrangement

In-line engines: In this type, (Fig 1) the cylinders are arranged in one line. The length of the crankshaft is longer than that of the other types of engines, and hence a limited number of cylinders are used. Better balancing and more uniform torque is obtained in this type.

Fig 1



V Engines: In this type,(Fig 2) 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 inline engine.

Opposed engines: In this type, (Fig 3) 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 outputs. The length of the engine increases too much, and the engine has to be placed in the transverse direction in the vehicle.

Fig 2

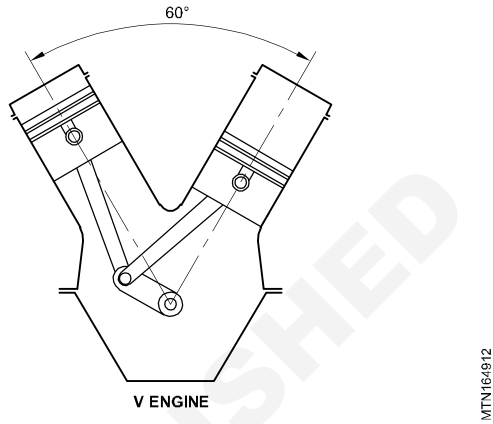
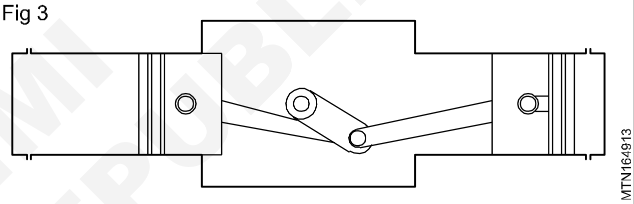
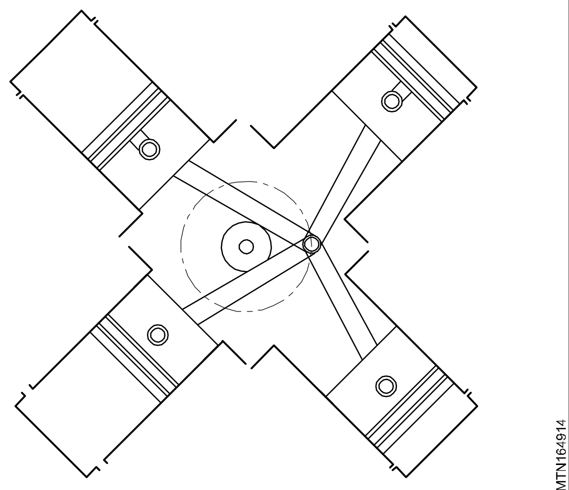


Fig 3



Radial engines: In this type, (Fig 4) the cylinders are arranged radially. This type of engine is shorter, lighter and more rigid. Since it is rigid, a higher engine speed is possible and a higher combustion pressure can be obtained. This leads to high fuel efficiency. The radial type engines are used mostly in aeroplanes.

Fig 4



Types of engine as per number of cylinders

Single cylinder engine: An engine which has only one cylinder is called a single cylinder engine. Since it is a single cylinder engine it cannot develop more power. It is normally used only in two wheelers like scooters and motor cycles.

Multi-cylinder engines: These engines have more than one cylinder. Two-cylinder engines are usually used in tractors. Three or four-cylinder engines are used in cars, jeeps and other vehicles. In heavy vehicles six-cylinder engines are used. A greater number of cylinders gives smoother engine operation.

Classification of engines

Objectives: At the end of this lesson you shall be able to
- **state the classification of engines**
- **state the technical terms used in relation to engine**
- **state the technical specification of an internal combustion engine.**

Engines are classified according to the following factors.

Number of cylinders

- Single cylinder
- Multi-cylinder

Arrangements of cylinders

- In-line engine
- 'V' shape engine
- Opposed engine
- Horizontal engine
- Radial engine
- Vertical engine

Types of fuel used

- Petrol engine
- Diesel engine

Types of valve arrangements

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

Application of engine

- Constant speed engine
- Variable speed engine

Cooling system

- Air cooled engine
- Water cooled engine

Strokes of engine

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

Basic technical terms used in relation to engines

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

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

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

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

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

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

Compression Ratio (CR)**:** Ratio of volume between compression strokes before 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. It is given by

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

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.

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.

$$IHP = \frac{PmLAN}{4500} \text{ x K}$$

where Pm is the mean effective pressure in kg/cm^2.

L is length of stroke in metres

A is the area of the piston in cm^2

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

$$\text{Mechanical efficiency} = \frac{\text{B.H.P.}}{\text{I.H.P.}} \times 100$$

Volumetric efficiency: It is the ratio between the mixture drawn in the cylinder during the suction stroke and the volume of cylinder.

Throw: It is the distance between the centre of the crankpin 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 data

– Type
– Number of cylinders
– Bore diameter
– Stroke length
– Capacity in cu.cm or 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.

Two-stroke engines

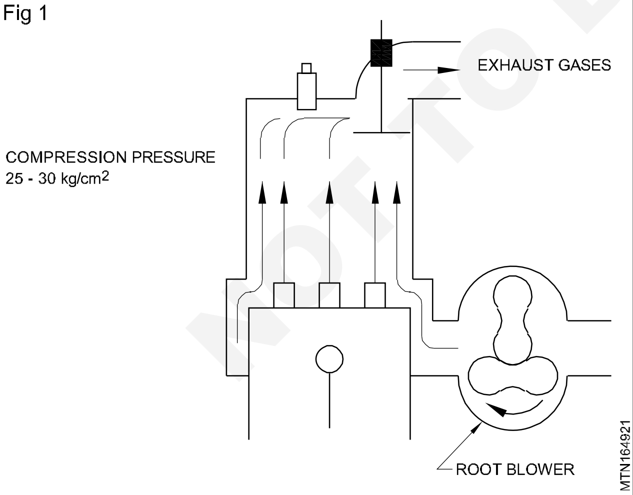
Function of Diesel Engine

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

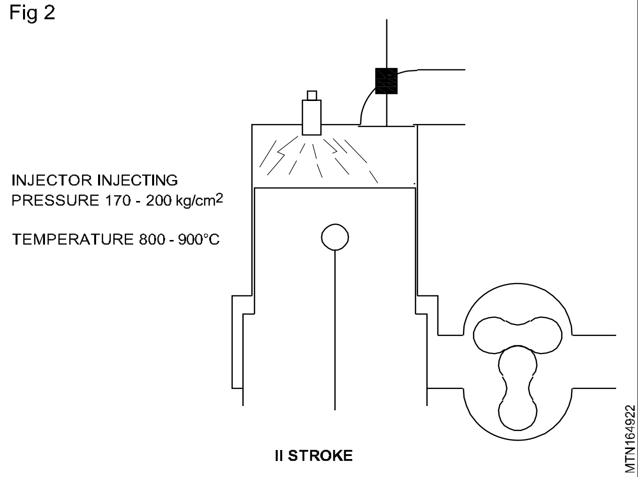
Fig 1



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

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

Fig 2



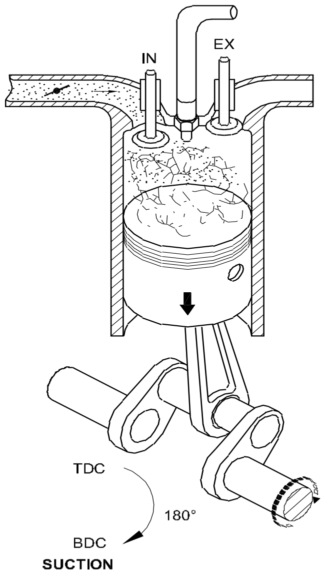
Four-stroke engine

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

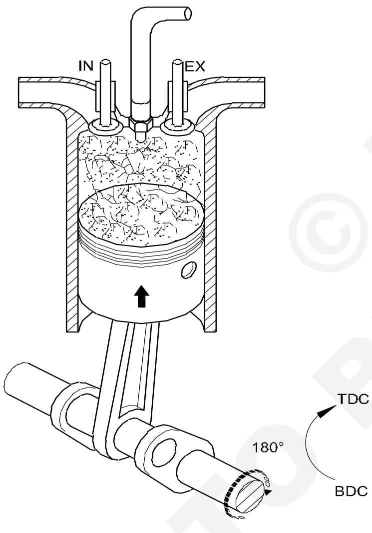


SUCTION STROKE

Compression stroke (Fig 4)

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

Fig 4

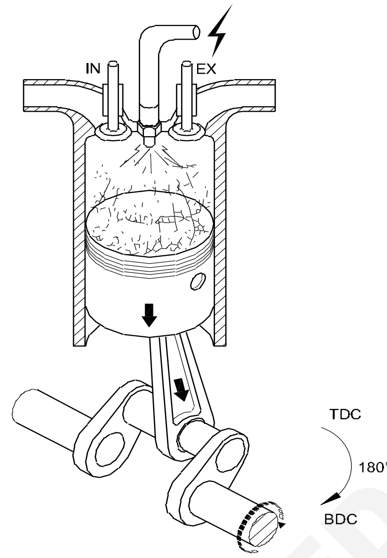


COMPRESSION STROKE

Power stroke

At the end of the compression stroke diesel fuel is injected into the hot compressed air in the combution chamber; result burning of diesel with an explosion the gas expand and pressure develops inside the cylinder. The piston

Fig 5



POWER STROKE

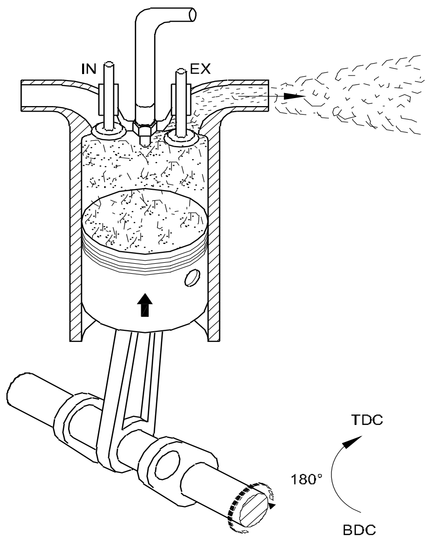
moves from TDC to BDC (Fig 5). Both the valves remain closed. Power is supplied to the fly wheel.

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.**

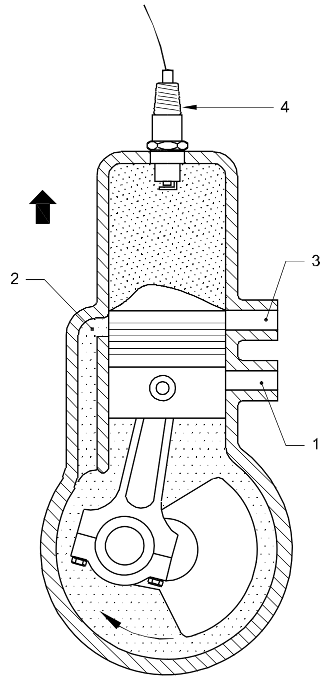
Two-Stroke spark ignition engine

To produce power in two stroke engine the following operations take place in the sequence given below.

First stroke (Suction and compression)

As the piston moves up from BDC,(Fig 1) it closes the inlet port (1), the exhaust port (3) and the transfer port (2).

Fig 1



FIRST STROKE

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.

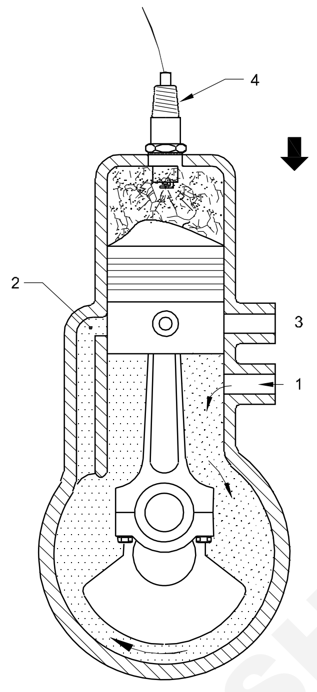
Further downward movement of the piston opens the transfer port and allows the partially compressed mixture, received during the previous stroke, to reach the combustion chamber from the crankcase.

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.

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

Fig 2

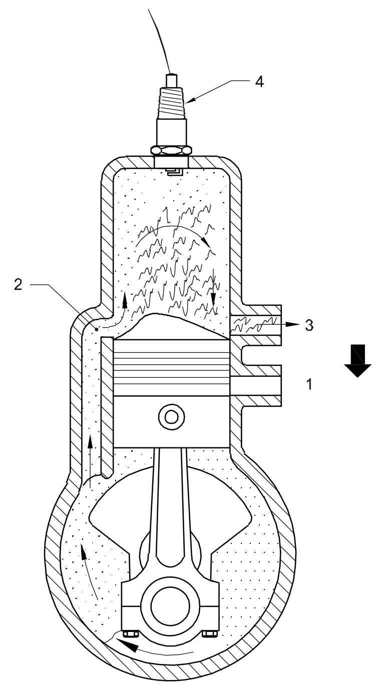


FIRST STROKE

cylinder. The quantity of the mixture is metered by the carburettor according to the load and speed. The ratio of air/fuel mixture is also metered by the carburettor. During the compression stroke, this air/fuel mixture is ignited by the spark and the mixture is burnt. It raises the pressure of the gas above the piston. The piston is forced down and this power is supplied to the flywheel. During the exhaust stroke burnt gases escape through the exhaust port/valve.

In this type of engine the compression ratio is low.

Fig 3



SECOND STROKE

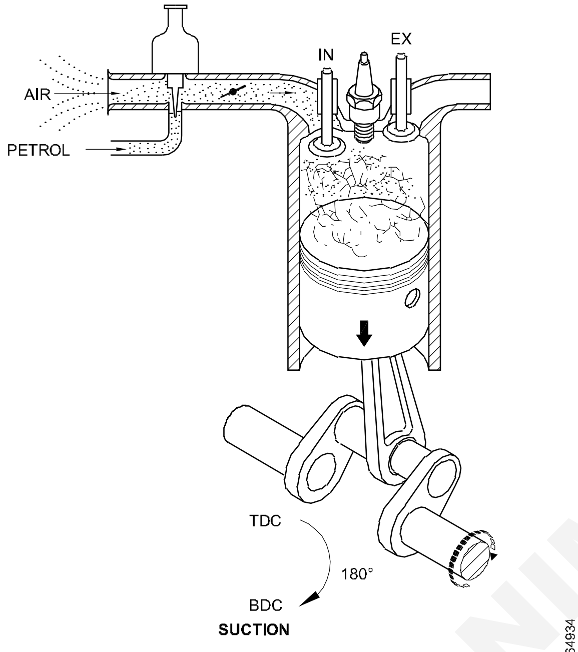
Four-stroke spark ignition engine

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

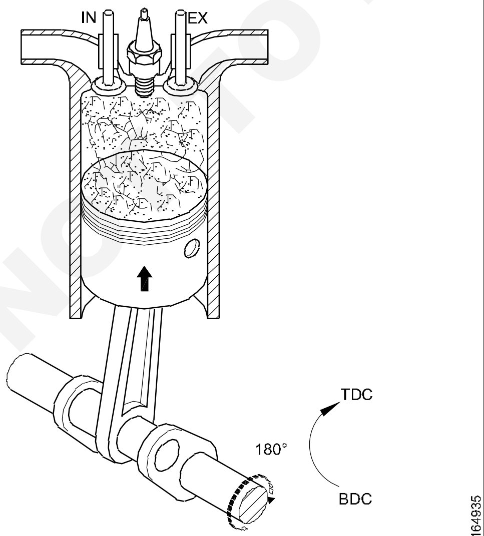


SUCTION STROKE

Compression stroke

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

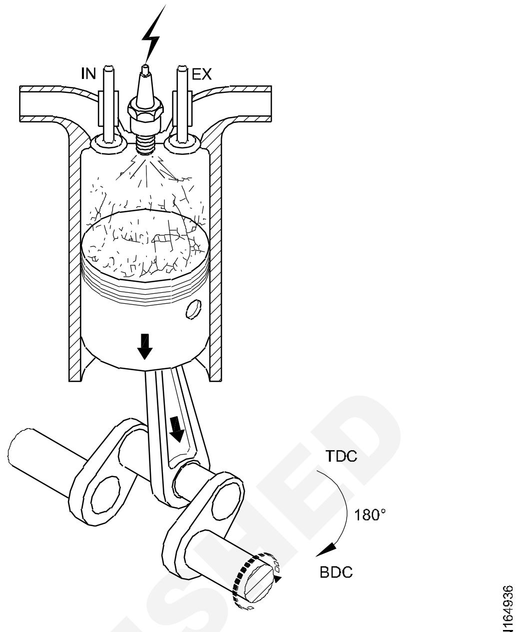
Fig 5



COMPRESSION STROKE

Power stroke

Fig 6



POWER STROKE

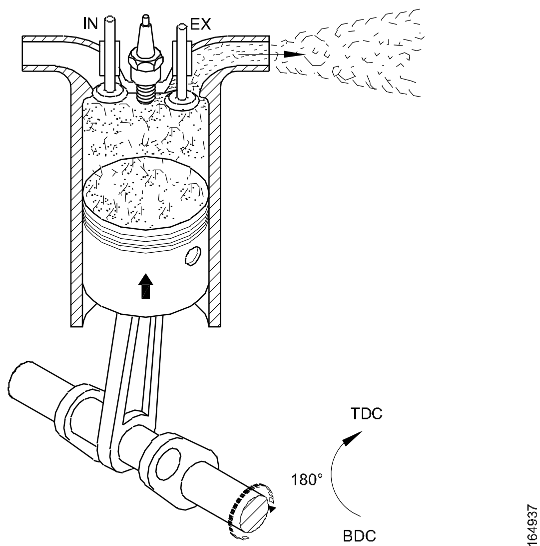
The compressed air fuel mixture is ignited and pressure develops inside the cylinder. The gas expands and the piston is forced down from TDC to BDC (Fig 6). Both the valves remain closed. Power is supplied to the flywheel.

Exhaust stroke

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

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

Fig 7



EXHAUST STROKE

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.
- Engine design is complicated and heavier flywheel is used	- Engine design is simple
- Engine require more space	- The engine has more uniform load as every time the piston comes down it is the power stroke. As such a lighter flywheel is used.
- The engine has more parts such as valves and its	- Engine require less space.
- More thermal efficiency.	- The engine has no valves and valve - operating mechanism
- The engine efficiency is more.	- The engine is less expensive
- Engine has heavy weight.	- The engine efficiency is less.
- Complicated lubricating system.	- Simple lubricating system

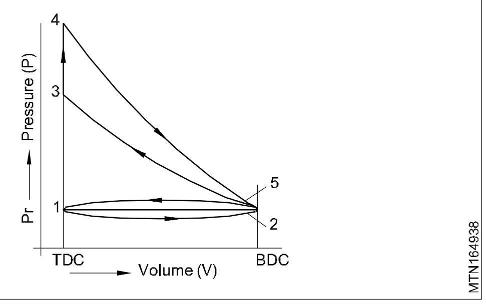
Comparison between S.I and C.I. Engine

SI engine	CI engine
Petrol is used as fuel.	Diesel is used as fuel.
During the suction stroke air fuel mixture is sucked in to 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 carburettor is used to atomize, vaporize and meter the correct amount of fuel according to the requirement.	Fuel injection pumps and atomizers are used to inject metered quantities of fuel at high pressure according to the requirement.
Less vibration, and hence, smooth running.	More vibration, and hence, rough running and more noisy.

Otto Cycle

1 - 2 - Suction

Fig 8



2 - 3 - Compression

3 - 4 - Heat addition

4 - 5 - Power

5 - 2 - 1 - Exhaust

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

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

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

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

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

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

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

Diesel Cycle

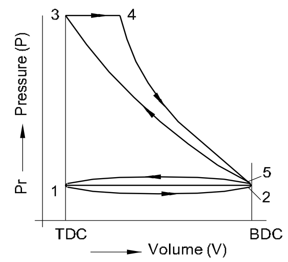
1 - 2 - Suction

2 - 3 - Compression

3 - 4 - Heat addition

4 - 5 - Power

Fig 9



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)

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

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

Main parts of internal combustion engine

Objective: At the end of this lesson you shall be able to
- **locate the engine parts**

Internal combustion engine parts

Internal combustion engine's function is associated with the different types of components and it is connected in outer JPG & inside of the engine.

Name of the components (Figs 1, 2 & 3)

1 Air compressor
2 F.I.P
3 Injector
4 Air cleaner
5 High pressure fuel
6 Fly wheel
7 Oil filter
8 Fuel filter
9 Fan belt
10 Alternator
11 Self starter
12 Water pump
13 Cam shaft
14 Inlet manifold
15 Exhaust manifold
16 Valve door (cover)
17 Rocker assembly
18 Push rod
19 Tappets
20 Cylinder head
21 Piston
22 Timing chain / Belt
23 Oil sump
24 Strainer
25 Fly wheel housing
26 Dip stick
27 Connecting rod
28 Crank shaft
29 Timing gear
30 Turbo charger
31 Oil pump
32 Oil pipes
33 Strainer

Petrol Engine

- Carburettor
- Distributor
- Super charger
- Spark plug
- Ignition coil

Fig 1

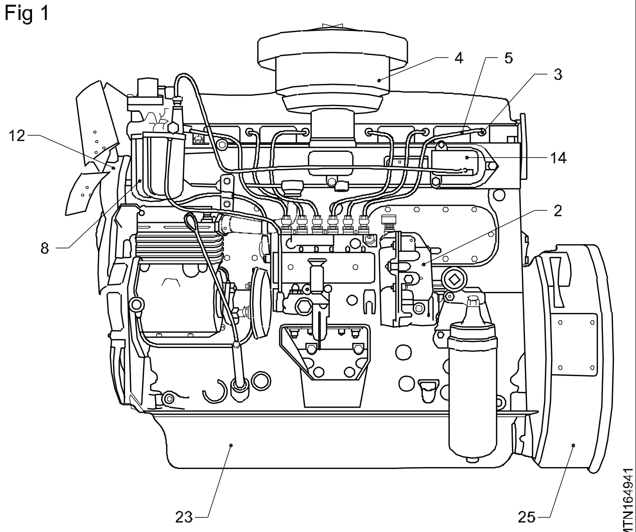


Fig 2

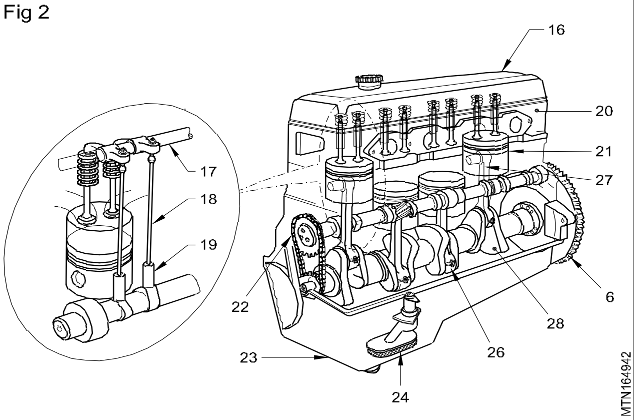
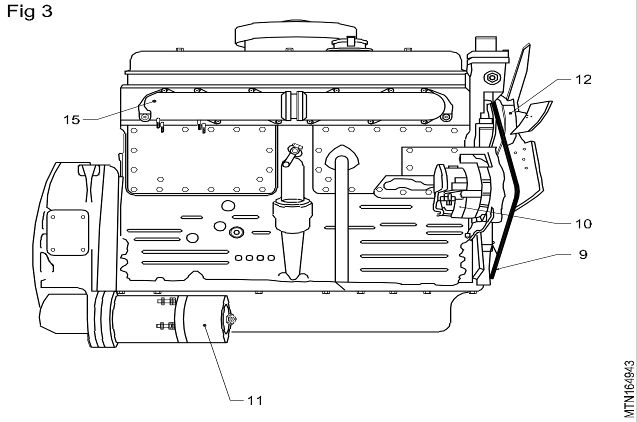


Fig 3



Direct and indirect fuel injection system

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

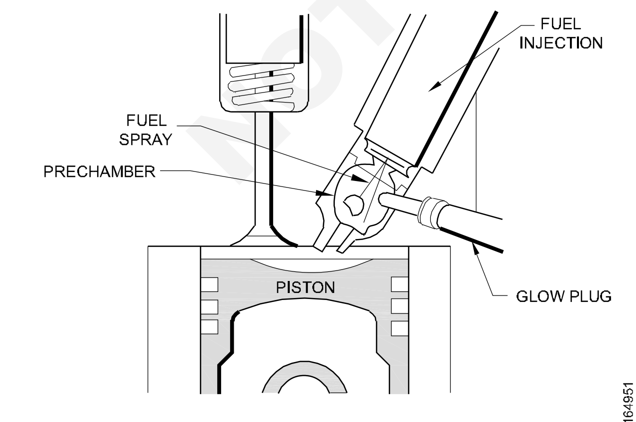
Direct Fuel Injection Works (Fig 1)

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

Advantages of Direct Fuel Injection

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

Fig 1



DIRECT INJECTION

Disadvantages of Direct Fuel Injection

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

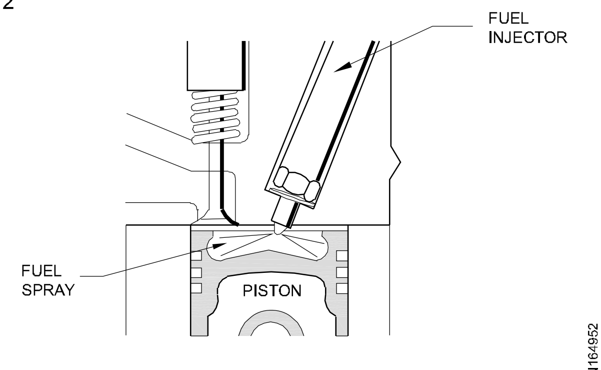
Indirect injection (Fig 2)

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

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

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

Fig 2



INDIRECT INJECTION

Classification of indirect combustion chambers

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

Overview

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

Advantages of indirect injection combustion chambers

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

Disadvantages

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

Basic technical terms used in relation to engines

T.D.C. (Top dead centre)

It is the postion of the piston at the top of a cylinder, where the piston changes its direction of motion from the top to the bottom.

B.D.C. (Bottom dead centre)

It is the position of the piston at the bottom of the cylinder where the piston changes its direction of motion from the bottom to the top.

Stroke

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

Cycle

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

Swept volume (VS)

Displacement volume of a piston.

Clearance volume (VC)

Volume of the space above the piston when it is at TDC.

Compression ratio (CR)

Ratio of compression volumes before the stroke and after.

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

where VS = Swept volume

VC = Clearance volume

VS+VC = Total volume at BDC.

Power

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

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

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.

Common Rail Direct Injection (CRDI)

The common rail direct diesel injection system delivers a more controlled quantity of atomized fuel, which leads to better fuel economy reduction, of exhaust emissions and engine noise.

The Common rail diesel fuel injection system consists of four main functions.

1 Low pressure delivery.
2 High pressure delivery with high pressure pump and accumulator
3 Electronically controlled injectors
4 Electronic control unit associated with sensors and switches.

Compression ration

It is the ratio of the volume of the charge in the cylinder above the piston at bottom dead centre and the volume of the charge when the piston is at top dead centre. Since the volume above the piston at bottom dead centre is the displacement of the cylinder plus the clearance volume; and the volume above the piston at top dead centre is the clearance volume, the compression ratio can be stated as:

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

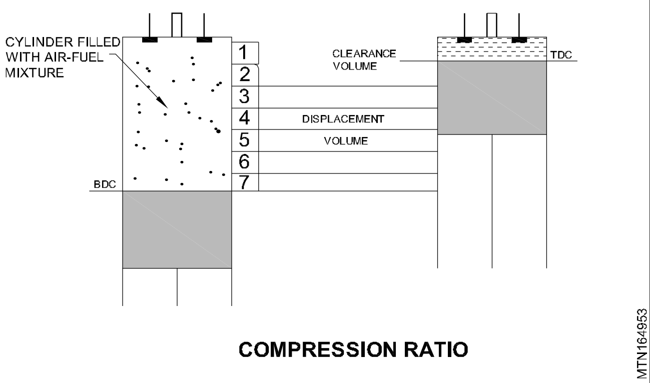
For example, if clearance volume is $90cm^3$ and displacement volume is 540 cm^3, the compression ratio will be,

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

The compression ratio 7:1 is illustrated in Fig.3. Early automobile engines had low compression ratios 3:1 to 4:1. They are known as low compression engines. The fuel available at that time could not be subjected to greater pressure without detonation. The modern gasoline engines have compression ratios 7:1 to 10:1. Diesel engines have much higher compression ratios from 11.1 to 24.1. The compression ratio of an engine will be increased by any condition that will decrease the size of the clearance volume such the accumulation of carbon deposits. High compression ratio results in decreased operating efficiency and grater power output for a given engine.

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

Fig 3



COMPRESSION RATIO

Description and constructional feature of cylinder head

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of the cylinder head**
- **state the importance of cylinder head design.**

Cylinder head (Fig 1)

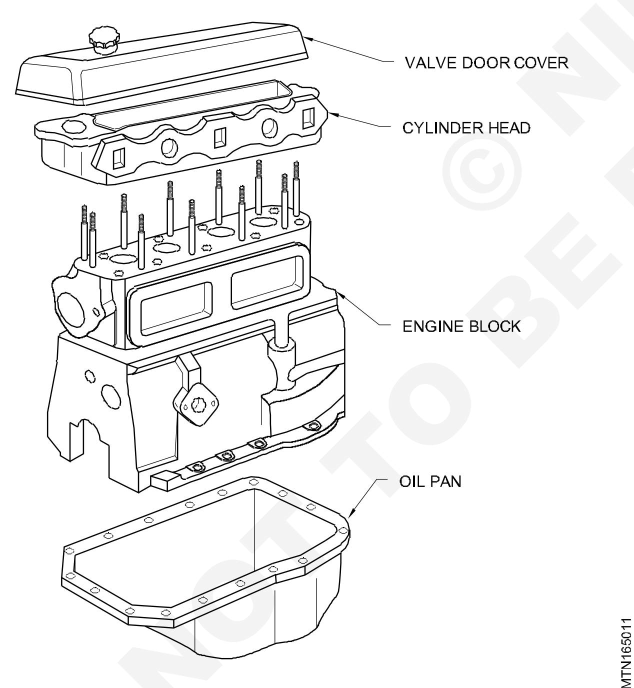
The cylinder head is made of a single casting. It is bolted on the top of the cylinder block. It has passages for oil and water circulation. It accommodates valves, spark plugs/ injectors (in the case of diesel engines) and heater plug. A combustion chamber is also provided in some cylinder heads. In the case of the overhead valve system, the cylinder head supports the rocker shaft assembly.

The lower surface of the cylinder head is machined to the specified accuracy and a gasket is used in between the cylinder head and cylinder block to avoid leakage.

The head also provided spaces for the passages that feed air, water fuel to the cylinder and that allow the exhaust to escape.

Material: Cast iron, aluminium alloy.

Fig 1



Types of cylinder heads

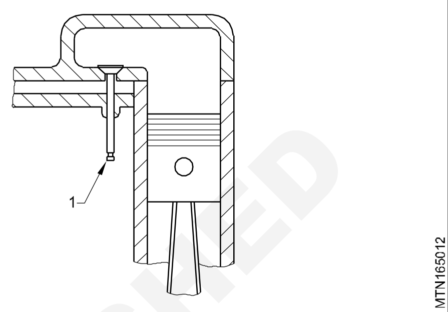
Four types of cylinder heads are used in an automobile engine as per the valve arrangements.

They are as follows.

- 'L' head (Fig.2)
- 'I" head (Fig.3)
- 'F' head (Fig.4)
- 'T' head (Fig.5)

'L' head

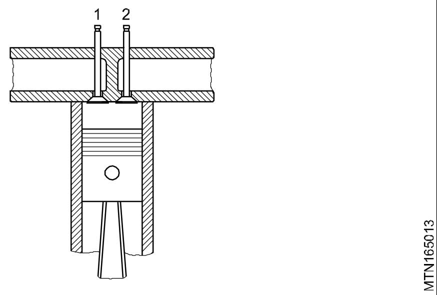
Fig 2



In the 'L' head, the inlet and exhaust valves (1) are located on one side of the cylinder block and the valves are operated by a single camshaft through the tappet directly. (Eg. Dodge)

'I' head

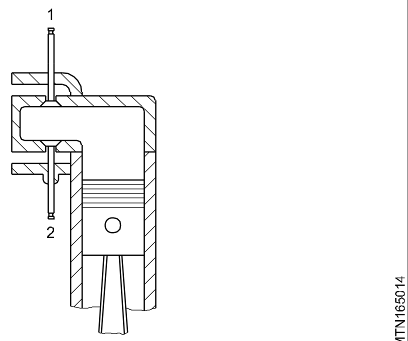
Fig 3



In the 'I' head the inlet (1) and exhaust valves (2) are located on one side of the cylinder head. The valves are operated by a single camshaft through the tappet, push-rod and rocker arm mechanism. (Eg. Ambassador, Ashok Leyland).

'F' head

Fig 4

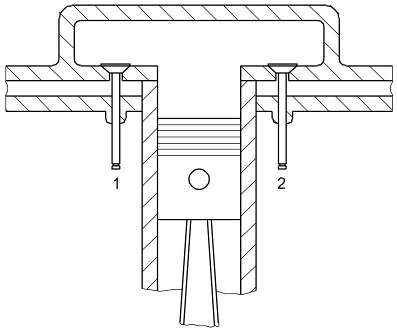


In the 'F' head, the inlet valves (1) are located on one side of the cylinder head and the exhaust valves (2) are located on the other side of the cylinder block. The valves are operated by a single camshaft.

The inlet valves are operated by the tappet, push-road and rocker arm mechanism. The exhaust valves are operated by the tappet directly. (Eg.Mahindra & Mahindra jeep)

'T' head

Fig 5



In the 'T' head, inlet valves (1) are located on one side of the cylinder block and the exhaust valves (2) are located on the other side of the cylinder block. Two camshafts are used to operate the valves, one for inlet and the other for exhaust. The valves are operated by the tappet directly. (Eg. Ford)

In thick fuel is injected into the combustion chamber against heigh compression pressure in the combustion chamber of the C.I. engine cylinder. The combustion depends upon the following factor.

- Fine atomization
- High temperature for quick ignition
- High relative velocity between air and fuel particles
- Good mixing of air and fuel particles.

Atomization, penetration and spreading of fuel depends on injection system, cylinder bore and stroke, compression ratio and cooling system is determine operating temperature. Fuel mixing depends upon air intake system, injection pattern and combustion chamber design.

The design of combustion chamber plays an important part in the combustion process. In diesel engines, the following types of combustion chambers have been used.

a Open combustion chambers (Fig 6)

b Turbulence chambers (Fig 7)

c Precombustion chamber (Fig 8)

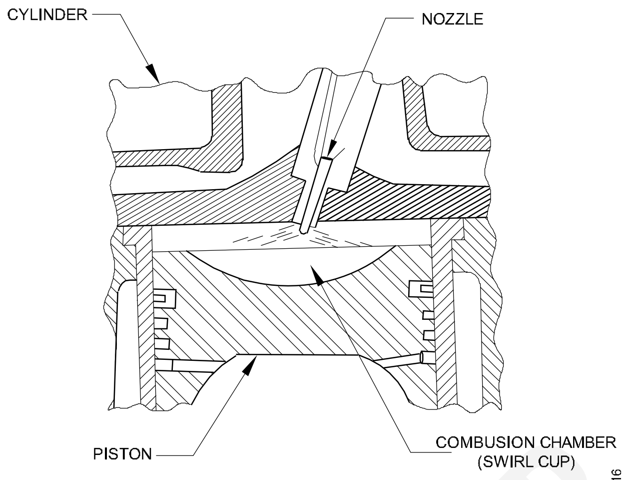
d Air cells (Fig 9)

e Energy cells (Fig 10)

a **Open combustion chambers (Fig.6):** An open type of chamber is that in which all the air is contained in a single space at the time of injection. It is the simplest form of combustion chamber in which the injection nozzle sprays fuel direct into the combustion chamber. This arrangement is known as open system or direct injection system.

In this type of chamber, the fuel motion is greater than air upon which the nature of combustion largely depends. In order to bring fuel and air together, the flat head piston has been replaced by concave head piston in modern engines.

Fig 6



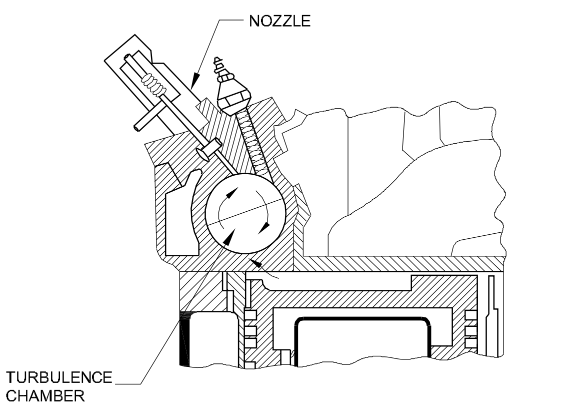
OPEN COMBUSTION CHAMBER WITH SWIRL CUP

The deep cut-out swirl cup on the piston crown is being widely used.

Open system combustion chambers are widely used in medium and large-bore engines operating at low and medium speeds.

b **Turbulence chambers (Fig.7):** In this type of chamber, the fuel is injected into an auxiliary chamber known as turbulence chamber with the cylinder by an orifice. The auxiliary chamber houses almost full charge at the end of compression and is nearly spherical in shape. The piston forces air charge into the turbulence chamber and sets up a rapid rotary motion. As the piston rises up, the velocity of air increases through the throat of orifice and reaches at the peak some waht before T.D.C. Near T.D.C. the injector nozzle injects fuel into the turbulent air currents which results in good mixing during combustion.

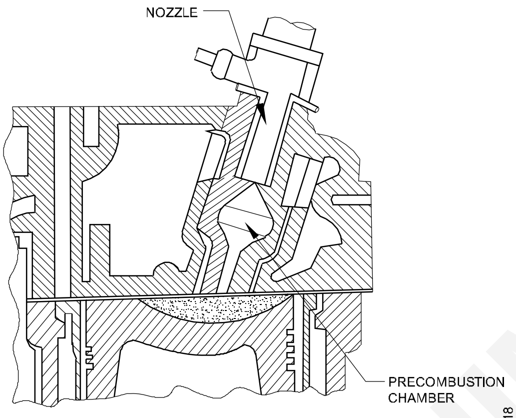
Fig 7



TURBULENCE CHAMBER OF WAUKESHA DESIGN

C Precombustion chamber (Fig.8): This chamber is located at the cylinder head and is connected to the engine cylinder by small holes. It occupies 40% of the total cylinder volume. During the compression stroke, air from the main cylinder enters the precombustion chamber. At this moment, fuel is injected into the precombustion chamber and combustion begins. Pressure increases and the fuel droplets are forced through the small holes into the main cylinder, resulting in a very good mix of the fuel and air. The bulk of the combustion actually takes place in the main cylinder. This type of combustion chamber has multi-fuel capability because the temperature of the prechamber vaporizes the fuel before the main combustion event occurs.

Fig 8



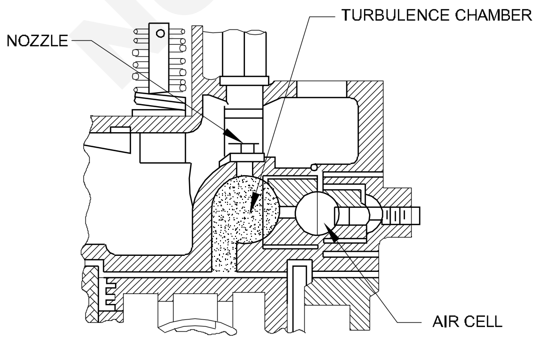
PRECOMBUSTION CHAMBER

MTN165018

d Air cells (Fig.9): Combustion chamber an air cell is a space provided in the cylinder head or piston crown in which a large part of air is trapped during compression. In air cell systems, the injector nozzle sprays fuel direct into the main chamber where combustion takes place.

When the piston moves down on its working or power stroke, air pressure is at its maximum in the cell and pressure in the main combustion chamber starts to fall down. The higher pressure in the air cell causes its air to expand and blow out into the main chamber. Thus an additional turbulence is created and complete combustion of fuel charge is ensured.

Fig 9



AIR CELL

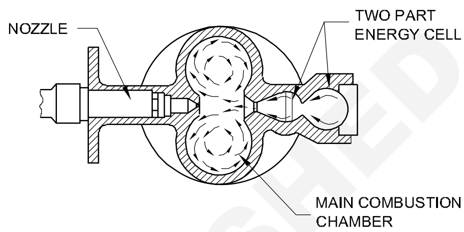
MTN165019

As a portion of air remains trapped without combustion in the cell so in improved designs, air cell is used in combination with turbulence or precombustion chamber to obtain better performance.

e Energy cells (Fig.10): The difference between air cell and energy cell is that fuel is blown into the energy cell where it burns using air in the cell. In air cell system, the cell simply stores and given up an air charge. The combustion in the energy cell creates a high pressure and grater turbulence and leaves no idle air in the cell.

The energy cell system consists of two rounded spaces cast in the cylinder head. The intake and exhaust valves

Fig 10



ENERGY CELL

MVN16431A

open into the main combustion chamber. The horizontal the nozzle sprays fuel across the main chamber in the direction of energy cell mouth. While the fuel charge is passing across the centre of main chamber, nearabout half the fuel mixes with hot air and burns at once. The remaining fuel enters the energy cell and starts to burn there. At this point, the cell pressure rises rapidly, tending the combustion products to flow back into the main combustion chamber at a high velocity. As a result of this, a sharp swirling movement of fuel and air is set up in each lobe of main chamber, promoting final mixing of fuel and air and ensuring complete combustion. The two restricted openings of energy cell control the time and rate of expulsion of blast from energy cell into main combustion chamber.

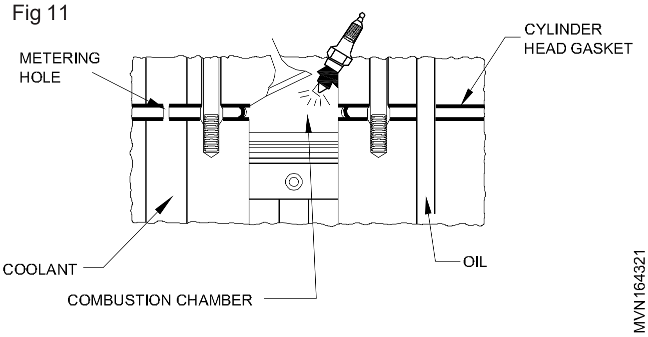
The energy-cell combustion systems fulfil the requirements of high speed engines and give high power output without high excessive pressures in the main combustion chamber.

air pressure are reacted to the behind /Rear portion the inlet valve face & larger face can withstand this pressure without any damage. For that reason the inlet valve face is designed to larger size than exhaust valve.

The main reason for the size difference is to avoid preignition and knocking.

Cylinder head gaskets: It Form the most critical seal on an engine - between the cylinder head and the engine block deck. (Fig.11)

Fig 11



The head gasket must seal the combustion, pressures up to 1,000 psi (689.5 kPa) in gasoline engines and 2,700 psi (1,862 kPa) in turbocharged diesel engines. In addition, the head gasket must withstand combustion temperatures that are in excess of 2,000°F (1,100°C).

The head gasket also must seal coolant and hot, thin oil flowing under pressure between the block and head. Modern coolant formulas and oil detergents and additives tend to cling to surfaces and soak into gaskets. Gaskets materials must be chosen carefully to resist these fluids and maintain an effective seal. many head gasket coolant holes also meter the coolant flow to ensure proper circulation.

Head gaskets must resist the forces that tend to scuff gasket surfaces and inhibit proper sealing. One factor is engine vibration and head shifting and flexing that result from combustion pressures.

Another factor is the differing expansion rates of bi-metal (aluminum head and cast iron block) engines. Aluminum expands about twice as much as cast iron . The uneven expansion rates create a shearing action that the head gasket must accommodate.

Head gaskets also must resist crushing from cylinder claiming forces that may be unevenly distributed across the head. These claiming forces run as high 200,000 lbs (90,800 kg).

The following materials are used in cylinder head gasket

1 Copper - as-bestos gasket

2 Steel - as-bestos - copper gasket

3 Steel - as-bestos gasket

4 Single steel ridged gasket

Importance of turbulence

Turbulent flow in an engine plays an important role in determining the combustion efficiency. It improves the thermal efficiency of engine, reduce the knocking, reduces NOX emission, oxidized carbon, hydrogen and other combustible elements. Turbulence ensure a thorough mixing of the air and fuel which ensures that fuel is quickly burnt and releasing the complete energy.

Valves

Objectives: At the end of this lesson you shall be able to
- **describe the function of the valve**
- **state the constructional features of valves**
- **list out the different types of valves and their material.**

Functions of valves

- To open and close the inlet and exhaust passages of the cylinder.
- To dissipate heat, through its seat to the cylinder head.

Construction of a valve

The head (1) of the valve is ground with a margin (2) to provide strength. (Fig 1)

The valve face (3) is ground to 30° or 45° angle which matches with the seat angle to avoid leakage. The valve stem (4) is of a round shape. The length of the stem varies from engine to engine. At the end of the stem a groove (5) is provided to hold the spring lock.

In some heavy duty engines, the valves are hollow, and sodium is filled inside, which helps in the quick cooling of the valve.

Types of valves

- Poppet-valves (Fig.1)
- Rotary valves (Fig.2)
- Sleeve valves (Fig.3)
- Reed valves (Fig.4)

Poppet-valves

As the name indicates these valves pop on their seat. Three types of poppet-valves are in use.

- Standard valve
- Tulip valve
- Flat top valve

Rotary valve (Fig.2)

In this type a hollow shaft runs in the housing which is attached to the cylinder head. This hollow shaft has two ports cut in it, and it aligns the opening in the cylinder head with the inlet manifold, and at the time of the exhaust stroke its opening aligns with the exhaust manifold. (Fig 2 & 3)

Fig 1

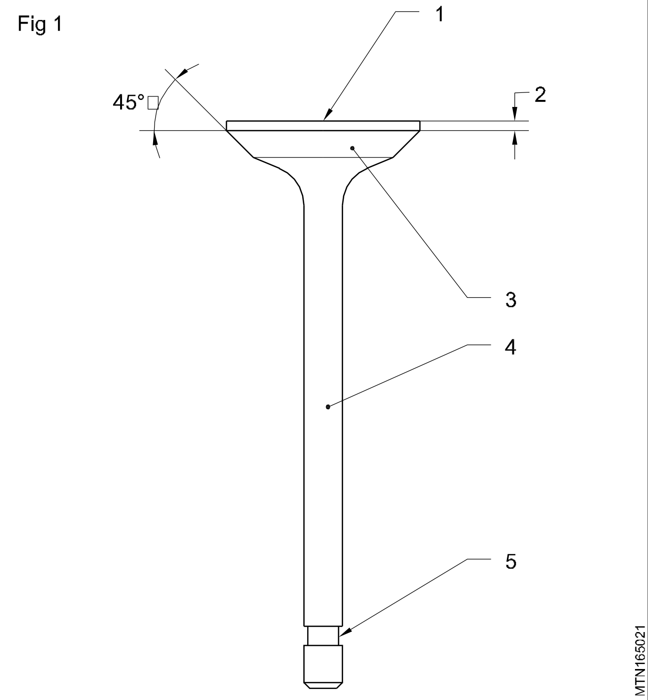
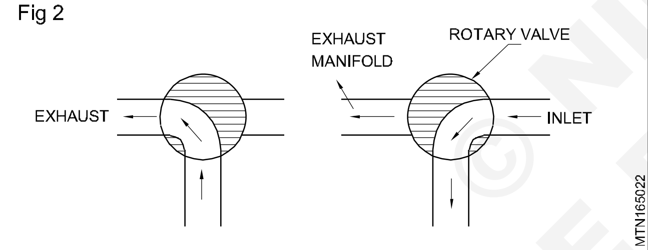


Fig 2



Sleeve valve (Fig.3)

In this type, ports are cut in the cylinder liner. It runs with a slight up and down motion. It is also having rotary motion in another sleeve. This aligns with the inlet and exhaust ports at a set time when the inlet and exhaust manifold open.

Reed valve (Fig.4)

It is a metallic strip hinged at one end. It covers the passages and allows air or charge to flow in one direction only. It is normally used in two-stroke engines and air compressors.

Fig 3

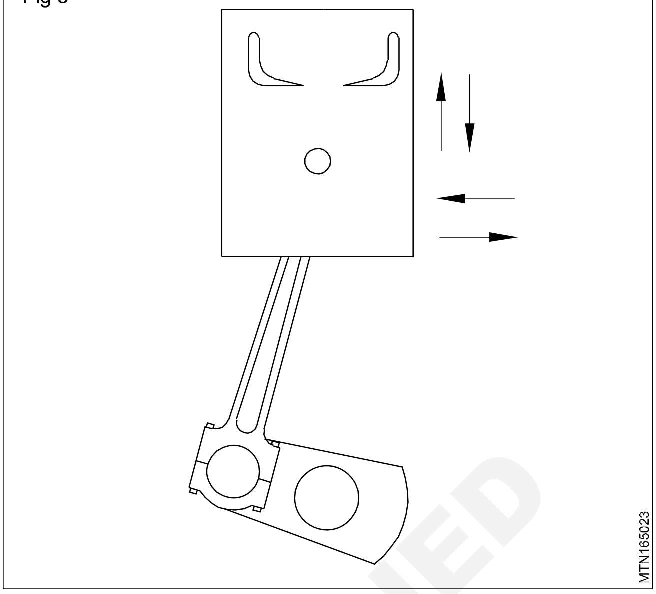
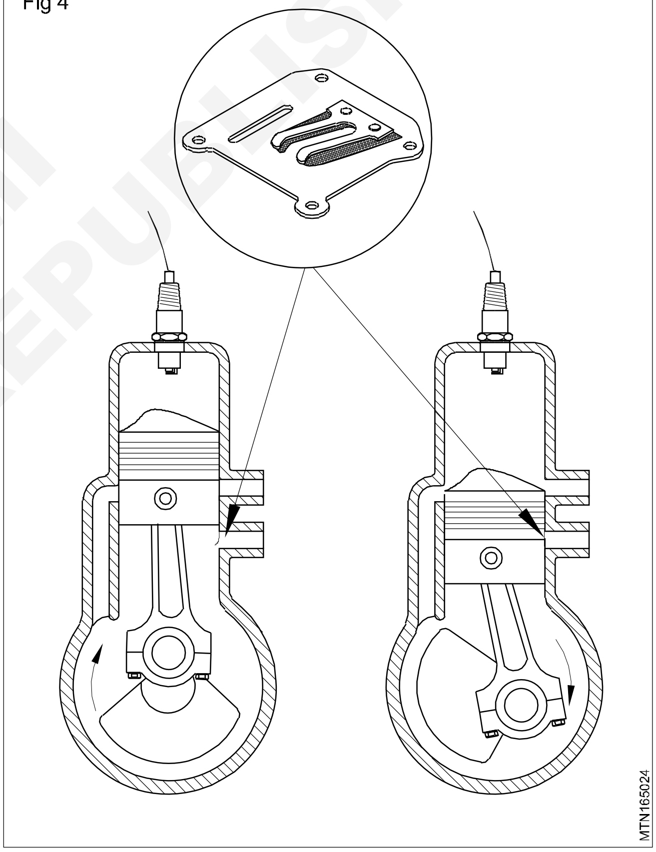


Fig 4



Valve Materials

Inlet valve - Nickel steel alloy stellite facing

Exhaust valve - Silicon - chrome alloy steel sodium filled valves

Valve operating mechanism

Objectives: At the end of this lesson you shall be able to
- **state the requirements of valve operation**
- **state the types of valve operating mechanism**
- **list out the parts of the valve mechanism**
- **state the importance of valve seats**
- **method of valve seats inserts in cylinder heads.**

Requirements for valve operation

1 Valve must seat tightly and properly on its seat.
2 Valve must be properly timed.
3 Valve must be operate without log.
4 Valve tappet clearance must be correct.
5 Valve steam and guide clearance must be correct.

Valve operating mechanisms

Two types of value operating mechanisms are used in engines. They are as follows.

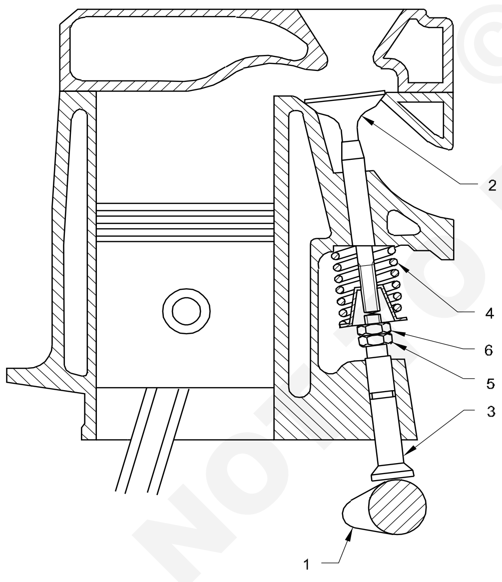
- Slide valve mechanism
- Overhead valve mechanism

In overhead valve mechanism, the position of camshaft is considered as the types of valve mechanism i.e.,

1 Single overhead camshaft mechanism
2 Double overhead camshaft mechanism

Side valve mechanism (Fig.1): In the side value mechanism both the inlet and exhaust valves are fitted in the cylinder block.

Fig 1

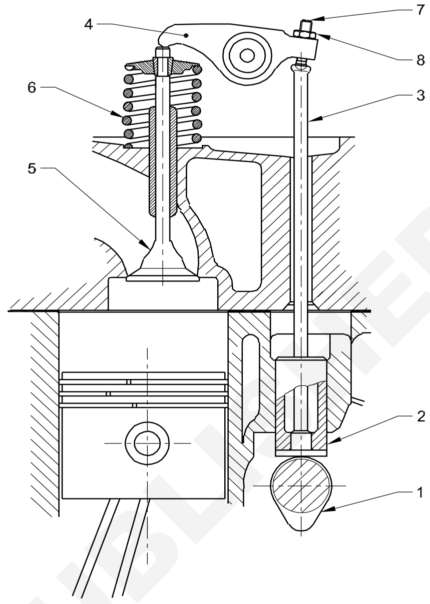


Overhead valve mechanism (Fig 2): In this mechanism, the valves are located in the cylinder head. Push-rods and rocker arms are used in addition to the side valve mechanism.

Working

When the cam shaft rotates, the cam lobe (1) lifts the tappet (2) upward. When the tappet (2) moves up, it pushes the push-rod (3) and one end of the rocker arm upwards. The other end of the rocker arm's (4) tip, moves downward and the valve (5) opens against the spring's (6) tension.

Fig 2



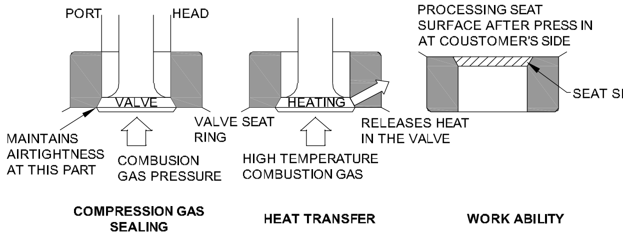
When the cam lobe (1) reaches the maximum height, the valve opens fully. Further rotation of the cam shaft causes the tappet (2) to move down and the valve is closed by the tension of the spring (6).

Tappet clearance is provided in between the valve (5) tip and the rocket arm's (4) tip. This clearance can be adjusted by the adjusting screw (7) and the lock-nut (8).

In many cases, even these rockers or followers (Fig 3) and their pivots are dispensed with and the valves are actuated directly by the camshaft through bucket type.

Importance of valve seats (Fig.3): Valve and valve seats are ground to correct and shape so that the valve may seat properly on the seat for effective valve seating and seating. The valve face angle must be match the valve seat angle. Value seating and sealing is closely realted to the engine performance.

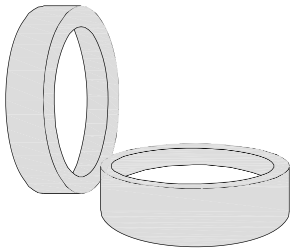
Fig 3



Function of valve seats (Fig 4)

1 Compression gas sealing prevents compressed gaseous bodies and combustion gas from leaking into the manifold.

Fig 4



2 Heat transfer releases heat in the valve to the cylinder head.

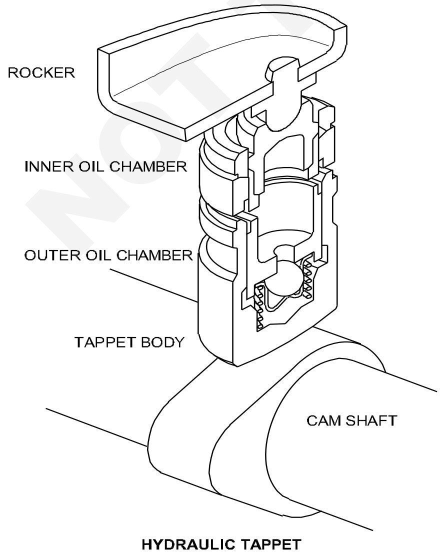
3 Strength holds tight when the valve is mounted.

4 Wear-resistance hard to wear down under high heat and high load.

Importance of valve seats inserts in cylinder head

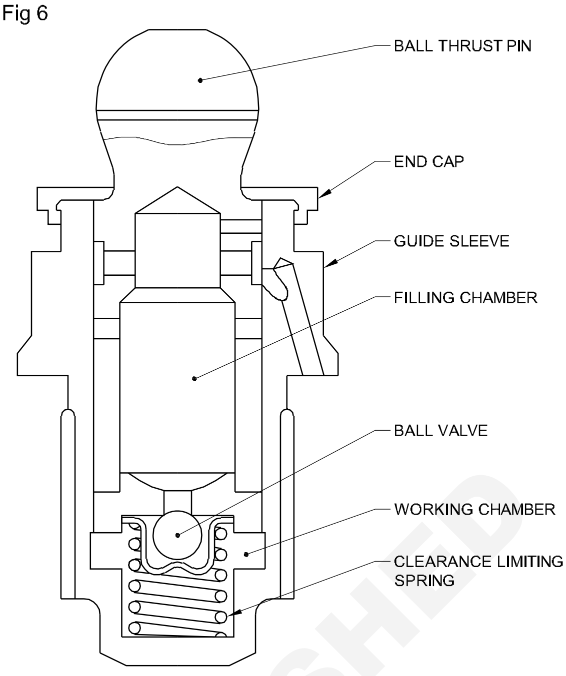
Hydraulic tappet: Hydraulic tappets (Fig 5) enable the valve gear to operate without fixed clearances. They consist of the tappet body, the tappet piston, a ball valve with spring and the clearance eliminating spring. When the engine is running, lubricating oil from the oil pump is forced through an oil way to the tappet. It flows through the outer chamber (to lubricate the tappet itself) and hence to the inner chamber (plunger lubrication) and to the interior of the piston. By way of a filling bore, the oil passes through the ball (check) valve to the pressure chamber. The clearance eliminating spring (Fig 6) forces the tappet piston to prevent any valve clearance from occurring. When the camlifts the tappet, the ball valve closes and the oil-filling the pressure chamber acts as an almost rigid link. Thermal expansion of valve gear components is compensated for by precisely calculated oil loss as a result of tappet piston operating clearance. Although hydraulic tappets are heavier and therefore suffer from increased inertia, this drawback can be compensated for an engines which operate the valves by followers from the overhead camshaft. On these engines, the hydraulic clearance adjuster an be installed in the follower mount instead of in the tappet; it is of similar design to the hydraualic tappet just described.

Fig 5



HYDRAULIC TAPPET

Fig 6



CLEARANCE ELIMINATING ELEMENT

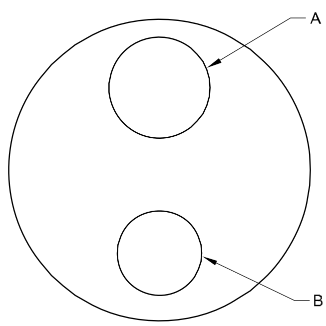
Types of valve arrangement

1 Two valve arrangement in one cylinder Fig.7

A One inlet valve

B One exhaust valve

Fig 7

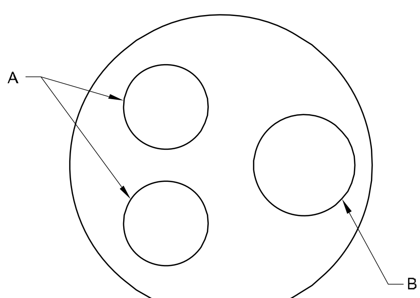


2 Three valve arrangement in one cylinder Fig 8

A Two inlet valves

B One exhaust valves

Fig 8



3 Four valve arrangement in one cylinder Fig 9

A Two inlet valves

B Two exhaust valves

Fig 9

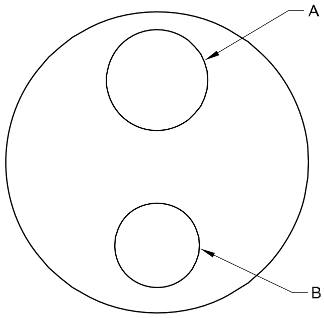
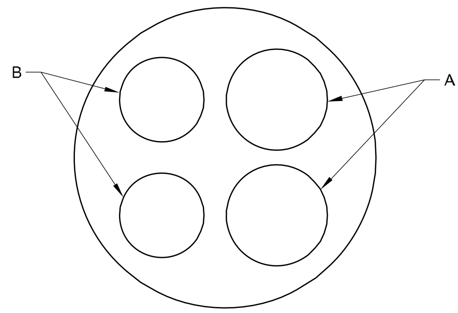


Fig 10



4 Five valve arrangement in one cylinder Fig 10

A Three inlet valves

B Two exhaust valves

Valve constructional features and valve timing

Objectives: At the end of this lesson you shall be able to
- **state the function of valve rotation**
- **state the function of valve stem oil seals**
- **state the size of intake valve**
- **describe the valve trains**
- **explain valve timing**
- **state the of variable valve timing.**

Valve rotation

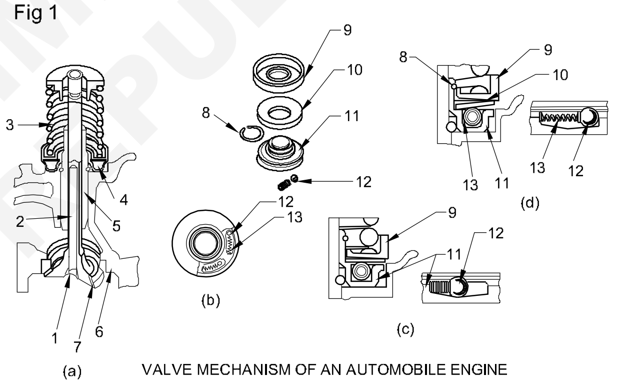
The main scope of the valve and tappet rotation is to reduce the wear, the friction and increase the life period of the components and maintain the conical valve face and seat clean of carbon deposit that might appear on surfaces during valve opening. To uniform the thermal stress of the valve head because of the asymmetry exhaust manifold and uniform the wear of the conical face providing a good sealing of the cylinder.

If the valve is rotating the contact point between valve head and seat will varying and in this way the wear marks or cranks can be avoided.Valve rotation is the uniformity of the oil film in the valve guide on the valve stem. Auxilary rotation system is rotate the valve during opening or closing period on those systems components are rotocap, turnomat, rotocoil, rotomat, duomate.

The tappet rotation reduce the wear caused by the contact with the cam, improves the lubrication of those two surfaces and increases the tappet life.

Valve rotation mechanism of an engine (Fig.1)

Fig 1



VALVE MECHANISM OF AN AUTOMOBILE ENGINE

(a) EXHAUST VALVE COMPELETE WITH VALVE ROTATOR:

(b) VALVE ROTATOR:

(c) VALVE ROTATOR POSITION WITH CLOSED VALVE:

(d) VALVE ROTATOR POSITION WITH OPEN VALVE:

1-STOPPER
2-HOLLOW VALVE STEM
3-VALVE SPRING
4-VALVE ROTATOR
5-VALVE GUIDE
6-INSERT VALVE SEAT
7-VALVE FACE
8-SNAP RING
9-SEATING COLLAR
10-FLEXIBLE WASHER (CONE SPRING)
11-VALVE ROTATOR HOUSING
12-STEEL BALL
13-RETURN SPRING

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Function of valve stem oil seal (Figs 2 & 3)

The purpose of the valve stem oil seal is to prevent the oil from the cylinder head entering the combustion chamber value stem seals play a critical role in controlling valve lubrication as well as oil consumption.

There are two basic valve stem seal designs

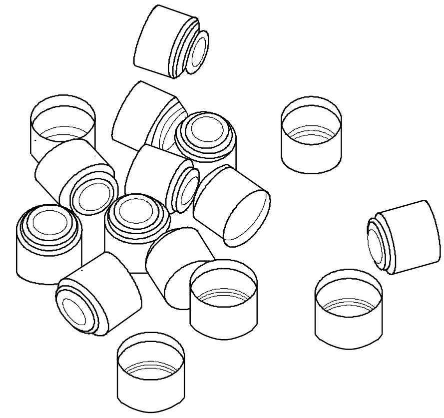
1 Deflector seals - also called umbrella seals, deflect oil away from the valve stem. They are secured to the valve stem and move with the valve to shield the valve guide from excess oil. Umbrella type seals were commonly used prior to the development of positive type seals.

2 Positive seals - attach to the valve guide boss and function as squeegees, wiping and metering oil on the stem as they pass through the seals. State the size of in take valve.

Exhaust valves are made to close certain degrees after T.D.C. to develop a suction effect by the outgoing gases. It also helps in the scavenging of the exhaust gases by using the intake charge's momentum.

Causes the engine suck oil down the guides and into the cylinder

Fig 2



VALVE STEM OIL SEAL

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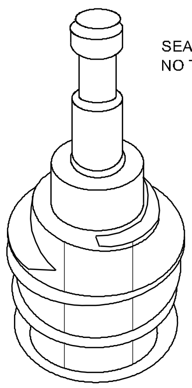
Fig 3

SEAL #3 DOES FIT INSIDE OF SPRING WHEN ON GUIDE

SEAL #4 FIT THE SAME BUT NO TEFLON



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- Seal worn
- Seal cracked
- Seal missing
- Seal broken
- Seal improperly installed

When stem oil seals lose their ability to control the oil that enters oil through the guide, that can cause a variety of problem.

- Excessive smoke
- High oil consumption
- Carbon deposited in valve and piston
- OFF - throttle braking
- Running engine OFF in idle speed.

Valve train: (Fig.4) The valve train of an internal combustion engine includes components required to control the flow of gases into and out of the combustion chamber valves and related component required to allow the air or air fuel mixture to enter the combustion chamber, the combustion chamber during compression and combustion and evacuate exhaust gases when combustion is compete. This type of valve train used for a reciprocating engine depends on the engine design and whether the engine is a four /two stroke cycle unit.

Fig 4

DEFLECTOR SEALS MOVE WITH VALVE STEM

POSITIVE SEALS ARE FIXED TO THE VALVE GUIDE BOSS

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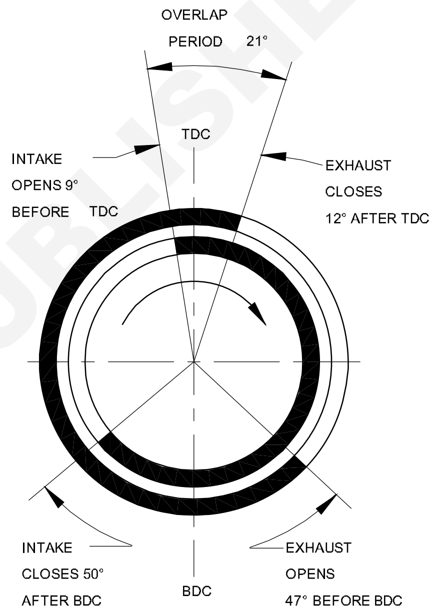
Valve timing

Each manufacturer specifies the timings of the opening and closing of the valves as per the design of the engine to give the maximum output under all loads and speeds.

The opening and closing of the valves in an IC engine in relation to the movement of the piston and flywheel is called valve timing. Fig 5

Fig 5



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The opening and closing of the valves exactly at TDC & BDC do not improve the volumetric efficiency of an engine. Burnt gases also are not driven out fully.

Practically, the valves are arranged to open early and close late to fill the cylinder fully and to allow all burnt gases to escape from the cylinder.

Inlet valve

Lead

Inlet valves are made to open certain degrees earlier than T.D.C. This enables air fuel mixture to fill the cylinder to its capacity. It also helps in scavenging burnt gases by using the momentum of intake air/air fuel mixture.

Lag

Inlet valves are made to close certain degrees after B.D.C. to increase the volumetric efficiency by allowing more charge.

Exhaust valve - Lead

Exhaust valves are made to open certain degrees earlier than B.D.C.

Lag - Exhaust valves are made to close certain degrees after T.D.C. to develop a suction effect by the outgoing gases. It also helps in the scavenging of the exhaust gases by using the intake charge's momentum.

Overlap period - At the end of the exhaust stroke and the beginning of the suction stroke, both the valves remain open for certain degrees. This period during which both the valves remain open is called the valve overlap.

Graphical representation of valve timing

The valve timing is represented by a diagram drawn on the face of the flywheel in degrees of the crankshaft rotation.

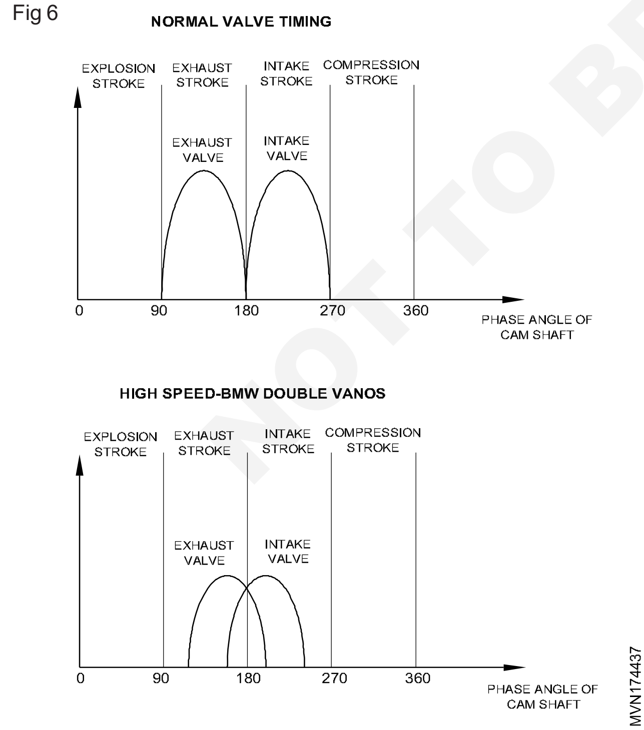
Valve timing (Jeep)

- Inlet valve open 9 degrees before T.D.C.
- Inlet valve closes 50 degrees after B.D.C.
- Exhaust valve opens 47 degrees before B.D.C.
- Exhaust valve closes 12 degrees after T.D.C.
- Over lap period 21 degrees

Valve timing varies from one make of engine to another valves are exposed to various chemical, mechanical and thermal stresses during operation. They must maintain their basic shape and dimensions throughout the expected life of the engine. In addition. the integrity of the sealing surface of the valve and mating valve seat is critical to durability and performance. Engineers determine the valve material, shape, specifications, and surface coatings to match the specifications engine family, expected operating environment, and projected length of service. Valves commonly used in small engines are classified as one-piece, projection-tip welded, or two-piece-stem welded-stem valves.

Variable Valve Timing (VVT) (Fig.6)

Fig 6



Variable-valve (VVT) technology, became standard in engine design, variable valve timing becomes the next step to enhance engine output.

The valves activate the breathing of engine. The timing of breathing, that is, the timing of air intake and exhaust, is controlled by the shape and phase angle of cams. To optimse the breathing, engine requires different valve timing at different speed. When the valve increases, the duration of in take and exhaust stroke decreases so that fresh air becomes not fast enough to enter the combustion chamber, while the exhaust becomes not fast enough to leave the combustion chamber. Therefore, the best solution is to open the inlet valves earlier and close the exhaust valves later. In other words, the overlapping between intake period and exhaust period should be increased as revolution increases.

With variable valve timing, power and torque can be optimised across a wide rpm band. The most noticeable results are:

- The engine rpm higher, thus raises peak power. For example, Nissan's 2-litre neo VVI engine output 25% more peak power than its non-VVT version
- Low -speed torque increases, thus improves drivability. For example, Flat barchetta's 1.8 VVT engine provides 90% peak torque between 2,000 and 6,000 rpm.

Moreover, all these benefits come without any drawback.

Variable lift

In some designs, valve lift can also be varied according to engine speed. At high speed higher lift quickness air intake and exhaust, thus further optimise the breathing. Of course, at lower speed such lift will generate counter effects like deteriorating the mixing process of fuel and air, thus decease output even leads to misfire. Therefore the lift should be variable according to engine speed.

Cam-changing VVT

Many automobile engine's are used VVT in the late 80s by launching its famous VTEC system (Valve timing electronic control).

It has 2 sets of cams having different shapes to enable different timing and lift. One set operates during normal speed, say, below 4,500 rpm. Another substitutes at higher speed.

However, cam-changing system remains to be the most powerful VVT, since no other system can vary the Lift of valve as it does.

Ex.Honda's 3-stage VTEC

Cam-phasing VVT

Cam-phasing VVT is commonly used mechanism and it varies the valve timing by shifting the phase angle of camshafts. For example, at high speed, the inlet camshaft will be rotated in advance by 30° so to enable earlier intake. This movement is controlled by engine management system according to need, and actuated by hydraulic valve gear.

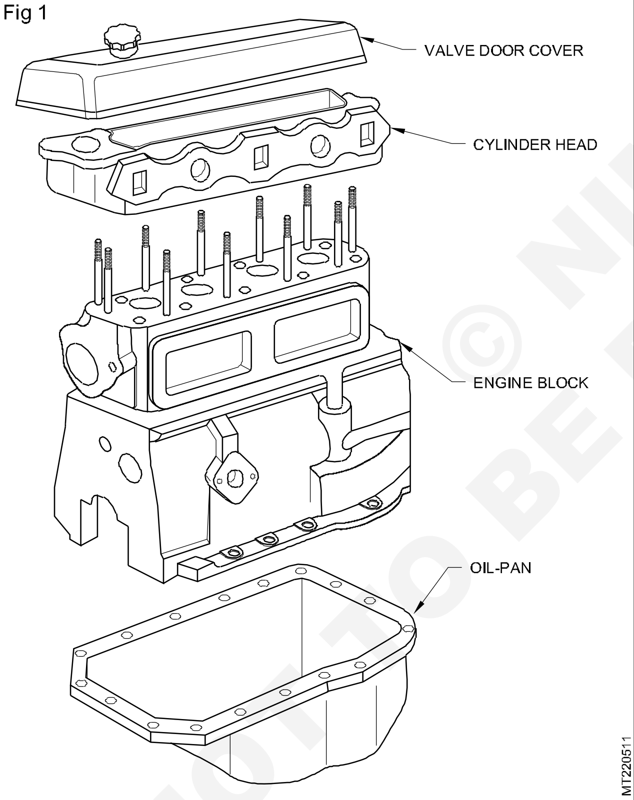
Cylinder block, cylinder liner

Objectives: At the end of this lesson you shall be able to
- **describe the function of the engine block**
- **state the constructional features of the engine block/clinder block**
- **state the function of the cylinder liner**
- **list out the various types of cylinder liners**
- **list the material of cylinder liners**
- **state the function of flywheel.**

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

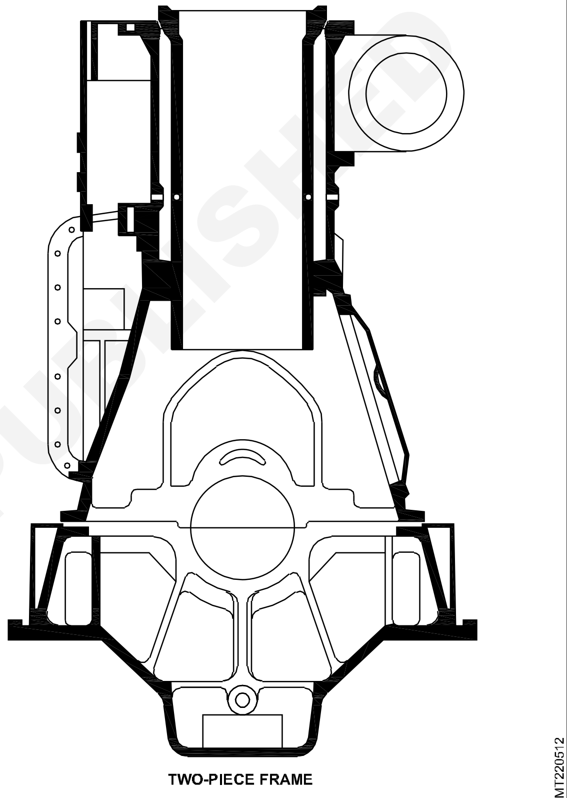
Single piece casting: In this the type cylinder block and crankcase are cast as one piece. It gives better rigidity and it is easy to cast, which reduces the cost of manufacturing. (Fig 1)

Fig 1



Two-piece casting (Fig 2)**:** In this type the cylinder block and crankcase are cast separately. The crankcase is bolted to the cylinder block. It reduces the problem of lifting the cylinder block from crankcase, during repairing or overhauling. This type of casting is used in heavy generating sets.

Fig 2

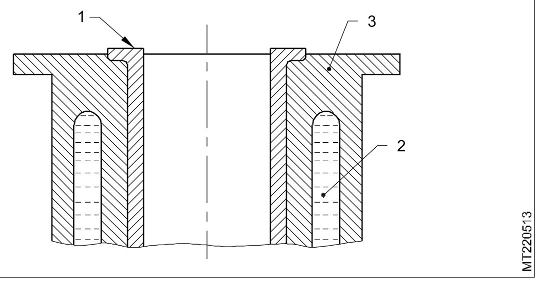


The cylinder block is made of cast iron or aluminium alloy. Inside the cylinder block, water jacket passages for the coolant and lubricating oil are provided. The cylinder head along with the valve assembly is fitted on the top of the cylinder block by nuts and bolts. The oil sump is bolted to the cylinder block /crankcase from the bottom. The crankshaft is supported on split type bearings. The half bearing is fixed on the web which is cast with the cylinder block, the other half bearing is fixed in the bearing cap. The bearing cap is fastened with the web by nuts and studs. This portion where the crankshaft is fixed is known as the crankcase. In the cylinder block passages are provided for the camshaft and camshaft bearing, push rods, tappets etc.

Liners: A liner is a thin cast iron circular shell which is centrifugally cast. It contains chromium for hardness. It protects the cylinder block from rapid wear and damage due to combustion. The life of the cylinder block is increased by using a liner, since the block does not bear combustion pressure and temperature directly.

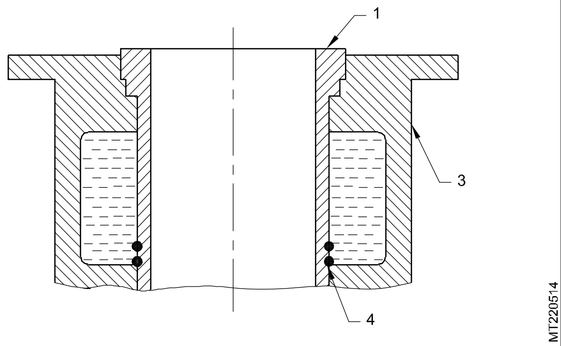
Dry type (Fig 3)**:** In the dry type liner (1) the cooling water (2) of the engine does not come in direct contact with the liner. (Fig.4) These liners have an interference fit with a cylinder block(3). In the dry type liner a special process is required to insert them into the bores, and to remove them from the bore.

Fig 3



Wet type (Fig 4)**:** In the wet type liner, the cooling water of the engine is direct contact with outer walls of the lines. Special rubber rings are provided to prevent water leaks into the oil sump/crank case.

Fig 4



Material

Material used for lines are nitrided steel, nitrided cast iron chromium coated alloy steel. Lines are harder than the blocks.

Piston and piston rings

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

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

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

Requirements of a piston

A piston should be:

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

Construction of a piston

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

The crown or head

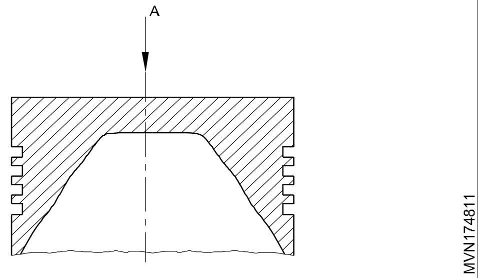
It is the top most portion of the piston. It is subjected to high pressure and temperature due to the combustion of the fuel.

Four types of heads are used.

Flat head

It is simple in shape and is most commonly used. It is simple in construction. Decarbonising of this is very easy. (Fig 1)

Fig 1



Domed head

It has a projection shaped like a dome on the crown. (Fig 2 & Fig 3) The dome acts as a deflector and helps to make a homogeneous mixture of air and fuel.

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

Fig 2

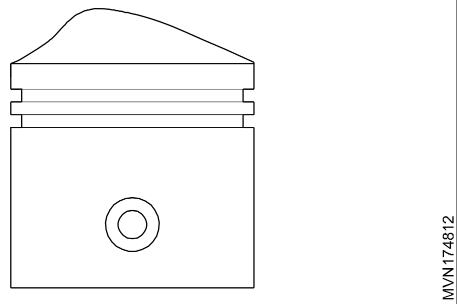
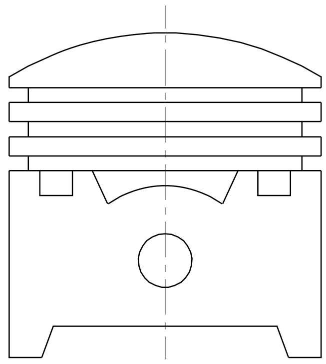


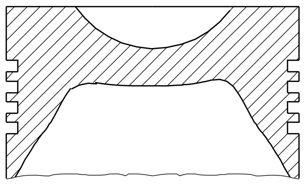
Fig 3



Concave head

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

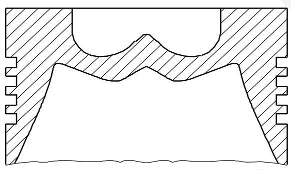
Fig 4



Irregular head (cavity piston)

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

Fig 5



Skirt

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

Ring section

It is the portion between the top of the piston and the last ring groove. It has more clearance with the cylinder than with the skirt. There are two types of piston ring grooves. (Fig 6)

- Compression ring groove

These grooves accommodate compression rings.

- Oil ring groove

These grooves accommodate the oil scraper rings.

Land

This is the piston's circumference left above the top ring groove and between the ring grooves. (Fig 7)

Fig 6

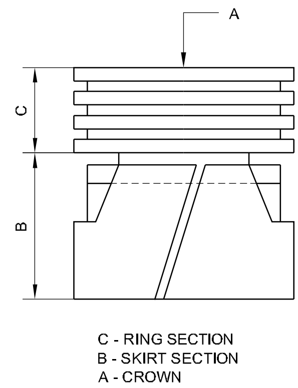
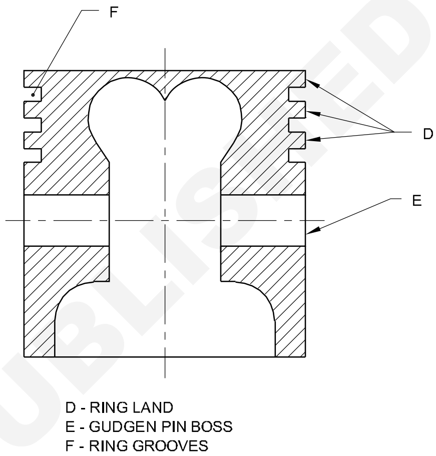


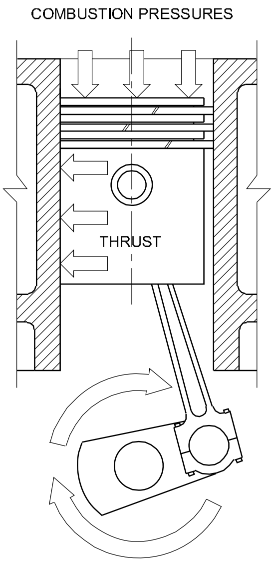
Fig 7



Gudgeon pin boss

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

Fig 8

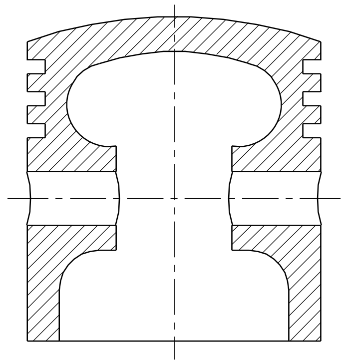


Designs/Types of pistons

Solid skirt piston

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

Fig 9

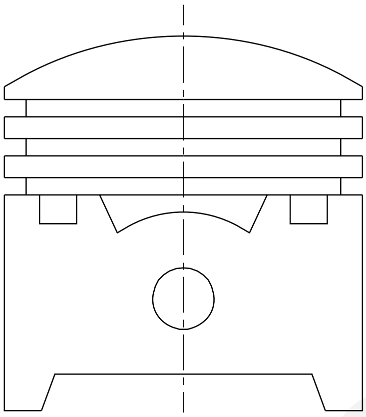


MVN174819

Slipper pistons

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

Fig 10

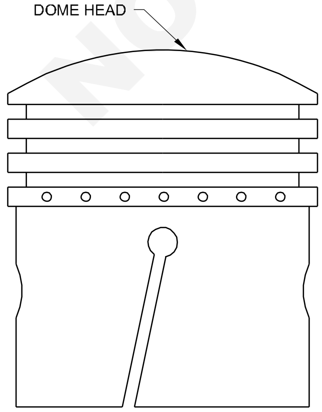


MVN17481A

Split skirt piston

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

Fig 11

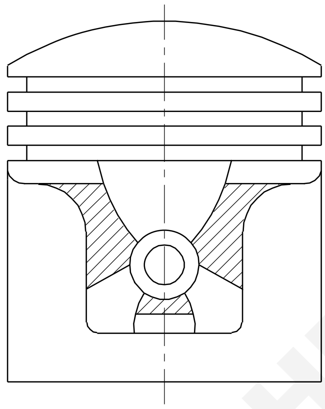


MVN17481B

Piston with steel alloy inserts

Steel alloy inserts (1) are cast between the thrust faces on the inside of the gudgeon pin bosses. This gives strength and controls expansion of the piston at high temperature. (Fig 12)

Fig 12

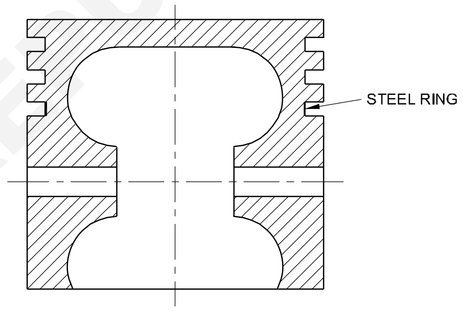


MVN17481C

Steel-belted pistons

A steel ring is cast above the gudgeon pin boss for strength. It controls expansion. This type of pistons are used in heavy duty engines. (Fig 13)

Fig 13

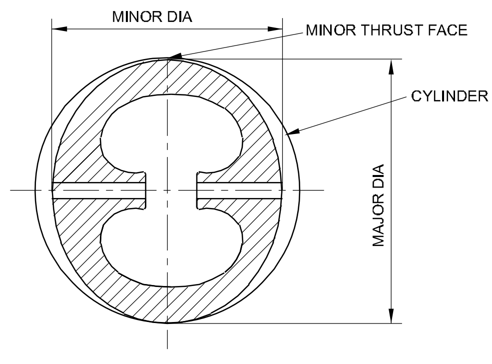


MVN17481D

Cam ground pistons

The skirt of this piston is ground oval in shape. The diameter across the gudgeon pin boss axis is less at the thrust side. When the engine runs and the piston heats up, the bosses expand outwards making the piston round, and the clearance with the cylinder bore uniform all round. (Fig 14)

Fig 14

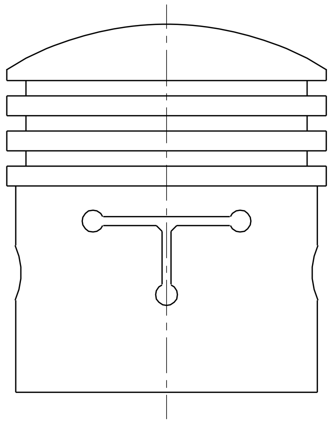


MVN17481E

Constant clearance pistons (Slot skirts)

These pistons have one or two slots cut in the piston skirt. When the piston gets heated up, the width of the slots decreases. It helps in maintaining a constant clearance with the cylinder bore. These slots are located under the oil ring groove at the minimum thrust side. The end of the slots is divided with holes to avoid stress concentration. (Fig 15)

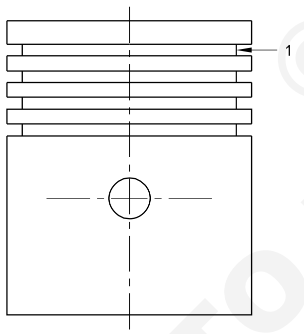
Fig 15



Heat dam pistons

These pistons have an extra groove (1) cast in between the top ring groove and piston crown. It is known as heat dam. It reduces the heat path on the piston head to the skirt. It enables the piston to run cooler. In this groove no ring is fitted. (Fig 16)

Fig 16



Alfin piston/ring carrier piston

Wear in the ring groove will result in excess oil reaching the combustion chamber. To reduce the wear on the top ring groove in piston(3), a ferrous ring (1) is inserted. This insert reduces the wear of the top ring groove (2). (Fig 17)

Piston rings

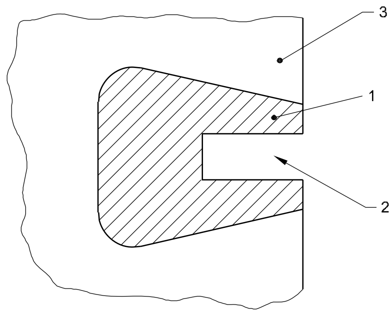
Types

- Compression ring
- Oil control ring

Compression rings

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

Fig 17

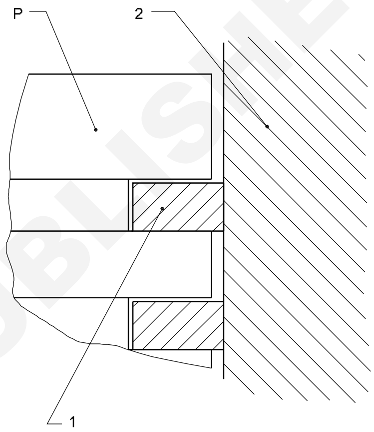


The following types of compression rings are used.

Rectangular rings

These rings are very popular and easy to manufacture at a lower cost. The face of the rings (1) remains in full contact with the wall of the liner (2). (Fig 18)

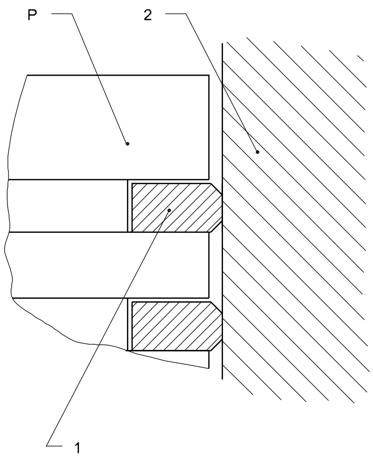
Fig 18



Taper-faced rings

The face of the ring (1) is tapered (Fig 19). The lower edge of the ring is in touch with the liner (2). These rings are good for controlling oil consumption by scraping all the oil from the liner (2). These rings cannot effectively control blow-by.

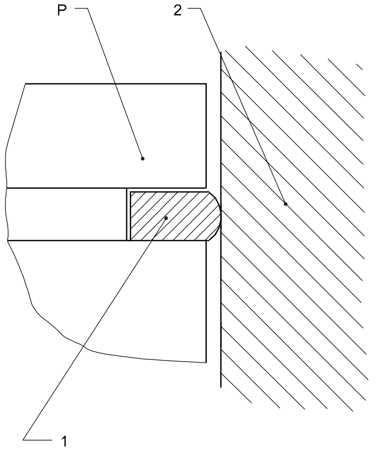
Fig 19



Barrel-faced rings

In this type, the corners of the rings (1) are rounded off to give a barrel shape. These rings are used only for top grooves to prevent blow-by. (Fig 20)

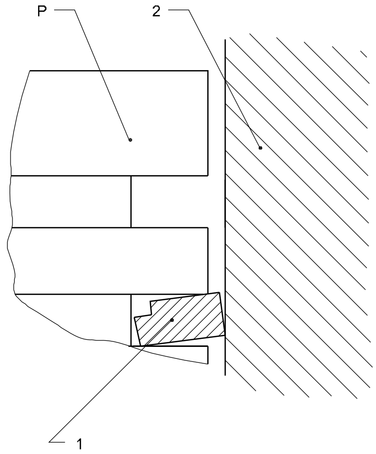
Fig 20



Inside bevel rings

In this type a step is cut on the top surface at the inner diameter of the ring (1). The step allows the ring to twist slightly when the piston moves. It is more effective in preventing blow-by. These rings are used in second grooves. (Fig 21)

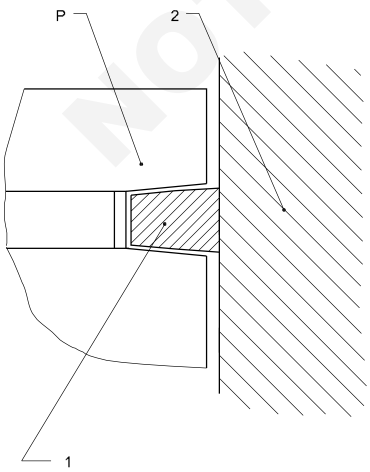
Fig 21



Keystone ring

This types of rings (1) does not allow carbon to settle in the ring groove. It is generally used in heavy vehicles. (Fig 22)

Fig 22

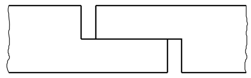


Joints of compression rings

Step joint

It is considered to be one of the best to prevent blow-by. It is difficult to manufacture, and to set a correct gap while fitting. These types of joints are not used much in automobiles. (Fig 23)

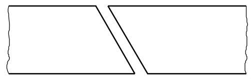
Fig 23



Angle joint (Diagonal cut)

This type of joints is easy to manufacture and the gap can be set quickly. It is commonly used in automobiles. (Fig 24)

Fig 24

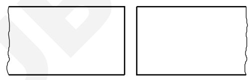


Straight joint

These rings are easy to manufacture and the gap can be set easily. Most of the engine rings have straight joints. (Fig 25)

Oil control rings

Fig 25



The main purpose of an oil ring (2) is to scrape the excess oil from the liner and drain it back to the oil sump during the downward movement of the piston. It prevents the oil from reaching the combustion chamber. One or two oil control rings are used in a piston. If two rings are used, one is fitted above and the other is fitted below the gudgeon pin in the piston.

These rings exert enough pressure on the cylinder wall to scrape the oil film. To keep the sealing and avoid metal-to- metal contact, a thin film of oil stays on the liner. These rings are provided with drain holes or slots. These slots allow the scraped oil to reach the oil sump through the piston holes.

Types of oil scraper rings

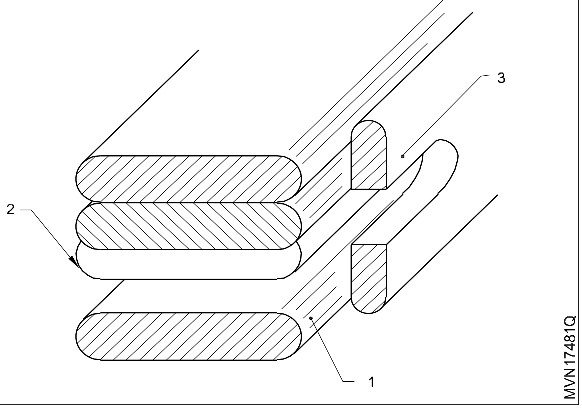
One piece (Solid rings)

These rings are easy to install. They have greater force against the cylinder wall and reduce oil consumption.

Duraflex rings (Three pieces)

These rings (Fig 26) are used specially for re-ringing jobs, where the cylinder has worn out excessively. One set of rings consists of rails, a crimped spring and expander. The rail (1) is of a circular shape. It is made of high quality, polished spring steel. The number of rails vary in accordance with the width of the groove. It wipes oil from the liner. The crimped spring (2) keeps the rail space apart and seals the top and bottom of the groove. It ensures the ring tightens in the groove irrespective of wear. The expander (3) exerts the correct amount of pressure against the rail and provides a sealing effect on the cylinder wall. The main advantage of this type of ring is that it provides enough pressure irrespective of cylinder wear in all conditions.

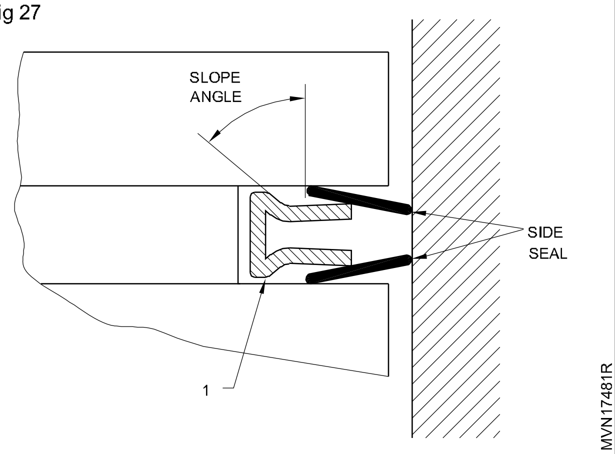
Fig 26



`T' Flex rings

It has one `T' shaped expander (1) with two scraper rails (2). The rails (2) also serve as spacers. The expander (1) forces the rails (2) against the cylinder wall. This enables the ring to scrape excess oil. The steel rail provides an effective side sealing of the cylinder walls. (Fig 27)

Fig 27



Materials

Piston rings are made of high grade cast iron, centrifugally cast and ground. This provides good elasticity, and minimises vibration. In some cases steel- chromium plated rings are also used in cast iron cylinders. Chromium plated rings are only used in the top groove.

These rings have less friction, less wear and longer life.

Description & function of connecting rod

Objectives: At the end of this lesson you shall be able to
- **describe the function of connecting rod**
- **decribe the construction and materials of big and small end bearing of connecting rod.**

Connecting rod

Functions

It is fitted in between the piston and crankshaft. It converts the reciprocating motion of the piston to the rotary motion in the crankshaft. It must be light and strong enough to withstand stress and twisting forces.

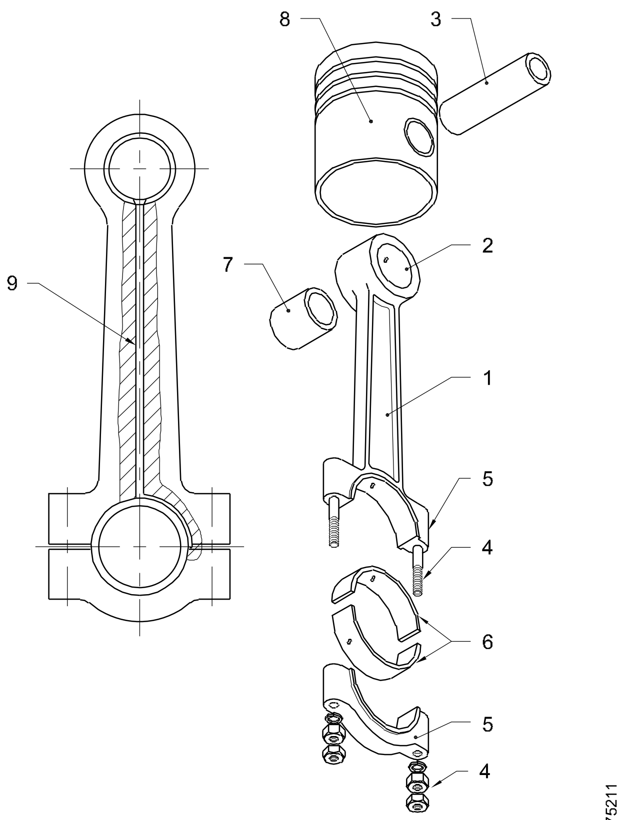
Construction

The connecting rod (1) (Fig 1) is made of high grade alloy steel. It is drop-forged to 'I' shape. In some engines aluminium alloy connecting rods are also used. The upper end of the connecting rod has a hole (2) for the piston pin (3). The lower end of the connecting rod (1) is split, so that the connecting rod can be installed on the crankshaft. The top and bottom halves (5) of the lower end of the connecting rod are bolted together on the big end journal of the crankshaft, by bolt and nut (4).

A large bearing area is provided to take the load, heat and wear. The split halves are usually fitted with babbitt bearings (6) or bearing lining steel-backed copper lead. In the upper end of the connecting rod a bronze bush (7) is fixed. The small end of the connecting rod is connected to the piston (8) by means of a piston pin (3).

In some engines a hole (9) is drilled in the connecting rods from the big end to the small end. It allows oil to flow from the big end to the small end bush.

Fig 1

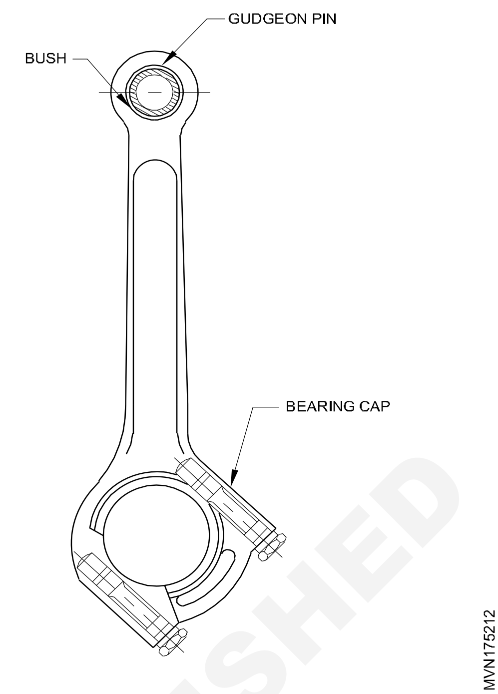


CONNECTING ROD SPILT AT RIGHT ANGLE

Control split at an angle (Oblique cutting) (Fig.2)

The connecting rod big end is split at an angle for assembly easily on the crankpin.

Fig 2



Locking methods of piston pin

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

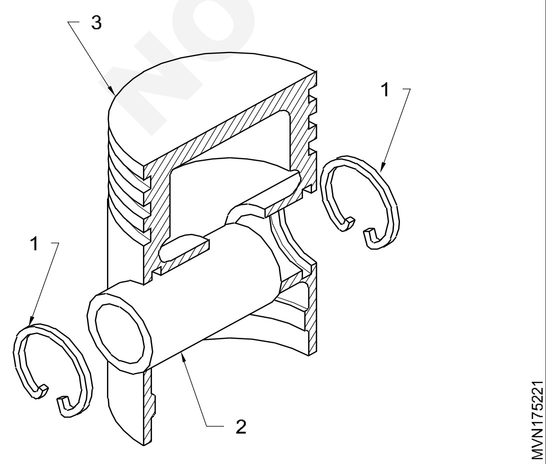
The piston pin or gudgeon pin connects the piston with the connecting rod. It should be strong enough to transmit power and withstand pressure of combustion. Piston pins are made hollow to reduce inertia load due to the reciprocating motion.

Types of piston pins

Fully floating piston pin

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

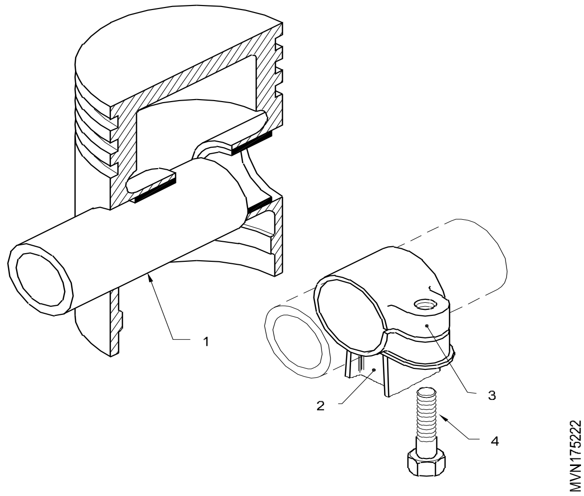
Fig 1



Semi-floating piston pin

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

Fig 2



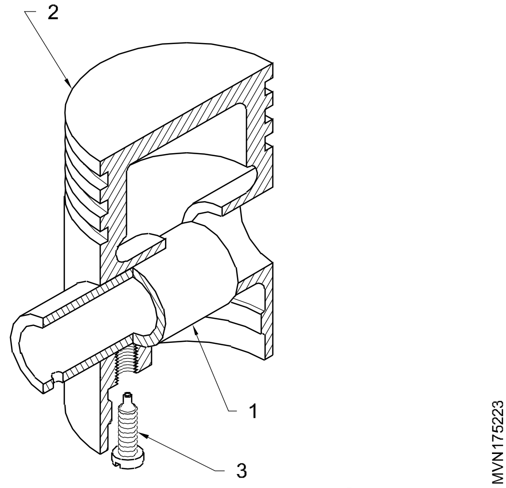
Set screw type piston pin

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

Piston pin materials

The piston pin are made of Nickle / chromium alloy steel. The outer surface is ground, chromium plated and case hardened.

Fig 3



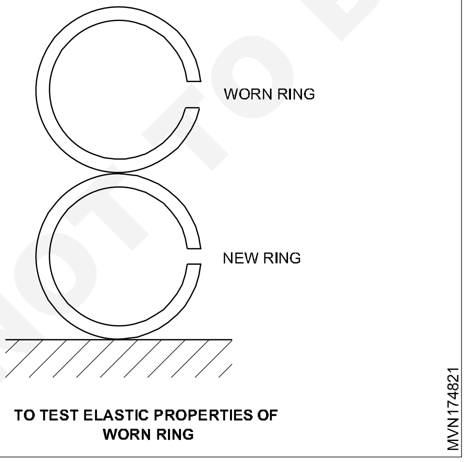
Piston ring

Objectives: At the end of this lesson you shall be able to
- **state the recommended clearances for rings**
- **state the piston rings fitting precautions**
- **state the causes and remedies of piston rings**
- **state the compression ratio.**

Piston clearance

Piston rings have gap so that they may be installed into the piston grooves and removed when worn out by expanding them. The gap ensures radial pressure against the cylinder wall thus having effective seal to prevent leakage of heavy combustion pressure. This gap must be checked because if it is too great due to cylinder bore wear, the radial pressure will be reduced. To check this gap clean the carbon from the ends of the ring and then check it with feeler gauges. This gap may be in the region 0.178 - 0.50 mm governed by the diameter of the bore but if it exceed 1 mm per 100 mm of bore diameter, new rings must be fitted. (Fig 1)

Fig 1



The gap between the ring and the groove in the piston should also be checked by feeler gauges. This gap is usually 0.038 - 0.102 mm Fig 2 for compression rings and a little less for the oil control rings.

The gap between piston and liner is measured by feeler gauge from the bottom of the liner (skirt) is 25.4 mm Fig 3.

Fig 2

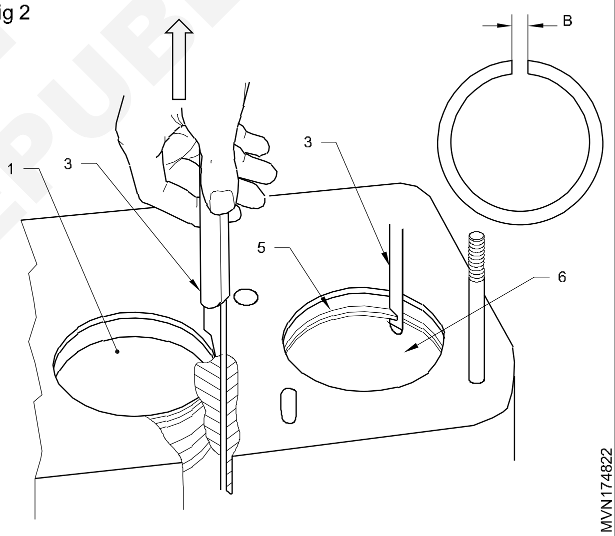
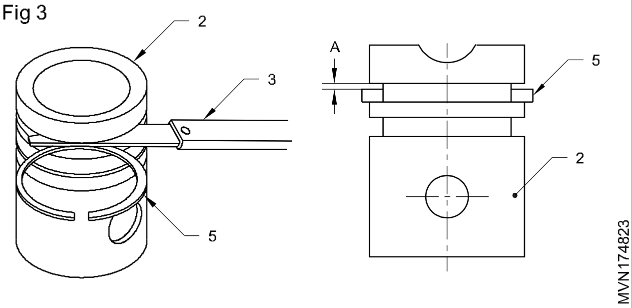


Fig 3



Precautions while fitting rings in the piston

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

1 Remove the ridge in the liner.

2 Use proper ridge cutter.

3 Measure the end gap of new ring.
4 Use piston ring cutter to remove excess material.
5 Use piston ring grooves cleaner to remove carbon from groose.
6 Clean the piston groove, liner rings with specified cleaning liquid.
7 Excess piston ring expand lead broken , so limit the ring expansion as need
8 Use the ring expander to fit the ring in the piston.
9 Check the end gap clearance of the ring.
10 Check ring side clearance in the piston's groove.
11 Ensure the piston rings and gap should not be inline.

Causes and remedy

1 Wear in the piston ring grooves causes the rings to rise and fall during movement of piston and its pumping action resulting in high oil consumption.
2 Exercise gas blow by, loss of compression will also take place if gap is too much (cylinder wall and piston ring).
3 During service the piston ring may have lost some of its elastic properties due ti which radial pressure will be reduced on the cylinder wall. This properly can be checked by pressing together worn and a new ring and observing whether the gap of the worn ring closes more than the new ring.

Application of bearing failure & its causes and care & maintenance

Objectives: At the end of this lesson you shall be able to
- **state the application of bearing**
- **state the causes for bearing failure**
- **state the care and maintenance of the bearing.**

The device for supporting the rotating shaft is called bearing, bearings are used in all types of machineries, engines and mechanism for supporting and controlling the motion of rotating, sliding or reciprocating parts, shafts, spindles, axles, rods & pins.

The contact surface of bearing may wear out due to friction and rubbing by rotating or moving parts.To minimise the frictional resistance, bearing are lubricated and adjusted that they serve their purpose with a minimum of friction power loss and generation of heat.

Application of the bearing: Bearings are different types depending upon the construction and direction of load act on the bearing.

Bearing failures

Fatigue failure

This is identified by small sections of bearing material detaching from the steel back and this spreads to the entire bearing. Excessive loading, detonation, inadequate lubrication, high temperature build up are the major causes for this problem.

Foreign matter on bearing surface

Dirt, dust, metal particles left before assembly, due to improper cleaning, dirty oil, due to inadequate maintenance result in suspended hard particles staying the lub. system. These find a way into the bearings under pressure with lub. oil and when they are too big to pass through the bearing clearances, they get embedded into the bearings, displacing the bearing material. continued condition of such nature, lead to the bearing surface getting full of such particles which work on the journals as an abrasive and score them. This will accelerate bearing and journal wear. Hygienic conditions in the system and also during assembly is therefore very important.

Improperly seated bearing

This is possible due to existence of foreign matter or dirt between bearing back and seating at parent bore, filed parting faces or bearing caps or shims below the bearing shells or between parting faces when not needed. This will affect full contact with parent bore, oil clearance and load distribution, thermal conductivity etc. and the problems following them. Localised wear or peeling of bearing material or seizure may be the result.

Dirt between bearing and the seat is due to improper cleaning before assembly, Bearing crush may be lost by filing parting faces and even the bearings may start working loose in the parent bore. This may lead to bearing rotation and complete seizure very quickly.

Filed bearing caps result in out of round parent bores. This is ignorantly attempted to reduce oil clearance. This may lead to excessive crush and insufficient oil clearance and landing up in a total bearing failure.

Con.rod mis-alignment

Bend and twisted con.rods wear the bearing unevenly. This affects bearing clearances also.

Shifted bearing caps

This can be caused by

- Improper doweling or by damaged dowel holes.
- Using too bigger socket spanner for the cap screws.

P.T.F.E. bearings

Polytetrafluoro ethylent (PTFE) is extremely insert plastic material with an unusually low dry co-efficient of friction its use is limited by its thermal properties. This bearing particularly suitable for applications where corrosive liquids would attach conventional bearing materials.

Care and maintenance of bearing

- Identify correct size of bearing for selected application.
- Clean the dirt, dust, rust and metal particules on the bearing before use.
- Setting proper bearing clearance and proper seating in its place

- Specified lubricant use for bearing lubrication.
- Periodically change the lubricant for increase the bearings life.
- Replace the damaged or worn out bearings.
- Use the quality of bearings as specified in service manual.

Types of bearings damages

- Abrasive damage
- Erosion damage
- Fatigue damage
- Corrosion damage
- wiping damage
- Cracks, scoring, overheating

Factors affecting bearing clearance

- Desired operating temperature extremely critical
- Engine speed
- Oil flow rate
- Oil flim thickness
- Working viscosity of lubricant
- Load carrying capacity
- Operating temperature of engine

Bearing defect simptoms

- Low oil pressure
- Reduce load capacitor
- High impact load on crankshaft
- Noise

Description and function of crankshaft

Objectives: At the end of this lesson you shall be able to
- **state the function of the crankshaft**
- **state the constructional features of crankshaft**
- **state the material of crankshaft**
- **state the necessity for heat treatment, and the balancing of the crankshaft**
- **state the constructional features of bearing shells**
- **list out material of the bearing shells.**

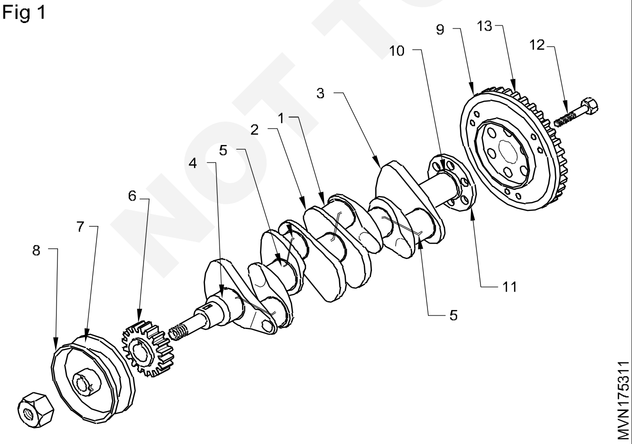
Function of the crankshaft

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

Construction

A crankshaft consists of a crank pin (1) (Fig 1), webs or crank arm (2) and balancing weights (3) which are provided on the opposite side of the crank arms for balancing the main journals (4). Crankshaft have drilled oil passages (5) through which oil flows from the main bearings to the connecting rod bearings.

Fig 1



The front end of the crankshaft carries the gear or sprocket (6) to drive the cam shaft. A vibration damper (7) and a fan belt pulley (8) are fitted in front. The pulley (8) drives the water pump, engine fan and generator/alternator, through a fan belt.

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

Materials

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

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

Heat treatment of the crankshaft

A crankshaft is made of forged and heat-treated alloy steel. It is machined and ground to provide suitable journals for the connecting rods and main bearings. The following methods are used to harden the crankshaft journals.

- Nitriding
- Carburising
- Chrome plating

In the above process the case of the crankshaft journal is hardened. These process give very little depth of hardness. Some manufacturers recommend hardening of the crankshaft journals after regrinding.

Induction hardening

Induction hardening gives more depth of hardness, and, therefore, the crankshaft need not be hardened again and again.

Crankshaft bearings

These bearings are made into two halves. These bearings operate at critical loads and high rotational speeds. These bearings run quieter and are easy to replace.

These bearings are also called thin wall bearings. These are made of a thin steel shell base with a thin lining on it.

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

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

Fig 2

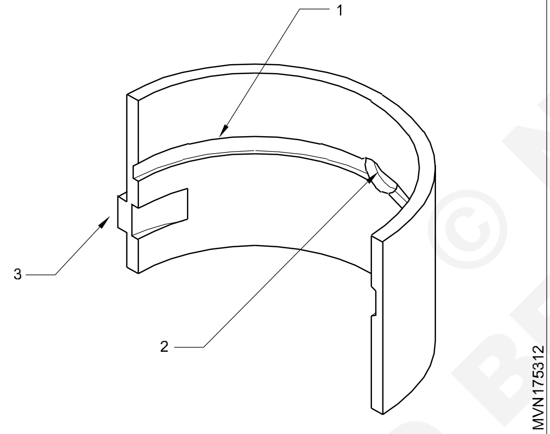


Fig 3

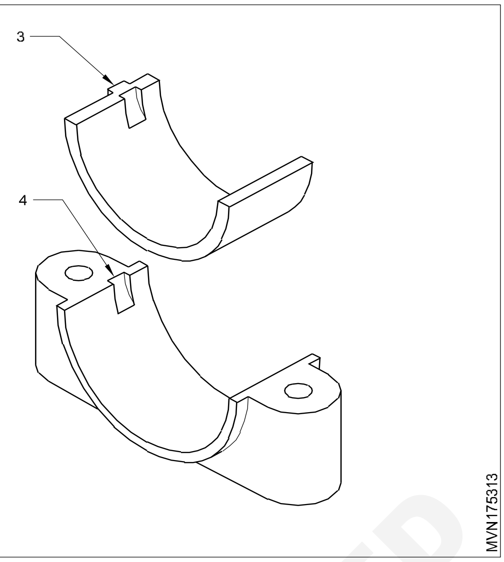
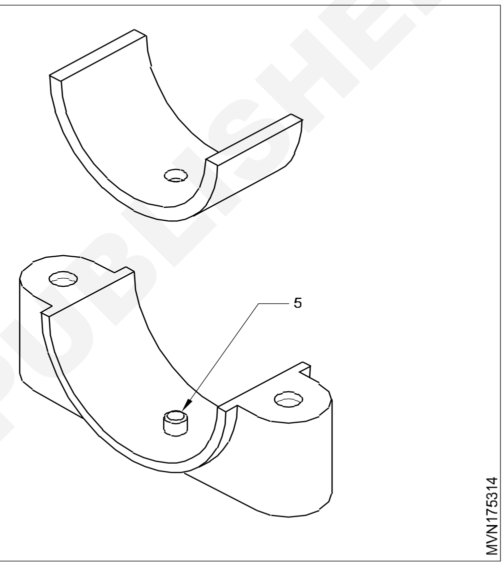


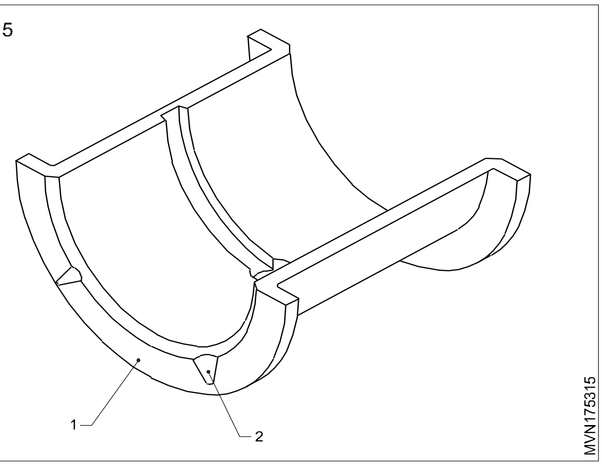
Fig 4



Thrust bearings

This type of bearing (Fig 5) takes care of thrust loads. The bearing shells on the crankshaft, which has thrust faces (1) on it, takes the end thrust of the crankshaft when it is in operation. The thrust faces have oil notches (2) to hold lubricating oil. In some cases separate thrust washers made up of bearing material are also used to take the end thrust.

Fig 5



Camshaft

Objectives: At the end of this lesson you shall be able to
- **state the function of the camshaft**
- **state the constructional features and material of the camshaft.**

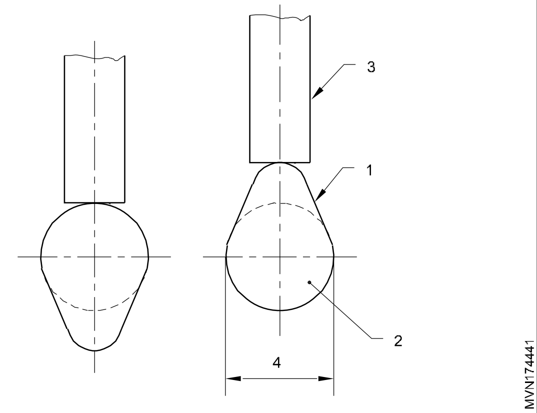
Functions of the camshaft

The camshaft is used to convert the rotary motion into reciprocating motion with the help of the cam lobe. This reciprocating motion is transmitted to the valve through the tappet, push-rod and rocker levers. The camshaft is driven by crank shaft and it rotates half the speed crankshaft. The camshaft also drives the oil pump shaft. In petrol engines the fuel pump and the distributor get their drive from the camshaft.

Construction of the camshaft

The camshaft (2) (Fig 1) is either forged or cast with the cam lobes (1) one for each valve. The camshaft has a series of support bearings along its length.

Fig 1

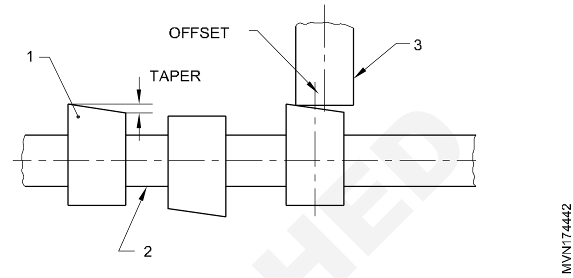


The cam surface (Fig 2) is hardened for longer life. In some engines the axis of the tappet/lifter (3) is slightly offset from the axis of the cam lobe (1). This off set gives a little rotation to tappet/lifter, when it moves up. So the bottom of the tappet/lifter (3) wears out uniformly. The lifter/tappet (3) rests on the cam lobe (1). The lifter (3) remains in its position on the base circle (4). When the cam rotates the lobe lifts the lifter (3).

Material for camshaft

Forged alloy steel

Fig 2



Camshaft drive mechanisms

Objective: At the end of this lesson you shall be able to
- **state the different types of camshaft drive mechanisms.**

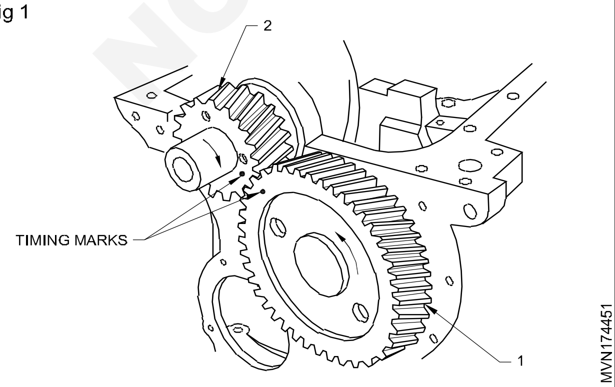
The camshaft gets the drive from the crankshaft and rotates at half the crankshaft speed, since each valve opens once in every two revolutions of the crankshaft. There are three types of camshaft drive mechanisms.

- Gear drive (Fig.1)
- Chain drive (Fig.2)
- Belt drive (Fig.3)

Gear drive

This direct drive (Fig.1) P No 58 is used where the crankshaft and the camshaft are very close to each other. Since the r.p.m. of the camshaft is half of the crankshaft speed, the camshaft gear (1) teeth is twice as many as the crankshaft gear (2) teeth. In this, the engine's camshaft rotates in the reverse direction of the crankshaft. In some engines an idler gear is used to have the same direction of rotation for the crankshaft and the camshaft.

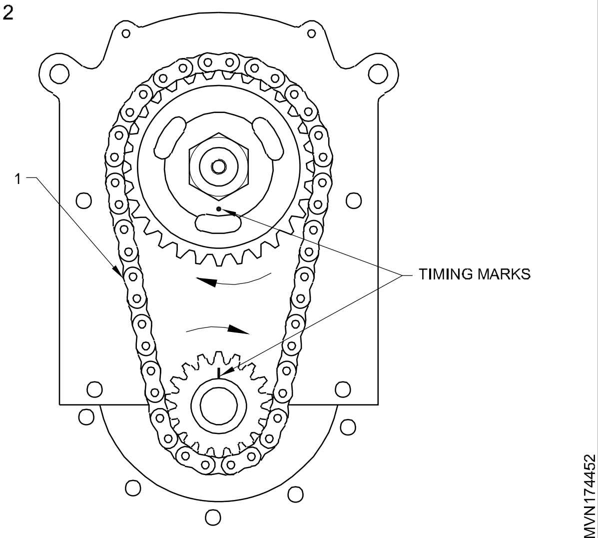
Fig 1



Chain drive

The timing gear sprockets (Fig 2) are driven by a chain (1). Hence this drive is called a sprocket drive. The direction of rotation of the crankshaft and camshaft is the same. It is used when the distance between the crankshaft and the camshaft is more. No idler gear is used in the chain drive.

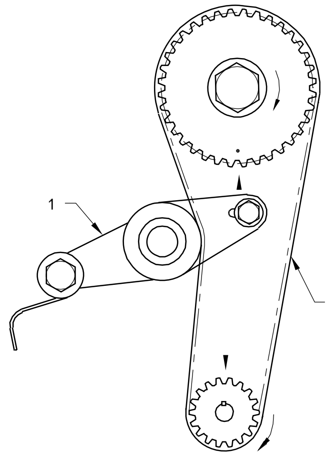
Fig 2



Belt drive

This drive (Fig 3) is similar to a chain drive. Instead of a chain a belt (2) is used to drive the camshaft. The belt drive is mostly used in overhead camshaft design. The direction of rotation of the camshaft and crankshaft is the same. An automatic belt tensioner (1) is used to avoid slipping of the belt.

Fig 3



Cam shaft classification

Cam shaft are clssified based on its location and number of shafts

1 Bottom mounted traditional camshaft (OHV) - (Fig.4) and single over head valve (SOHV) - (Fig.5)

2 Single over head cam shat. (Fig.6)

3 Double over head cam shaft (DOHC) (Fig.7)

The main disadvantages of an OHV design is that it'sdifficult to control precisely the valve timing at high rpm.

Advantages of an OHV engine include lower cost, proven durability, low-end torque and compact size. OHV design is better suited for slow speed engines. In heavy duty engines offers higher torque at lower rpms. (Fig.4)

Bottom mounted traditional cam shaft (OHV Engine) (Fig 4) & SOHV (Fig.5)

OHV in general means over head or valves are fitted in the cylinder head. Often the term "OHV is used to describe the engine design where the camshaft is fitted inside the engine block and valves are operated through lifters, pushrods and rocker arms. This design is also known as a "Pushrod" engine. The OHV design has been successfully used for decades.

Fig 4

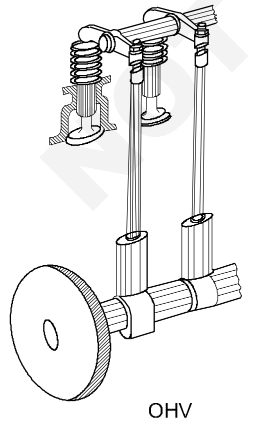
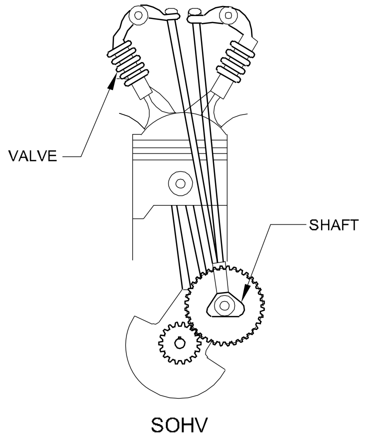


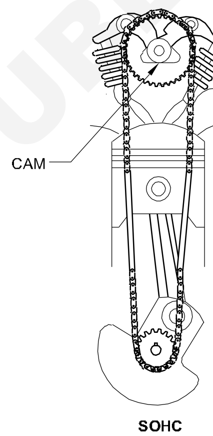
Fig 5



Over head cam/single over head cam shaft (OHC/ SOHC) (Fig.6)

OHC means over head cam in general, while SOHC means single over head cam or single cam. In SOHC engine the camshaft is installed in the cylinder head and valves are operated either by the rocker arms or directly through the lifters.

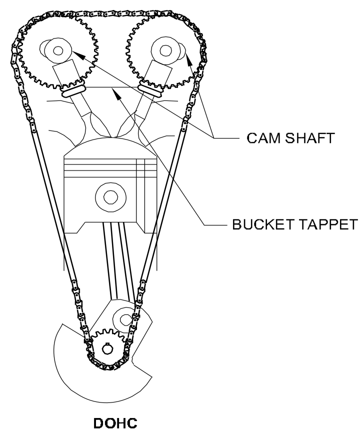
Fig 6



The main advantage of an OHC design is that valves are operated almost directly by the camshaft, which makes it easier to maintain precise timing at higher rpms. It's also possible to install three or four valves per cylinder.

Double over head cam shaft (DOHC) (Fig.7)

Fig 7



DOHC means double over head cam. Most modern vehicles have DOHC engines. DOHC engine has two camshafts and 4 valves per cylinder. One camshaft operates intake, while another camshaft operates exhaust valves. This allows the intake valves to be at a larger angle from the exhaust valves, so the volumetric efficiency increases and produces more horse power out of smaller engine volume.

The main advantage of the DOHC design allow technologies like direct injection, variable valve timing and variable valve lift cab be easily implemented in a DOHC engine, further improving fuel efficiency.

The main disadvantage of the DOHC technology includes a larger size and more complex design with additional timing belt or chain components. A timing belt needs to be replaced at recommended intervals, adding to maintenance costs.

Crankcase ventilation

Objectives: At the end of this lesson you shall be able to
- **state the purpose of crankcase ventilation**
- **describe the working principle of positive crank case ventilation (PCV) system**
- **explain different stages of PCV valve operation**
- **describe the working principle of crankcase depression regulator valve (CDRV) for diesel engine.**

Purpose of crankcase ventilation

The firstcontrolled emission was crankcase vapors. While the engine is running during combustion some unburned fuel and other products of combustion leak between the piston rings and the cylinder walls, down into the crankcase. This leakage is called blow-by. Blow by gases are largely HC gases

Unburned fuel, and water from condensation, also find their way into the crankcase, and sump. When the engine reaches its full operating temperature , the water and fuel evaporate. To prevent pressure build - up, the crankcase must be ventilated.

In earlier vehicles, crackcase vapors were vented directly to the atmosphere through a breather tube, or road draught tube. It was shaped to help draw the vapors from the vapors from the crankcase, as the vehicle was being driven.

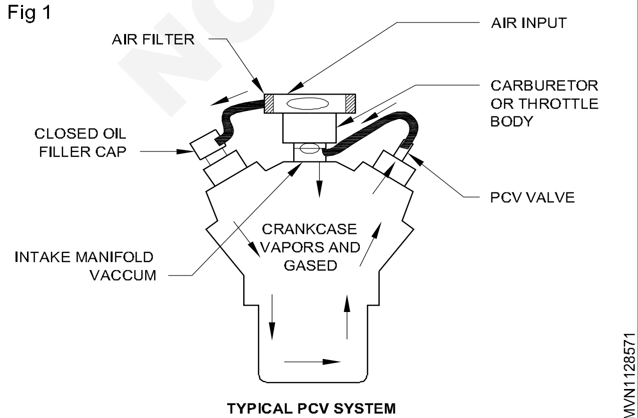
Modern vehicles are required to direct crankcase breather gases and vapors back into the inlet system to be burned.

A general method of doing this is called positive crankcase ventilation, or PCV.

PCV working principle

The PCV vacuum circuit works as follows (Fig 1). Air for the system enters the air cleaner area. The air then goes through the air filter, through a tube, and through the closed oil filler cap.

Fig 1



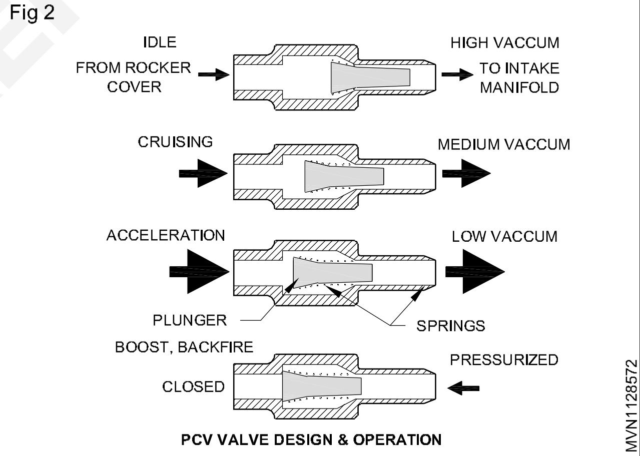
TYPICAL PCV SYSTEM

The intake main fold vacuum the draws the crankcase vapors and gases back to the PCV valve. From the PCV valve, the vapors and gases are drawn into the intake of the engine to be burned by combustion.

If too many vapors and gases get into the intake main fold, it may upset the air-fuel ratio. The PVC valve helps to control the amount of vapors and gases going back into the intake main fold.

As shown in the diagram (Fig 2), the PCV valve consists of a tapered plunger and two springs, and limits the air flow based on intake main fold vacuum.

Fig 2



PCV VALVE DESIGN & OPERATION

During idle and deceleration when blow-by gases are minimal, the low pressure (or “high” vacuum) in the intake manifold pulls the plunger against the springs and restricts the airflow through the valve.

During acceleration and heavy-load operations when blow-by gases are at their maximum, low vacuum in the intake main fold allows the springs to keep the plunger “ back” for maximum airflow through the PCV valve.

In the case when the intake main fold becomes pressurized, such as during boost on turbocharged engines or during backfire, the plunger’s seat is forced against the valve case preventing air from entering the crankcase.

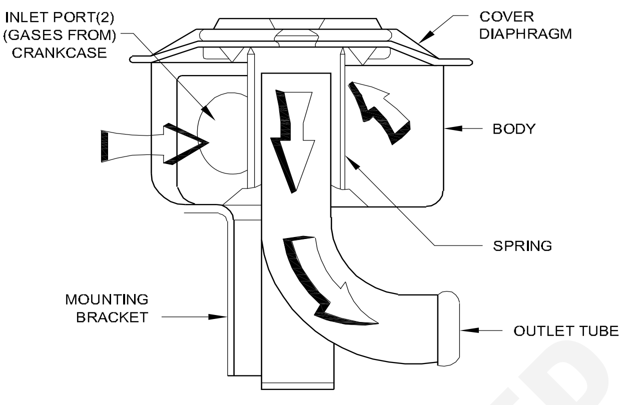
Crankcase depression regulator valve (CDRV) for diesel engine

A crankcase depression regulator valve (CDRV) is used to regulate the flow of crankcase gases back into the engine. This valve is designed to limit vacuum in the crankcase. The gases are drawn from the valve cover through the CDRV and into the intake main fold.

Fresh air enters (Fig 3) the engine through the combination filter, check valve, and oil fill cap. This air mixes with blow-by gases and enters the opposite valve cover. These gases pass through a filter on the valve cover and are drawn into the connected tubing.

Intake main fold vacuum acts against a spring loaded diaphragm to control the flow of crankcase gases. Higher vacuum levels pull the diaphragm close to the top of the outlet tube. This reduces the amount of gases being drawn from the crankcase and decreases vacuum in the crankcase. As intake vacuum decreases, the spring pushes the diaphragm away from the top of the outlet tube allowing more gases into the main fold. The diesel crankcase ventilation system should be cleaned and inspected every 15,000 miles (24,000 km) or at 12 month intervals.

Fig 3



THE CRANKCASE DEPRESSION REGULATOR VALVE

Crankshaft balancing, firing order of the engine

Objectives: At the end of this lesson you shall be able to
- **state the types of crankshaft balancing**
- **state the importance of the crankshaft balancing**
- **state the function of firing order.**

Balancing of crankshaft

Internal combustion engines have reciprocating parts and they create vibrations, when the engine is running. Every two revolutions of the crankshaft one power impulse in four stroke engine. Balancing of the engine is necessarily required for smooth running of the engine.

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

Types of balancing

There are two types engine balance, (i) power balance (ii) mechanical balance

Power balance: When the engine power impulses occur at regular intervals with relation to the revolution of the crankshaft and each power of the engine impulse exerts the same force.

Mechanical balance: Engine assembling parts of crankshaft connecting rod and pistons are rotating in reciprocating motion, so that crankshaft counter balanced in operation mechanically minimize the vibration of the engine. The rotating parts of an engine can be balance by bringing them into static and dynamic balance. The main rotating parts are balanced mechanically by crankshaft counter weight and flywheel piston and connecting rods shocks on crankshaft are called primary intertie force. The angularity of the connecting rods produce secondary vibration, it is called secondary intertie force. The perfect static and dynamic balance of crankshaft and flywheel reduce the vibration.

Firing order: The sequence of power impulses occur is an engine is called firing order. The firing order in which cylinder deliver their power strokes is selected as a part of the engine design to obtain the best engine performance. The firing order is shown by the sequence of the number of cylinder in which the cylinder deliver their power strokes. Which is the nearest cylinder to radiator is designated as number one cylinder in an inline engine

Three cylinder 1 -3 -2

Four cylinder 1 -3-4-2

Five cylinder 1-3-5-4-2

Six cylinder 1-5-3-6-2-4

Eight cylinder inline engine 1-8-7-3-6-5-4-2

Eight cylinder v8 engine 1-3-2-5-8-6-7-4

Flywheel

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

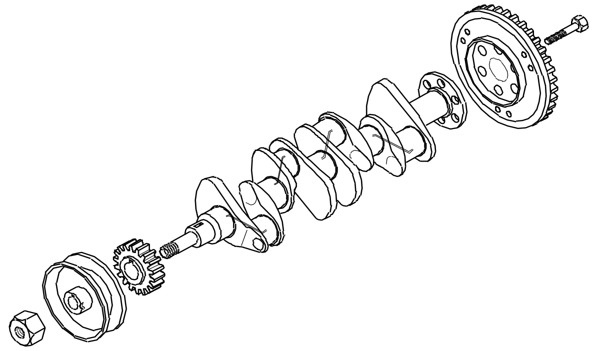
Function of Flywheel

The flywheel stores energy during the power stroke and supplies it to the crankshaft during the idling stroke i.e. suction, compression and exhaust. In many engines the flywheel also serves as a mounting surface for the clutch.

Construction

The flywheel Fig 1 is attached to the rear end of the crankshaft (1) by means of bolts (4). A large ring gear (3) is attached to the flywheel. While starting, the engine starter motor 's gear engages with the ring gear (3), and the flywheel (2) rotates to crank the engine. When an automatic transmission is used the torque converter assembly acts as the flywheel. The flywheel also serves as a mounting and frictional surface for the clutch assembly. The size of the flywheel depends upon the number of cylinders and general construction of the engine.

Fig 1



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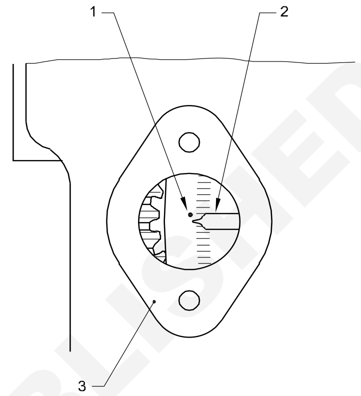
Timing marks of the flywheel

An engine is provided with timing marks (Fig 2) on a rotating member and a stationary pointer. The timing mark (1) in punched on the circumference of the flywheel / crank pulley. A pointer (2) is fixed on the flywheel housing (3) / timing cover. Timing is adjusted when the pointer (2) coincides with the flywheel mark (1) and at this times distributor contact should just start at open.

A pointer (2) is fixed on the flywheel housing (3) / timing cover. Timing is adjusted when the pointer (2) coincides with the flywheel mark (1) and at this times distributor contact should just start at open.

Fig 2



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Vibration damper

Objective: At the end of this lesson you shall be able to
- **functions of a vibration damper.**

Vibration dampers are fixed the front end of the crankshaft.

The main function of a vibration damper is to reduce torsional vibrations and stress. It helps in reducing the flywheel weight and increases the crank-shaft life.

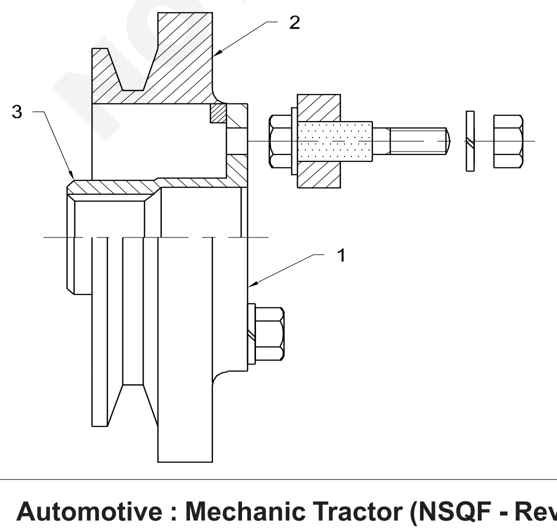
Types and Construction

There are mainly two types of vibration dampers in use.

Rubber floating type

The damper (Fig.1) is made into two parts, a small inertia ring or damper flywheel (1) and the pulley (2). They are bonded to each other by a rubber insert (3).

Fig 1



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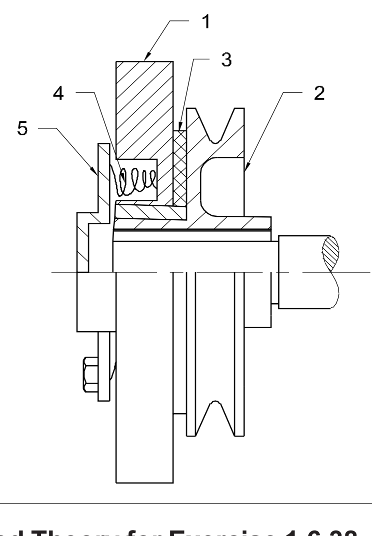
As the crankshaft speeds up or slows down, the damper flywheel has a dragging effect. This effect slightly flexes the rubber insert (3) which tends to hold the pulley and crankshaft to a constant speed. This tends to take on the twist and untwist action and torsional vibrations of the crankshaft.

Clutch and rubber bush dampers

In this type (Fig 2), in between the damper (1) and the pulley (2), two friction facings (3) are provided. A spring (4) and a plate (5) are fixed to control the friction between the damper (1) and the pulley (2).

Fig 2



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Engine cooling system

Objectives: At the end of this lesson you shall be able to
- **state the necessity of the cooling system**
- **list out the different types of cooling systems**
- **state the advantages of the forced type of cooling system**
- **draw the water circulation path in an engine block**
- **state the function of the water pump, radiator, temperature indicator, pressure cap**
- **state the need and function of the thermostat valve, recovery system**
- **state the different types of thermostat valves.**

Combustion of fuel inside a cylinder develops a very high temperature (Appx.2200°C). At this temperature the engine parts will expand and tend to seize. Similarly the lubricating oil will loose its property. Therefore it is necessary to keep the engine temperature to operating limits. This is done by the cooling system. Heat is removed from the engine by cooling media (water or air) and is dissipated to the atmosphere.

Types of cooling systems

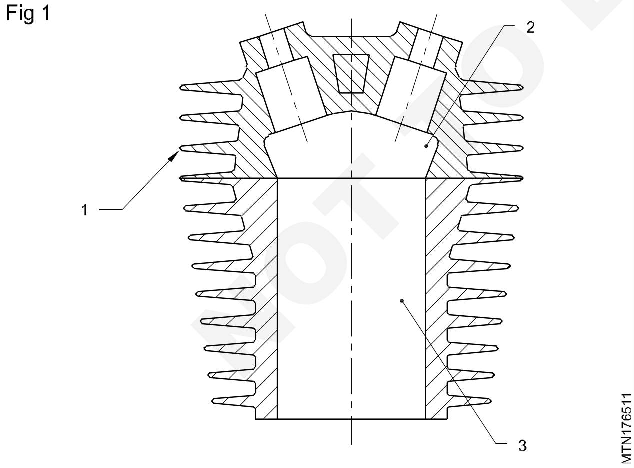
There are two types of cooling systems used in engines.

- Direct cooling - air cooling.
- Indirect cooling - water cooling.

Air-cooled engines

In air-cooled (Fig 1) engines, cylinders are semi-independent. They are not grouped in a block. Metal fins (1) are provided on the head (2) and cylinder (3), to help dissipate heat from the engine. In some engines fans are also used to improve air circulation around the cylinders and heads. This type of cooling system is employed in two-wheelers and small stationary engines. These are used in both S.I. and C.I. engines.

Fig 1



Water cooling

Two types of water cooling systems are used.

- Thermo-siphon system (Fig 2)
- Forced circulation system (Fig 3)

Fig 2

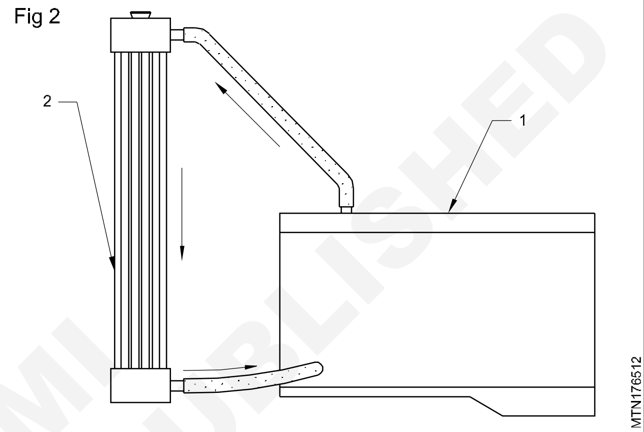
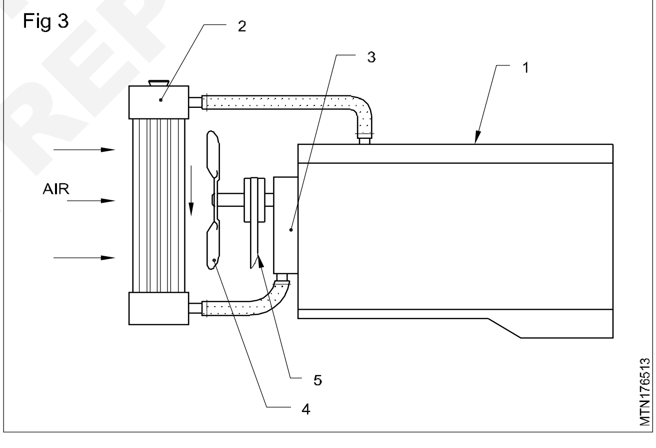


Fig 3



Thermo-siphon system

In this system no pump is used for water circulation. Water circulation is obtained due to the difference in the densities of hot and cold water. Water absorbs the heat and rises up in the block (1) and goes to the radiator's (2) top side. Water is cooled in the radiator (2). It again goes to the water jackets in the engine. To maintain a continuous flow of water the level of water is maintained at certain minimum level. If the water level falls down the circulation will discontinue. This system is simple but the rate of cooling is very slow.

Pump circulation system (Forced feed system)

In this system water is circulated by a pump (3). The pump is driven by a belt (5) which is connected with the crankshaft pulley. The circulation depends upon the engine speed. More water is circulated at higher engine speed.

Effect of boiling point: The boiling point of a substance is the temperature at which the vapor pressure of a liquid equals the pressure surrounding the liquid and he changes into vapor. Liquid may change into vapor at temperatures below their boiling point through the process of evaporation, boiling is a process in which modecules anywhere in the liquid escape, resulting in the formation of vapour bubbles within the liquid. Excess pressure of any liquid or gas will damage working parts.

Fan: The fan is mounted behind the radiator on the water pump shaft. When engine is running the fan is drawn air through radiator core tubes and fins to cool the water in radiator.

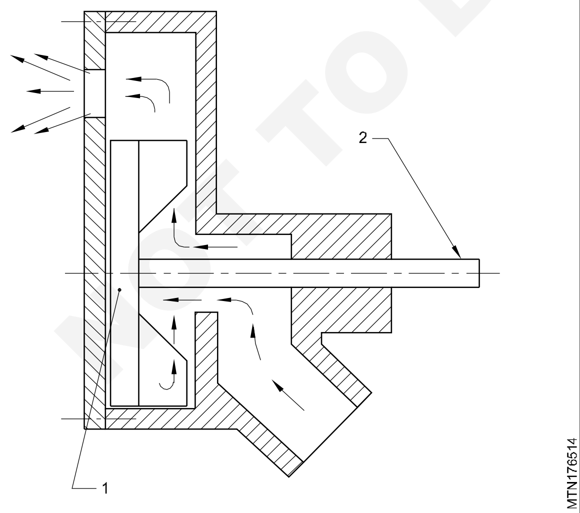
In modern vehicles cooling fan is operated through electing power and it has fun actioning as per sensor base signal delivered by ECU normally it is not operating till water temperature is not reached as specified temperature limit

The water absorbs heat from the engine and flows to the radiator's (2) top tank. Water from the top tank of the radiator (2) flows down to the bottom tank. The fan (4) draws the air through the radiator's fins and cools the hot water. Cold water from the bottom tank is again pumped to the engine and the cycle is repeated.

Water pump

The centrifugal type water pump (Fig 4) is used in engines. It is mounted on the front side of the cylinder block or head. The water pump is driven by the crankshaft pulley through the fan belt. The impeller (1) is mounted on one end of the water pump shaft (2). The shaft (2) is fitted in the pump housing with bearings. A water seal is provided in the pump to prevent leakage of water and to prevent water entering into the bearings. When the impeller rotates it draws water from the lower tank of radiator, and pumps water to the engine block, by centrifugal force under pressure. The fan is mounted on the water pump pulley.

Fig 4

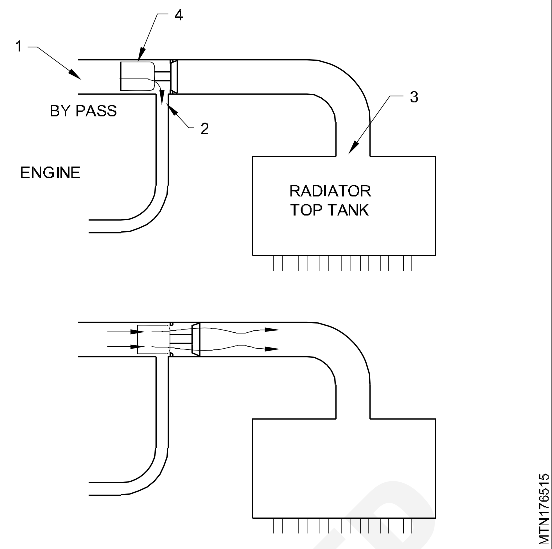


Thermostat

The thermostat (Fig.5) helps to bring the cold engine to the operating temperature quickly.

It is fitted in between the water outlet of the cylinder head (1) and the inlet (2) of the radiator in the water cooling

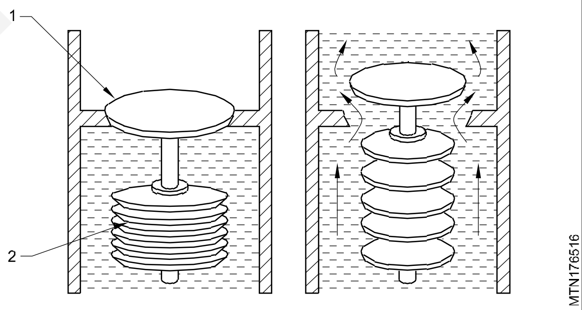
Fig 5



system. When the engine is cold, the thermostat (4) is closed. It does not permit water to enter the radiator. Water recirculates in the engine through the bypass hole (2) and the engine reaches the operating temperature quickly. Once the engine has reached the operating temperature the thermostat (4) opens. It closes the bypass hole (2) and now permits water to enter the radiator tank (3). Thermostats are rated to open at different temperatures. Two types of thermostats are used.

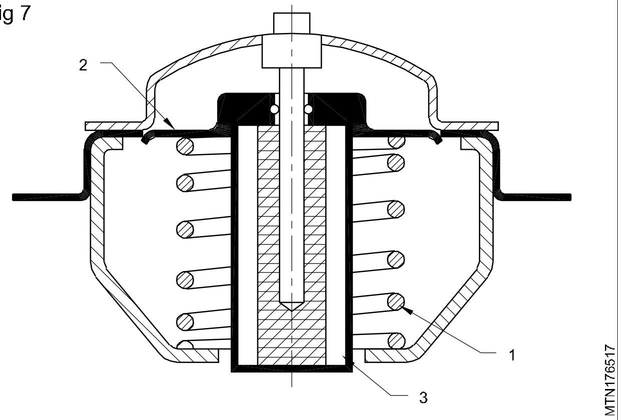
- Bellows type (Fig 6)

Fig 6



- Wax type (Fig 7)

Fig 7



Bellows type

It has a flexible metal bag closed at both ends. The metal bag is partially filled with ethyl which has a low boiling temperature.

When the engine is cold the valve (1) closes its outlet passage and does not allow water to reach the radiator top tank from the engine, but is circulated through the bypass port to the engine.

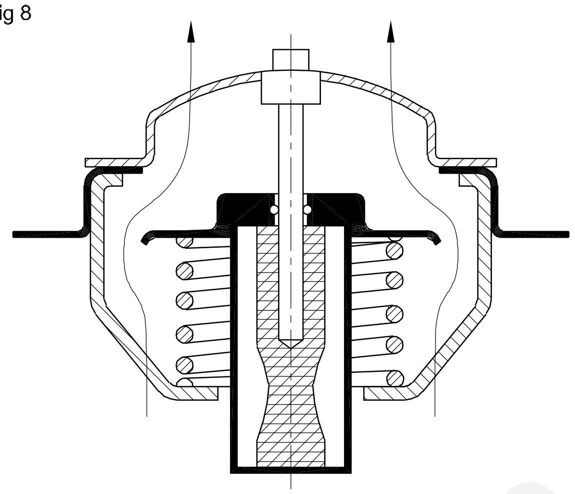
When the water reaches the working temperature, ethyl in the closed bellow (2) expands and opens the valve (1). Now the water reaches the radiator top tank from the engine. In the valve's opened position the bypass passage is closed.

Wax pellet type

In this type a wax pellet (3) (Fig 8) is used as a heating element. When the circulating water's temperature is lesser than the operating temperature, the spring (1) keeps the valve (2) in the closed position and the water does not reach the radiator top tank from the engine.

As the water reaches the operating temperature the wax pellet expands and forces the valve (2) to open against the spring tension. Now the water reaches the radiator top tank, from the engine. At this position the bypass port is closed by the valve.

Fig 8



Components of water cooling system

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of a radiator**
- **state the need of a pressure cap**

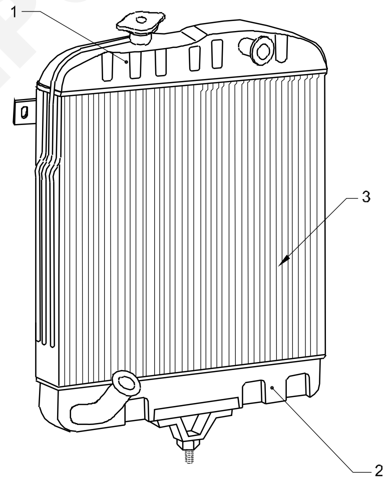
Radiator

The purpose of a radiator in the cooling system is to cool hot water coming out of engine.

It has a large cooling surface area to allow enough of air to pass through it. Water circulated through it is cooled by the passing air.

The radiator (Fig 1) consists of an upper tank (1),a lower tank (2) and in between the upper and lower tank radiator cores (3) are provided. The upper tank (1) is connected to the water outlet of the engine through a rubber hose. The lower tank (2) is connected to the water pump through rubber hoses.

Fig 1



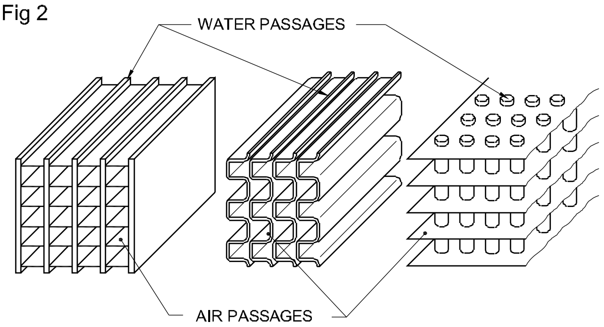
Radiator cores are classified into two types.

- Tubular core (Fig 2)
- Cellular core (Fig 3)

Tubular core

In a tubular type the upper and lower tanks are connected by tubes. Water passes through these tubes. Cooling fins are provided around the tubes, to absorb and radiate heat to the atmospheric air.

Fig 2



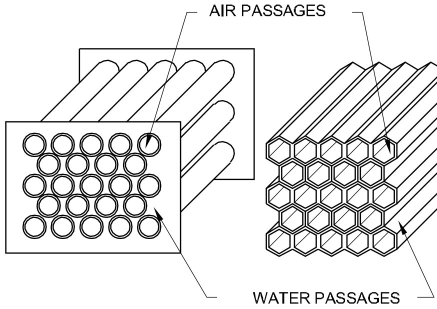
TUBULAR RADIATOR SECTIONS

Cellular cores

In the cellular type a large number of individual air cells are provided and surrounded by water. Because of its appearance, the cellular type is known as a 'honeycomb' radiator.

The material of the core is of copper and brass. The parts are normally connected together by soldering.

Fig 3

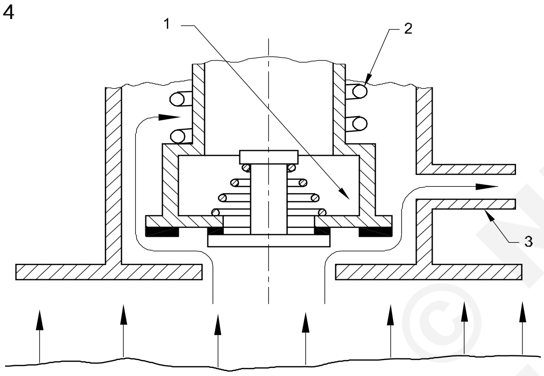


CELLULAR RADIATOR SECTION

Pressure cap

In normal atmospheric conditions water boils at 100°C. In higher altitude height the atmospheric pressure is low and water boils at a temperature below 100°C. To increase the boiling temperature of water the pressure of the cooling system is increased. This is achieved by providing pressure caps to seal the system. The coolant loss, due to evaporation is also minimized, by using a pressure cap. (Fig 4)

Fig 4



It also permits the engine to operate at a higher temperature so that better efficiency of the engine is achieved.

The pressure cap is fitted in the filler neck portion on the top of the radiator tank. If pressure is increased by 15 P.S.I., the boiling temperature raises to 113°C. The pressure cap has two valves.

- Pressure valve
- Vacuum valve

Pressure valve

If the pressure in the system rises it may damage the components. To avoid this a pressure relief valve (1) is used to release the excess pressure. It is a spring- loaded valve. The spring's (2) tension depends on the system's pressure.

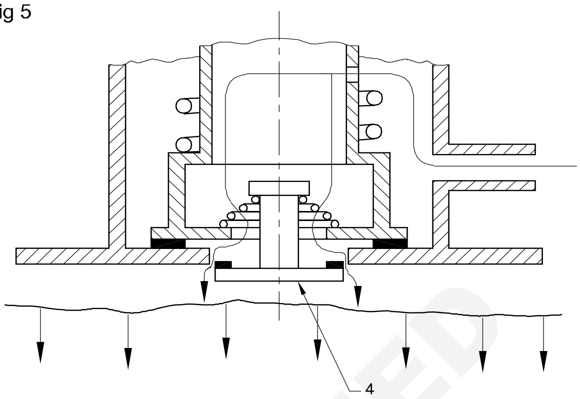
When the cooling water of the engine is heated up it expands which results in high pressure in the system. If the force due to pressure is more than the spring's (2) tension the valve opens and water vapour/steam escapes through the overflow pipe (3) until the pressure is lowered to the preset value.

Vacuum valve

When the engine cools down the pressure in the system decreases due to loss of the coolant and a vacuum is created.(This valve is also located in the cap and fitted in the filler neck of the radiator)

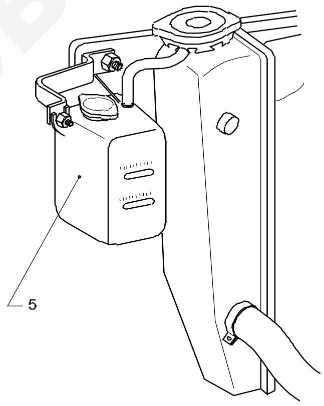
At this time the vacuum valve (4) (Fig 5) opens and air flows into the system until the vacuum is filled up in the system.

Fig 5



In some engines an overflow pipe is connected to an expansion tank (5). The expansion tank (5) (Fig 6) collects the water vapour during the pressure valve operation, and the same vapour, after condensing, goes to the radiator when the vacuum valve is in operation.

Fig 6



Temperature indicator

The temperature indicator is fitted on the instrument panel it indicates the temperature of the water in engine water jackets. There are two types of temperature indicator used in an automobile.

1 Mechanical type

2 Electric type

Mechanical type temperature indicator consists of a sealed bulb that fits in the cylinder head water jacket and connected by a fine tube to temperature pressure gauge on the dash board.

The electric type water temperature sending unit is fitted in the cylinder head water jacket and it is connected through electric wire from ignition switch to temperature use sending units cold terminal through panel indicator bulb, another wire is connected from temperature sending units hot terminal to temperature warning lamp. When the engine temperature reaches normal, the green light circuit is completed by the engine unit and the dial indicates green light. When the engine is over heated the engine unit completes red light circuit and the dial indicates the red light.

In latest vehicle engine coolant temperature (ECT) sensors are using.

Thermo switch

This device is prevents the engine from overheating by activating radiator cooling fan, measuring the coolant temperature and controlling the level gauges and warning lights on the engine control unit. This device have upto four terminals and be installed on the radiator, the cooling system tubes or thermostat, so that the coolant flows across the sensing element (bimetal disc or thermistor).

Function of thermo switch

Thermo switch operates independent from any current supply, temperature detection is effected by means of a by metal disk switch on temperature. When this fixed switch on temperature is reached this bimetal disk well snap over, closing a contact the circuit system and there by closing the electric of device to be started. After cooling down and reaching the cut off temperature. The bimetal disk will auto mechanically return into its original position and open the contact. The electric circuit is opened again.

Coolant properties of an engine

A efficient cooling system removes 30 to 35% of the heat generated in the combustion chamber.

- Coolant should be remove heat at a fast rate, when the engine is hot.
- Coolant should be remove heat at a slow rate when the engine is started until the engines reaches at its normal operating temperature.
- Coolant should not remove too much heat from the engine. Too much removal of the heat decreases thermal efficiency of the engine.
- It should circulate freely in the coding system.
- It should be prevent frequency and rust formations.
- It should be reasonably cheap.
- It should not waste by vaporisation.
- It should not deposit any foreign mater in the water jackets/radiator.

Change of engine coolant interval

1 Coolant should be replace as per specified by the manufacture.

2 Coolant should be replace during major repair in an engine or radiator.

3 Coolant should be replace at dilute (oil mix with water).

Anti- Freeze mixtures

1 Wood alcohol

2 Denatured alcohol

3 Glycerine

4 Ethylene glycol

5 Propylene glycol

6 Mixture of alcohol and glycerine

Engine lubricating system

Objectives: At the end of this lesson you shall be able to
- **list out the different types of engine lubricating systems**
- **explain the function of each system**
- **draw the oil circulation path in an engine block**
- **state the function of the pressure relief valve**
- **state the types of the pressure relief valve**
- **list out the different types of crankcase ventilation**
- **explain the positive crankcase ventilation.**

Types of lubricating system

The following types of lubricating systems are used in engines.

1 Petrol-oil lubrication

2 Dry sump lubrication

3 Splash lubrication

4 Pressurized lubrication

5 Combined lubrication

Petrol-oil lubricating system (Fig 1)

In this system the lubricating oil is mixed with the petrol(2). The ratio of petrol and oil is 20:1. When fuel goes in the crankcase chamber (1) and crankshaft bearings, the oil mist sticks to the moving parts and gives the lubricating effect. This system is mostly used in two-stroke engines.

Dry sump lubricating system (Fig.2)

In this system the lubricating oil is delivered from a separate tank (1) to the components by an oil pump (2). The oil lubricates the moving parts and flows back to the oil sump (3). A scavenging pump (4) is provided to pump oil from the sump to the tank.

The lubrication effect is not affected when the vehicle is climbing up or moving down.

Splash type lubricating system (Fig 3)

In this system the lubricating oil is stored in a sump(4). A dipper (1) is made at the lowest part of the connecting rod (2). When the crankshaft rotates the dipper (1) dips in the oil once in every revolution of the crankshaft and splashes oil on the cylinder walls.

Fig 1

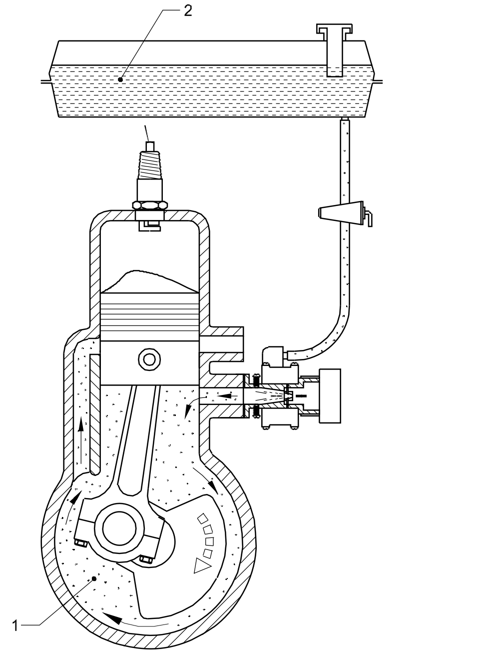


Fig 2

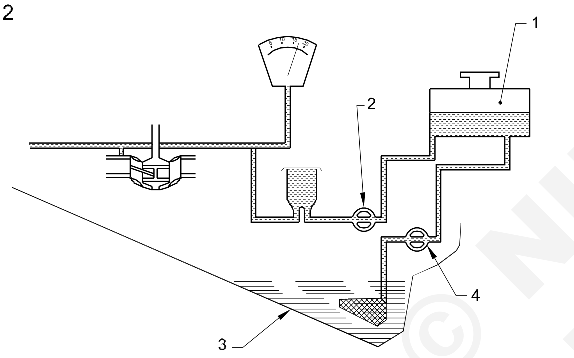
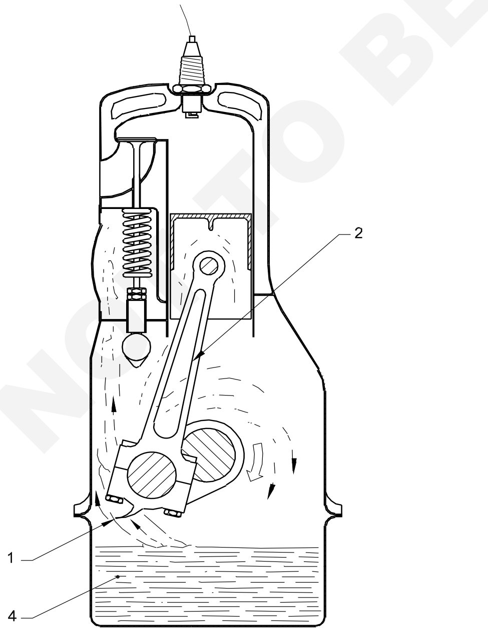


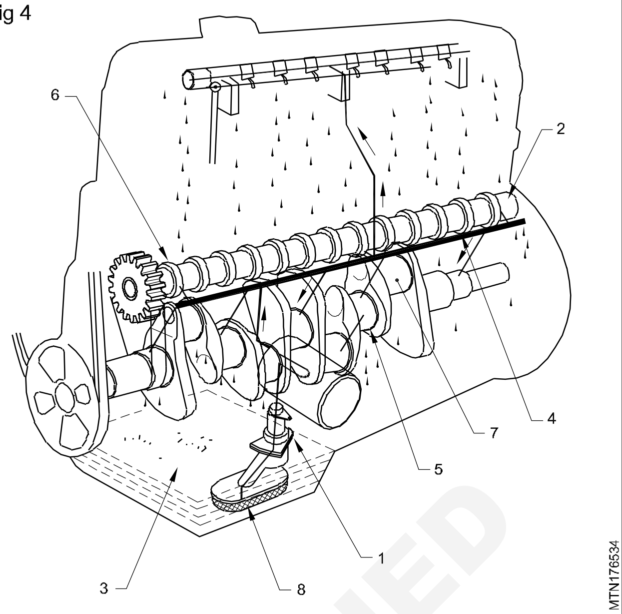
Fig 3



Pressure lubricating system (Fig 4)

In the system the lubricating oil is circulated to all the moving parts of the engine under pressure, by the oil pump (1) driven by the camshaft (2).

Fig 4



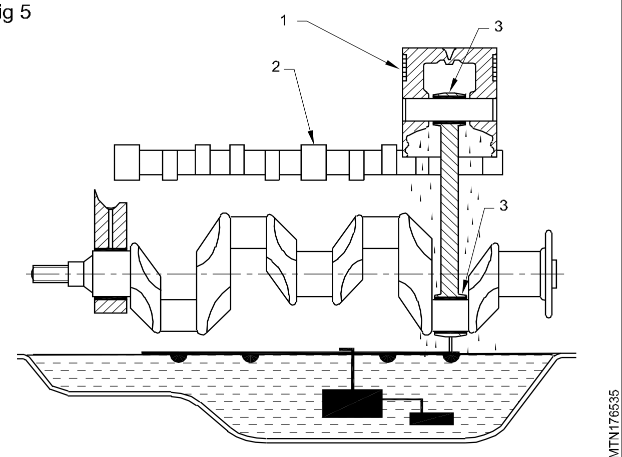
The oil from the sump (3) is sucked by the oil pump (1) through the strainer (8) and suction pipe. The strainer filters the solid dust particles. The oil flows to the main gallery (4) from the filter's outlet. From the main oil gallery (4) the oil flows to the crankshaft main journals (5) and camshaft bushes (6).

From the crankshaft main journal (5) the oil flows to the crankpin (7). From the camshaft bush it flows to the cylinder head and lubricates the rocker bushes. When the crankshaft rotates the oil splashes from the connecting rod bearings and lubricates the piston rings and liner. In some engines an oil hole is drilled from the connecting rod big end to the small end to lubricate the gudgeon pin bush.

A relief valve is provided in the path between the oil pump and the filter. The relief valve limits the maximum pressure of the oil in the system. An oil pressure gauge or indicating lamp is provided to indicate the oil pressure.

After lubricating the various parts of the engine, the oil reaches the oil sump.Combined lubricating system

Fig 5



Combined lubricating system (Fig 5)

It is a combination of splash lubricating system and pressure lubricating system. Some parts are lubricated by the splash lubricating system - such as the cylinder wall

(1), camshaft bearings (2), connecting rod bearing (3) and the remaining parts are lubricated by pressure lubricating system.

Pressure relief valve

The pressure relief valve is used to limit the maximum pressure of the oil. When the oil pressure increases more than the prescribed limit, the relief valve opens and allows oil to return back to the oil sump directly.

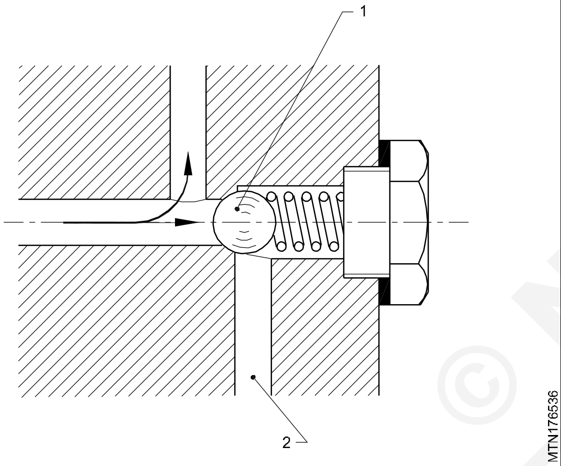
Following types of relief valves are used.

- Ball type
- Plunger type

Ball type (Fig 6)

In this type of relief valve a spring-loaded ball (1) opens the connection to the return channel (2) when the oil pressure over comes the spring force. The oil flows through the return channel back to the oil sump.

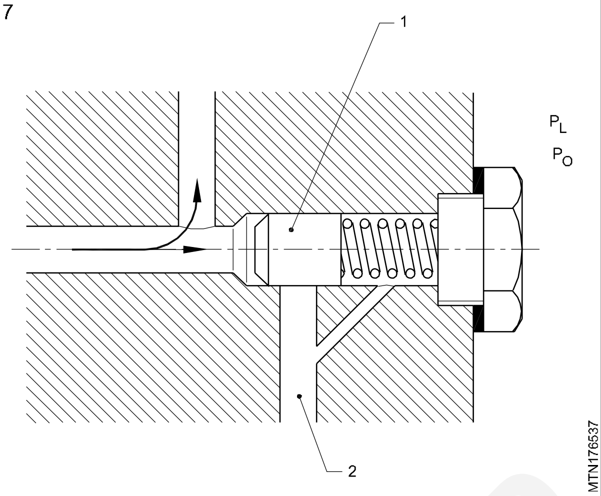
Fig 6



Plunger type relief valve (Fig 7)

This type of relief valve is similar to that of the ball type except that a plunger (1) is used instead of a ball. A leakage oil return passage is provided to allow oil to return to the oil sump which has passed through the plunger (1).

Fig 7



Function of sump

Oil sump is the lowest part of the crank case (Engine). It provides a covering for the crankshaft and contains oil in it. In wet sump lubricating system, the oil is taken out from the sump and after lubricating different parts of engine again oil drops in to oil sump. It is made of steel pressing/aluminium/ east iron. It contains drain plug at its lowest part to drawn out the oil. In dry sump lubricating system the oil is stored drain in a separate oil tank.

Oil collection pan

Oil pan is the lowest part of the engine. In dry sump lubricating system oil pan is collect the oil after lubricating different parts the engine oil drops in an engine and then oil is sent back to the oil tank by a separate delivery pump.

Oil tank

In dry sump lubrication system, two oil pumps are used one for feed the oil from tank to lubricating system and another pump scavenging pump is sent oil from dry sump to oil tank. In this system oil is not stored in oil sump.

Oil pick up tube: The oil pick up tube is located in oil pump and it is connected from oil strainer to oil pump in wet sump lubrication system.

Lubricant

Objectives: At the end of this lesson you shall be able to
- **state the need of lubricating an engine**
- **list out the properties of lubricating oils**

Functions of a lubricant

The main function of a lubricant is to minimise the friction between two moving surfaces which are in contact with each other.

It also helps to

- absorb heat from the moving parts due to friction.
- Minimise wear and tear of the components.
- Provide a cushioning effect between the moving parts.
- Clean the parts by carrying away metal chips with it.
- Protect parts from corrosion.
- Prevent blow-by of gases by provinding an oil film between the rings and the liner/bore.

Oil pump & Filter

Objectives: At the end of this lesson you shall be able to
- **state function of oil level and pressure indicator**
- **list out the types of oil pump**
- **list out the type of oil flow system**
- **purpose of the oil cooler.**

Oil level indicator

It is a steel stick graduated at the front end for measuring the level (amount) of oil in the sump. The graduations are "Full" , "Half", "Low" marks are provided on the bottom end of the dip stick. These marks show whether the oil is up to the required full or half level or the level is so low. The low oil level may cause danger to engine life.

For measuring oil level, remove the stick from the engine, clean and dipped into the oil sump and again taken out to see graduation oil has sticked.

Oil pressure indicator

Oil pressure gauge or oil warning light is provided on the dash board to indicate the lubrication. Oil pressure during engine running.

Oil pressure gauge

It is equipped with pressure lubricating system to warn the engine operator, what is the oil pressure is in the engine. The oil pressures are following types

1 Pressure expansion type

2 Electric type

a Balancing type

b Bimetal thermal type

Oil pressure indicating light

The light comes when the ignition switch is turned on and the oil pressure is low. The circuit uses four stage diaphragm switch, which operates a warning lamp according to the pressure required for different engine speeds. The switch is located at the oil main gallery. Its connection with the warning light is through the ignition switch.

Components of the lubrication system

Oil pumps

The oil pump is used to pump oil from the oil sump to the oil galleries at a certain pressure.

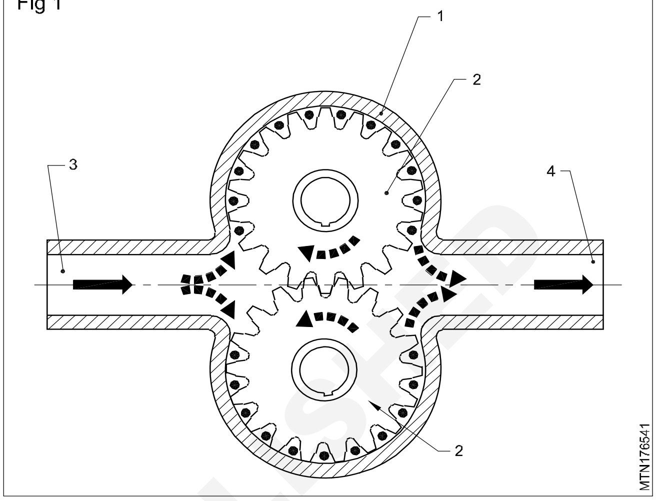
It is located in the crankcase and is driven by the camshaft. Four types of oil pumps are used.

- Gear type oil pump
- Rotor type oil pump
- Vane type oil pump
- Plunger type oil pump

Gear type oil pump (Fig 1)

In this type two gears are fixed in the pump housing (1). The gears (2) have little clearance with the pump housing (1). When the gears rotate a vacuum is created in the casing. Oil is sucked through the inlet (3) and pumped to the oil gallery through the outlet (4).

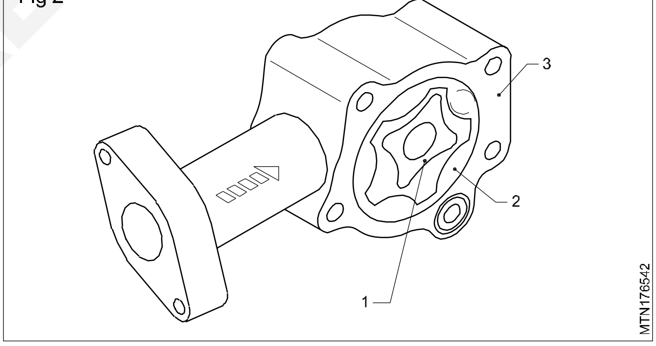
Fig 1



Rotor type oil pump (Fig 2)

The rotor type oil pump consists of an inner driving rotor (1), and an outer drive rotor (2) which rotates freely in the pump housing (3) and runs eccentrically in relation to the inner rotor.

Fig 2



The oil is sucked into the pump in the side where the volume between the rotor teeth increases and is pumped out on the side where the volume decreases.

Vane pump (Fig 3)

In the vane type pump the rotor (1) runs eccentrically in the pump housing (5). Spring- loaded vanes (2) slide against the pump housing walls. Suction us created by the vanes (2) when the rotor (1) rotates. Oil is sucked through the inlet duct (3) and discharged through the discharge duct (4).

Plunger type oil pump (Fig 4)

In this type of plunger (1) moves up and down in the cylinder. It is operated by a special eccentric cam (2). This pump has two non-return ball valves (3) & (4). These valves are spring-loaded balls. One of these is on the suction side (3).

During the upward stroke the oil is sucked through the valve (3). During the downward stroke the non-return valve (3) closes. The other non-return valve (4) which is on the delivery side opens and permits the oil to flow out from the pump. This type of plunger pump is used in medium and high pressure lubricating systems.

Fig 3

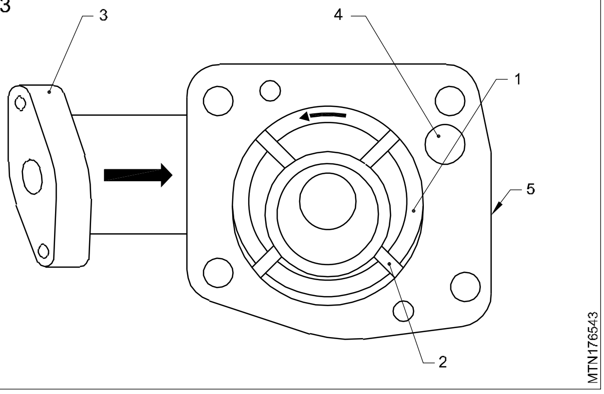
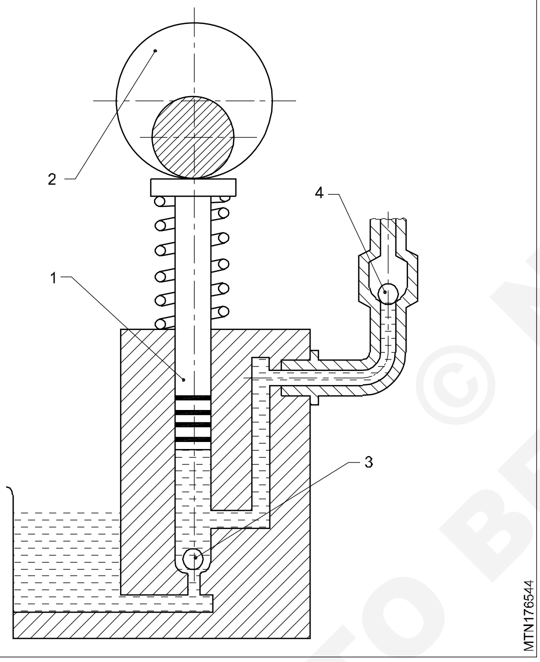


Fig 4



Oil filter

Full flow oil filter system (Fig 5)

In this system all the oil passes through the filter before reaching the main oil gallery. One bypass valve is provided in the filter which allows oil to reach the main oil gallery directly if the filter is choked.

Bypass oil filter system (Fig 6)

In this system only a part of the engine oil enters the filter. After filtering, the oil goes to the oil sump. The remaining oil goes directly to the main oil gallery.

Filter element

Filter elements are made of felt, cotton waste, cloth and paper. Oil filters are replaced after certain kilometres of running of the engine as specified by the manufacturer.

Fig 5

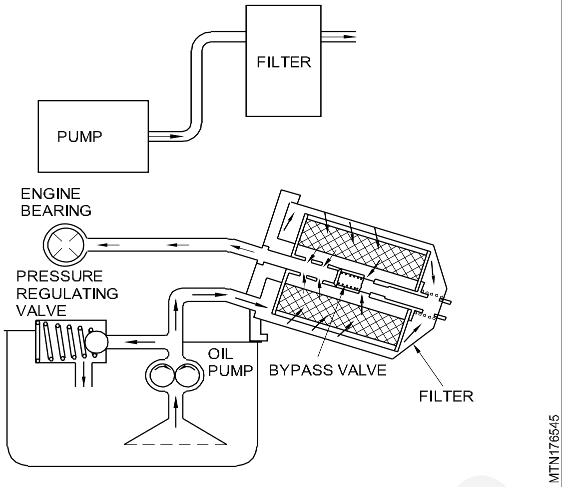
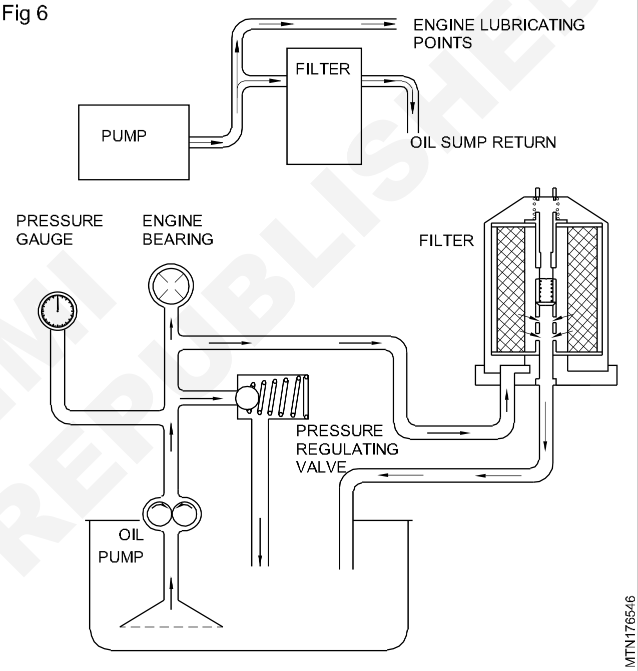


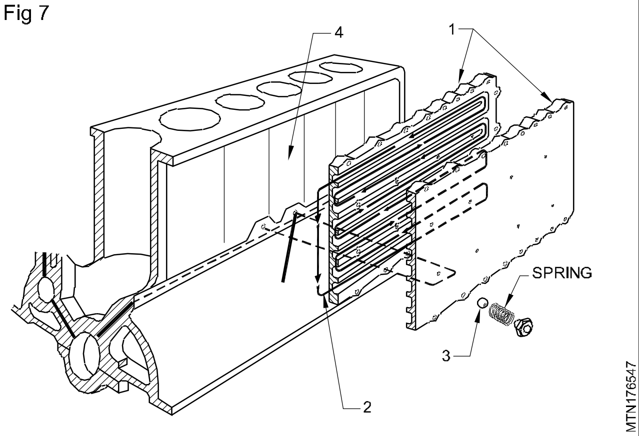
Fig 6



Oil coolers (Fig 7)

Oil cooler consists of two halves (1). Passages (2) are provided in between the cooler's halves for oil circulation. A ball valve (3) is provided to maintain the required oil pressure. This is made of cast iron. The purpose of the oil cooler is to transfer the heat from engine oil to cooling water and cool the engine oil.

Fig 7

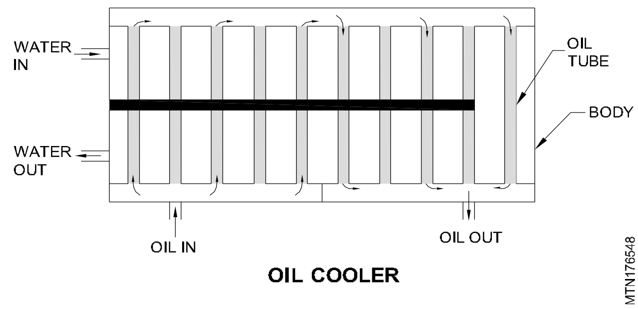


The inner wall of the oil cooler is in contact with cooling water. The engine oil which is made to circulate through the passages provided in the oil cooler, transfers its heat to the cooling water circulating in engine block (4), and the inner wall of oil cooler. This maintains the temperature of the engine.

Oil cooler purpose (Fig 8)

The purpose of an oil cooler us to cool the lubricating oil in heavy duty engines where the oil temperature become quite high the oil must be kept cold in the lubricating system.

Fig 8



An oil cooler is just like a simple heat exchanger. The oil may be cooled in it either by cold water from the radiator. At the time of starting when the water is hotter that the oil, the oil is heated to provide complete circulation in the system. At higher temperatures, when the oil becomes hotter than water, the water cools the oil.

A water type oil cooler, simply consists of tubes in which oil circulates. The water circulates outside the tubes in the casing of the cooler. The heat of the oil is carries away by the circulating water.

Spurt holes and maingallory

The engine parts are lubricated under pressure feed. The oil pump takes the oil through oil strainer and delivers it at pressure of 2.4 kg/cm^2 to main gallery. Further the pressurised oil goes through different size of spurt holes to main bearing camshaft bearing cranks pin, rocker arm and valves, main gallery is act as hub for oil distribution to engine moveable working parts.

Definition

Lubricant

The most effective method of reducting friction 15minimum and save the metals from wear and tear is called lubrication.

Lubricant

The substance is used for the purpose of lubrication is called lubricant.

with too low viscosity flows easily and does not stay in the clearances. So that the engine oil should be used as particular engine specifications and the season (plain area or high attitude area).

Oil additives

Any mineral oil by itself does not posses all the properties. The oil companies add a number of additives into the oil during the manufacturing process main oil additives

- Pour point depressants
- Oxidation inhibitors
- Corrosion and rust inhibitors
- Foaming resistance
- Detergents depressants
- Extreme pressure resistance

Synthetic oil

- Synthetic oils are made from substances other than crude oil
- They can be made from vegetable oils

Types

1 Polyalkylene glycols and their derived

2 Silicon which are manufactured from coal and sand

Application

a This oil can provide longer service life, less friction and improved fuel economy than convention oil.

b It, costs is more than regular SAE graded oils.

Low oil pressure

Low oil viscosity	Replace oil
Oil strainer blocked	Clean
Oil pump gear wornout	Replace gears
Strainer pipe mounting loose	Lighten
Defective oil pressure gauge	Replace
Defective pressure relief valve	Replace
Crank/camshaft bearing wornout	Replace bearing
Low oil level in the sump	Top up

High oil pressure

Causes	Replace oil
High oil viscosity	Replace oil and use correct viscosity
Defective oil pressure gauge	Replace
Defective pressure relief value	Replace or adjust correct value
Oil passages blocking	Clean the oil passages
High oil level in the sump	Frain and replace at correct level

High oil consumption

Causes	Replace oil
External oil leakage	Rectify the leakage
High oil level	Remove excess oil
Value oil seal damaged	Replace oil seal
Piston / rings wornout	Replace pistion/ rings
Engine oil low viscosity	Replace the oil
Oil reaching in exhaust manifold	Replace exhaust value guides and value stems
Oil reaching to combustion chamber	Replace the piston rings

Description of diesel induction and exhaust system

Objectives: At the end of this lesson you shall be able to
- **state the function of induction system**
- **state the function of exhaust system.**

Diesel induction system

In diesel engine only air is drawn into the cylinder from atmosphere through air cleaner, turbocharger, induction manifold, intake port and inlet valve. The induction manifold provides passage for the flow of fresh air from air cleaner via turbo charger towards the engine cylinder. The intake valve provides entrance for the fresh air charge into the combustion chamber and cylinder. The following air flow system is used in diesel induction system.

Air cleaner → Turbo charger → Induction manifold → Intake port → Inlet value → Combustion chamber and cylinder

Diesel exhaust system

The diesel engine used gases go out of the cylinder and combustion chamber through exhaust valve, which act as gate to provide exit for the burnt gases. The gases flow out through exhaust valve mouth space to the connecting passage of exhaust port into the exhaust manifold. The used exhaust gases from the manifold are let out into the atmosphere through catalytic converter muffler and tail pipe. The catalytic converter reduced the emission from the exhaust gases and muffler silence the noise of exhaust gases by reducing the pressure of the exhaust gases by slow expansion and cooling.

Further exhaust gases used for exhaust brake system to control the vehicle speed and to drive the turbo charger's turbine unit. The flow of exhaust gases is as follows.

Engine cylinder → used exhaust gases → exhaust port-exhaust manifold → exhaust brake → Turbim → catalytic converter → muffler → tail pipe → atmosphere.

Air compressor, Exhauster and Super Charger

Objectives: At the end of this lesson you shall be able to
- **explain constructional features of an air compressor**
- **explain operation of an air compressor**
- **explain constructional features of an exhauster**
- **explain operation of an exhauster**
- **explain constructional features of a supercharger**
- **explain operation of a supercharger.**

Air Compressor

An air compressor is part of an engine. It is driven either from the timing gear or from the camshaft to maintain air pressure for different purposes.

Normally, it is of a single cylinder type consisting of a piston assembly, connected to the crankshaft by means of a connecting rod. It has an inlet valve and a delivery valve. An aircompressor is having an inbuilt air cooling system with fins on its head. Valves are automatic in action and consist of hardened and lapped spring loaded steel discs against removable seats. Engine lubricating oil is circulated to lubricate the parts of air compressor

Operation

During the downward stroke of piston partial vacuum is created in cylinder which opens the inlet valve, air to enter into the cylinder. During the upward stroke, the pressure closes the inlet valve. So air is compressed in the cylinder which opens the delivery valve sending compressed air to the reservoir.

Exhauster

Vane type exhauster

Exhausters are fitted on diesel engine to develop vacuum to assist the pneumatic governor of F.I.P. A vane type exhauster is held by bolt over an opening in the engine and consists of a rotor, keyed to a shaft. The rotor is mounted eccentrically to the barrel (body) of the exhauster. Vanes are fitted with sliding fit in the slots of the rotor. A shift valve fitted on the exhauster, limits the vacuum to a predetermined pressure.

Impeller type exhauster

The impeller type exhauster has two spindles. One has an impeller. It is driven by auxiliary driving shaft and the other spindle has rotor whose vanes engage with those on the driven rotor.

Operation of exhauster

The vane type exhauster unit works on the principle of centrifugal force. When the engine is running due to centrifugal action, the vanes which have a sliding fit, fit into the slots in the rotor, which come out to the interior surface of the body (barrel). Air is thus evacuated throughout the section and is discharged into the crank case. Lubrication for vanes is provided by splash of oil from the crank case.

Superchargers

A supercharger is a device which increase the pressure of the air fuel mixture from the carburettor before it enters the engine. It is connected between the carburettor and the cylinder in the way of intake manifold. It is usually driven by the engine through suitable gears and shafts. There are three general types of superchargers:

1 Centrifugal type

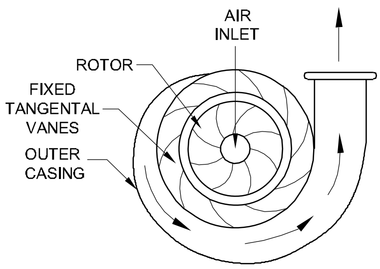
2 Vane type

3 Roots air-blower type

Centrifugal type supercharger (Fig 1)

It consists of an impeller which rotates at a very high speed, about 10,000 r.p.m. The air-fuel mixture enters the impeller at the centre and after passing through the impeller and diffuser vanes goes out of the casing to the engine cylinder. Due to the high speed of the impeller, the mixture is forced into the cylinder at a high pressure.

Fig 1

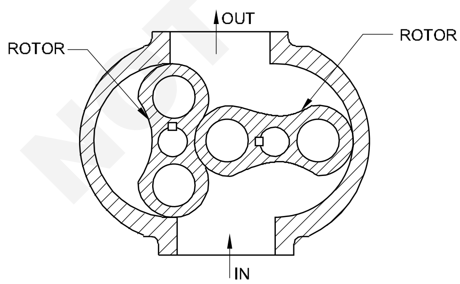


CENTRIFUGAL TYPE SUPERCHARGER

Roots air-blower type supercharger (Fig 2)

It consists of two rotors of epicycloid shape. Each rotor is fixed to a shaft by a key. The two shafts are connecred whether by means of gears of equal size the two trotors rotate at the same speed. The working action of such a supercharger is just like a gear pump, so that the mixture at outlet side is at a high pressure.

Fig 2

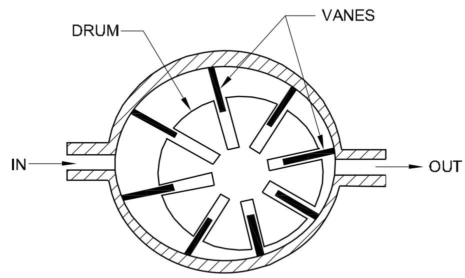


ROOTS AIR-BLOWER TYPE SUPERCHARGE

Vane type supercharger (Fig 3)

It consists of a drum on which a number of vanes are mounted in such a manner that they can slide in or out against some spring force, so that all the times they are in contact with the inner surface of the surper charger body. The space between the body and the drum goes on decreasing from the inlet to the outlet side. Thus, the air-fuel mixture entrapped between any two vane at inlet goes on decreasing in volume and increasing in pressure as in reaches the outlet.

Fig 3



VANE TYPE SUPERCHARGER

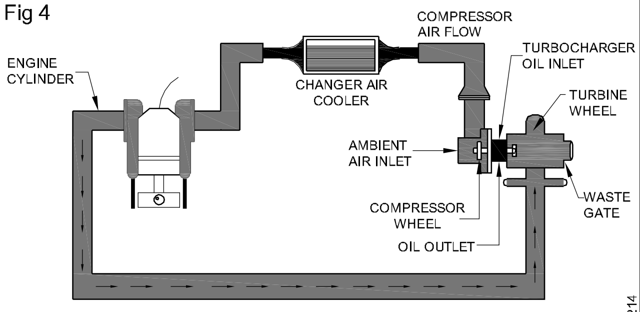
The roots supercharger is simpler in construction and requires least maintenance. It has comparatively long life. It works well even at lower speed ranges. Centrifugal type supercharger has poor working characteristics at lower speeds. Vane type supercharger has the problem of wear of vane tips.

Turbo charger passes compressed hot air into inter cooler and it heats up expands air the pressure increase from a turbocharger is the result of heating the air before it goes into the engine. In order to increase the power of the engine and get more air molecules into the cylinder.

Intercooler (Fig 4)

The intercooler (Fig 4) is an additional component that looks like a radiator, except that air passes through the inside as well as the outside of the intercooler. The intake air passes through sealed passageways inside the cooler, while cooler air from outside is blown across fins by the engine cooling fan.

Fig 4



INTERCOOLER

Charge air cooler and turbo charger

Charge air cooler and turbo charger are part of a high tech induction system that increases engine combustion efficiency. The turbo charger uses exhaust gases to compress air before it entire the charge - air cooler.

The compressed air going through the charge-air cooler is then cooled by the ambient air flowing across the cooler fins. The cooled air is more dense than warm air. So when it flow into the intake side of the engine, the increased density improves horse power, fuel economy and reduce the emissions.

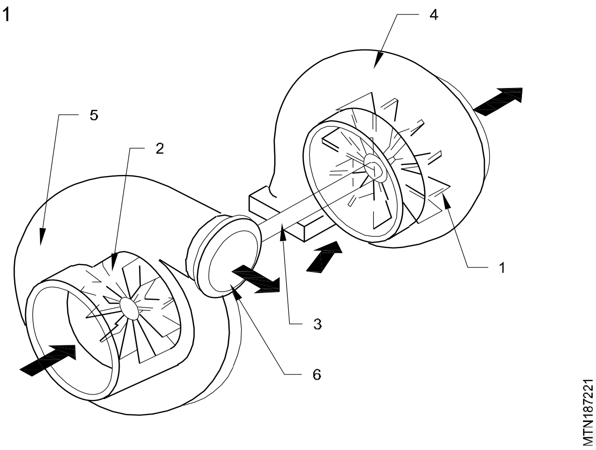
Turbocharger

Objectives: At the end of this lesson you shall be able to
- **explain constructional features of a turbocharger**
- **explain operation of turbo charger**
- **explain types of turbocharger.**

Turbocharger (Fig 1)

Turbo charger is mounted on the engine. It increases the amount of air delivered to the engine cylinder, thereby more fuel can be burnt which increases engine power. Whenever the density of air is less than the density at atmospheric pressure specially at higher altitudes, turbo charger helps the engine to get the sufficient air. An engine may have one or more turbo chargers.

Fig 1



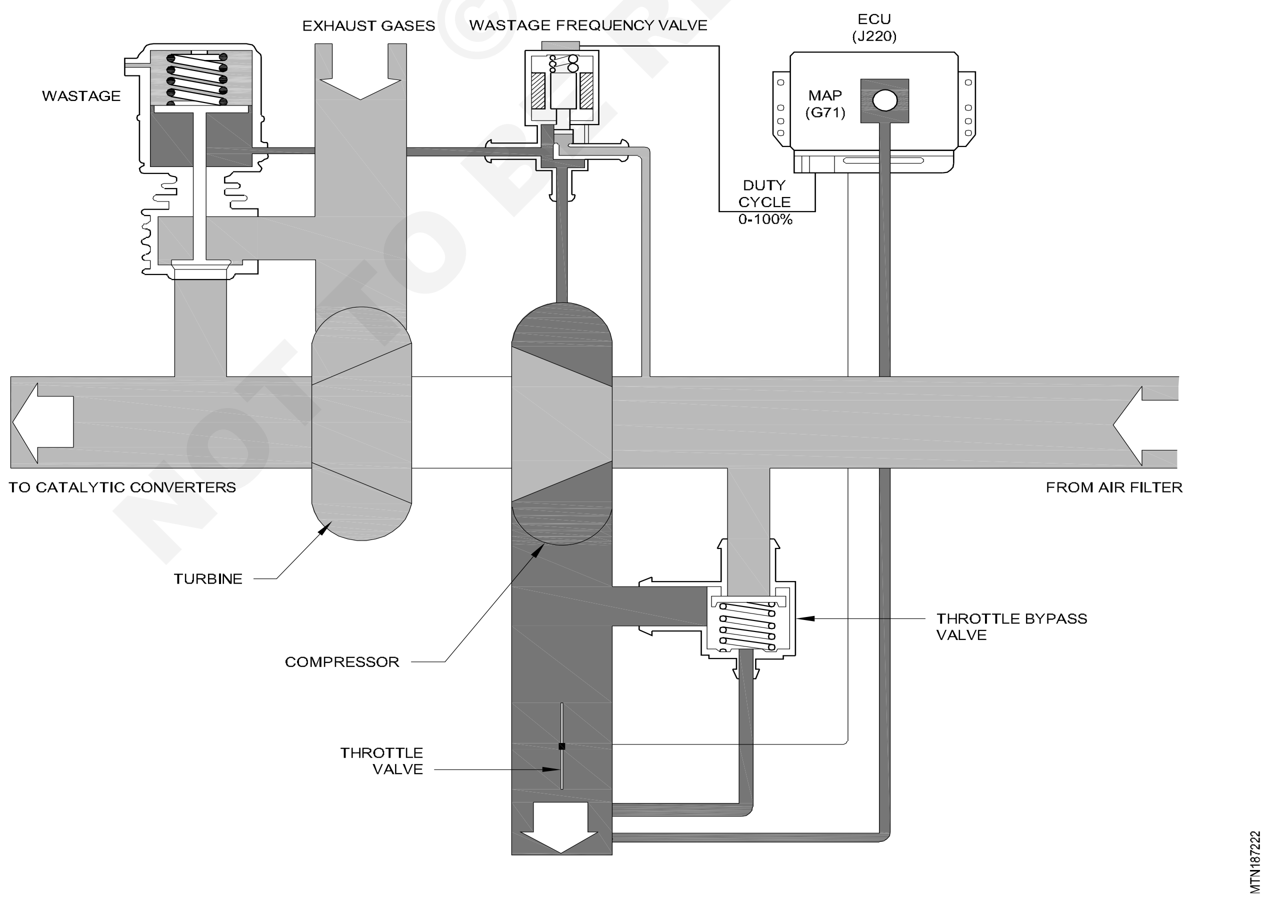
A turbocharger is mounted on the exhaust manifold. It has a turbine wheel (1) and a compressor wheel (2) on the same shaft (3). Exhaust gases enter in turbine housing (4) and rotate the turbine wheel (1). Compressor housing's (5) inlet is connected to the air cleaner and compressed air is discharged to inlet manifold through the outlet (6).

Turbocharger

Fixed Geometry Turbochargers (FGT)

A turbocharger consists of a turbine and a compressor linked by a shared axle. The turbine inlet receives exhaust gases from the engine exhaust manifold causing the turbine wheel to rotate. This rotation drives the compressor, compressing ambient air and delivering it to the air intake manifold of the engine at higher pressure, resulting in a greater amount of the air and fuel entering the cylinder. In FGT, (Fig 2) the amount of compressed air which has to be entered in the engine is controlled by a waste gate valve which regulates the turbo output depending on engine's speed.

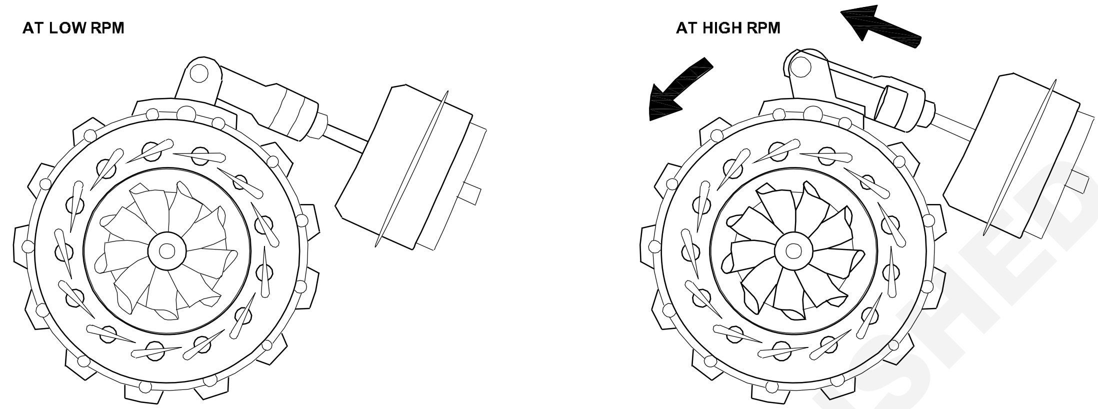
Fig 2



Variable Geometry Turbochargers (VGT)

Variable geometry turbochargers (VGTs) (Fig 3) are a family of turbochargers, usually designed to allow the effective aspect ratio of the turbo to be altered as conditions change. This is done because optimum aspect ratio at low engine speeds is very different from that at high engine speeds. If the aspect ratio is too large, the turbo will fall to create boost at low speeds; if the aspect ratio is too small, the turbo will choke the engine at high speeds, leading to high exhaust manifold pressures, high pumping losses and ultimately lower power output. By altering the geometry of the turbine housing as the engine accelerates, the turbo's aspect ratio can be maintained at its optimum. Because of this, VGTs have a minimal amount of lag, have a low boost threshold, and are very efficient at higher engine speeds.

Fig 3



Air cleaner and Air cooler

Objectives : At the end of this lesson you shall be able to
- **state the need of an air cleaner**
- **state the different types of air cleaners**
- **state the function of intake manifold**
- **state the function of an air cleaner.**

Atmospheric air consists of a large quantity of dirt and dust. Uncleaned air will cause faster wear of and damage to the engine parts, so air is filtered before entering inside the cylinder bore.

Purpose of air cleaner

- It cleans the intake air.
- It reduces the noise of the intake air.
- It acts as a flame arrester during engine backfire.

Location

It is mounted on the top of the air inlet manifold.

Types

- Wet-type (Fig 1)
- Dry-type (Fig 2 & 3)

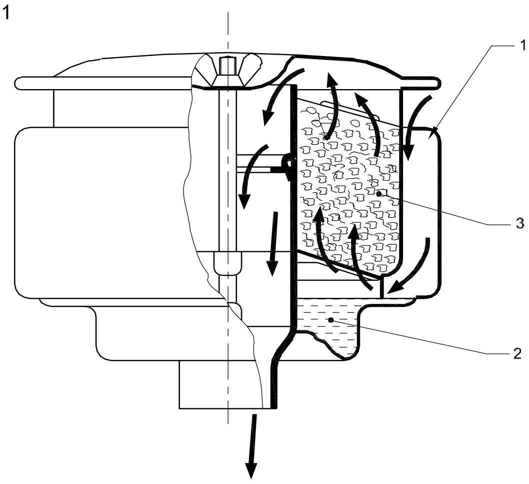
Wet type air cleaner

The atmospheric air enters the air cleaner through the side passage (1) and strikes on the surface of the oil (2). Heavy dust particles are absorbed by the oil. The partially filtered air, along with oil particles, moves upward through the filter element (3). Fine particles and oil particles are collected by the filtering element (3). Cleaned air then passes through the passage to the inlet manifold.

Dry type air cleaner

In this type of air cleaner, a specially treated paper element is used to filter the intake air.

Fig 1



Function

The atmospheric air enters the air cleaner (Fig 3) through the air entrance (1) and passes through the paper element (2). The filtered clean air goes to the intake manifold entrance (3).

Intake manifold

The intake manifold is connected with air cleaner and cylinder head intake port of the cylinder head. It is allow the fresh air to flow from air cleaner to cylinder through inlet valve. The intake manifold is made of a cast iron or aluminium.

Fig 2

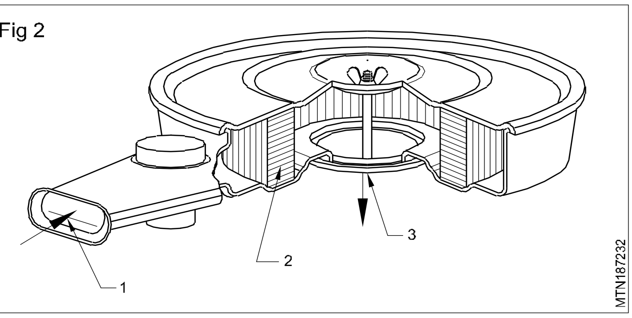
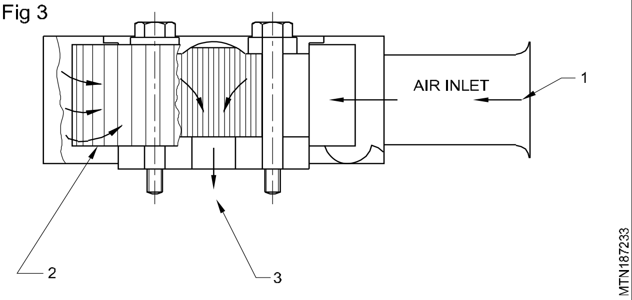


Fig 3

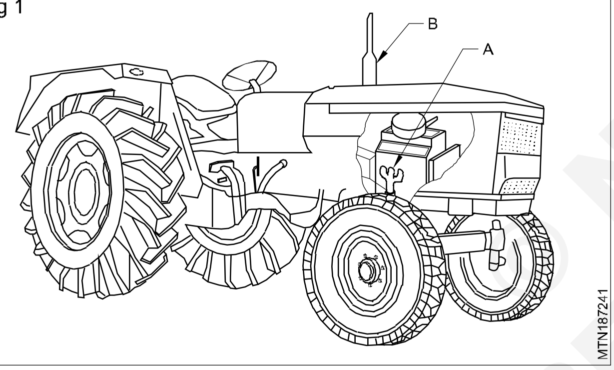


Manifolds and silencer

Objectives: At the end of this lesson you shall be able to
- **explain the purpose of the inlet manifold**
- **explain the purpose of the exhaust manifold**
- **explain the purpose of the muffler and tail pipe**
- **explain the constructional features of the muffler**
- **list out the different types of mufflers.**

Manifolds and silencer: The inlet manifold is used to supply the air-fuel mixture from the carburettor to the intake ports in the cylinder head. The inlet manifold is generally made of aluminium. In a diesel engine only air enters into inlet manifold from air cleaner.

Fig 1



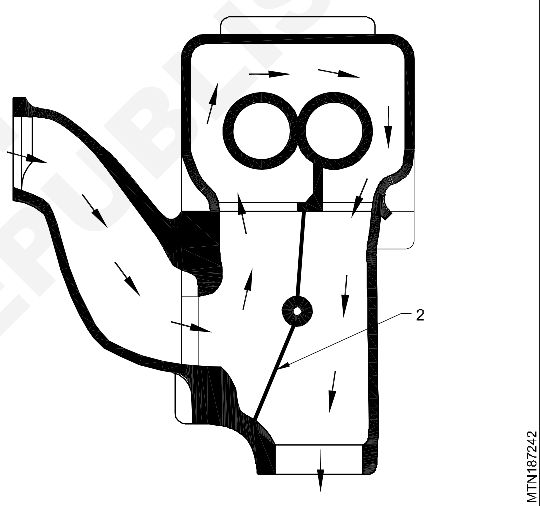
The exhaust manifold (A) is used to collect the exhaust gases from the different cylinders and send them to the silencer. The exhaust manifold is generally made of cast iron. The exhaust manifold may include a heat control valve (Fig 2) or a heat riser which has a thermostatically operated butterfly valve (2) fitted in exhaust manifold. When the engine is cold, the valve is closed and hot gases are directed around the inlet manifold. When the engine attains operating temperature the valve opens and the exhaust gases are directly sent to the muffler.

Exhaust pipes: The exhaust pipe takes the burnt gases from the manifold to the muffler. The pipes are steel tubes, suitably shaped and routed below the chassis to lead the gases away from the vehicle.

Mufflers: In many tractors, mufflers have a pipe extending from the outlet end. This pipe takes the exhaust gases higher above the tractor or lower, vertically keeping them away from the operator.

The upright mufflers have a cap attached to it. When the tractor is in operation, the counter balanced cap opens and when the tractor engine is shut off, it closes by gravity. The cap keeps out water and other materials entering the exhaust system, thus preventing damage to the engine.

Fig 2

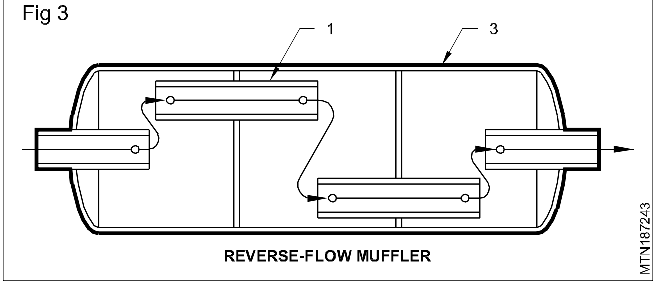


The muffler reduces the engine exhaust noise. It is a large cylindrical shaped container, fitted with passages and chambers that absorb and dampen the noise of the exhaust gases. Often a small or pre-muffler is fitted in the exhaust system between the manifold and the main muffler.

Types of mufflers

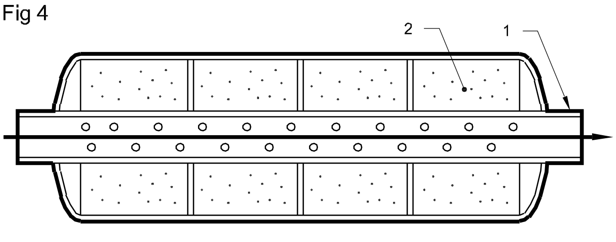
– **Reverse flow muffler** (Fig 3)**:** In this type, small pipes (1) are placed in the housing (3) of the muffler. Exhaust gases flow in a zigzag way, thus reducing the sound, by travelling through a longer length.

Fig 3



– **Straight through muffler** (Fig 4)**:** In this type a straight perforated tube (1) is placed throughout the length of the muffler. Glass wool or steel wool (2) is filled in between the perforated tube and the muffler housing, which acts as a sound absorbent.

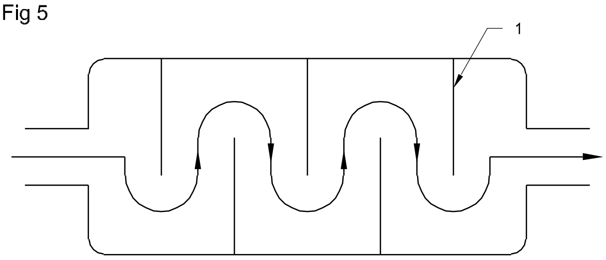
Fig 4



STRAIGHT THROUGH MUFFLER

– **Baffle type** (Fig 5)**:** In this type, a series of baffles (1) are placed in the muffler which causes restriction and back pressure to the exhaust gases, thereby reducing the sound of the exhaust gases.

Fig 5



Mufflers

Objectives: At the end of this lesson you shall be able to
- **describe the back pressure**
- **describe the back pressure muffler**
- **describe the electronic muffler.**

Back pressure

Any restriction to exhaust flow in the exhaust system creates back-pressure. Some back-pressure can be beneficial, excessive back-pressure reduces volumetric efficiency and reduces engine efficiency.

Variable flow exhaust/Back pressure muffler

A movable valve fitted within the exhaust system is used to change the amount of exhaust back-pressure. At higher engine speeds when exhaust noise levels are unacceptable, the valve is closed, thus reducing the bore of the exhaust. This enables greater back-pressure and noise reduction is the result. The valve can be operated by

- Pneumatics - exhaust gas pressure
- Electronics - a computer

When a variable flow exhaust is added to the baffle and chamber system, quieter noise emissions are the result. This is because the system can partially respond to changes in engine speed and load.

Electronic mufflers

Electronic mufflers are designed to produce anti noise without restricting exhaust flow. This computer-controlled system uses a microphone to detect the sound waves produced within the exhaust system. As the exhaust gas leaves the tail pipe, computer driven loudspeakers are operated to generate the correct amount of anti-noise.

The result is virtually silent exhaust without generating additional and unwanted back-pressure across all engine operating conditions. This increases fuel economy and reduces exhaust emissions.

Sensors and microphones pick up the pattern of the pressure waves an engine emits from its exhaust pipe (Figs 1&2). This data is analyzed by a computer. A mirror-image pattern of pulses is instantly produced and sent to speakers mounted near the exhaust outlet. Opposite waves are created that cancel of the noise. Noise is removed without creating back pressure in the muffler. Electronic mufflers can be designed to emit certain sounds or no sound at all.

Fig 1

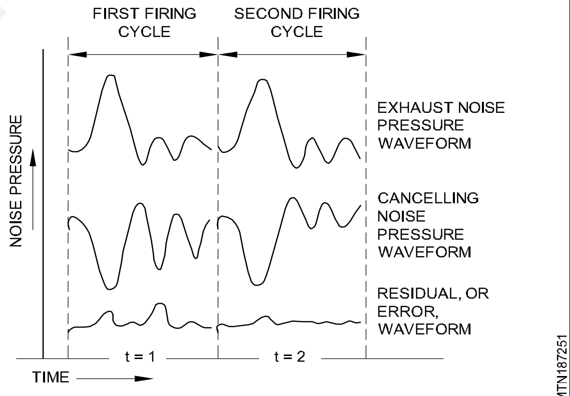
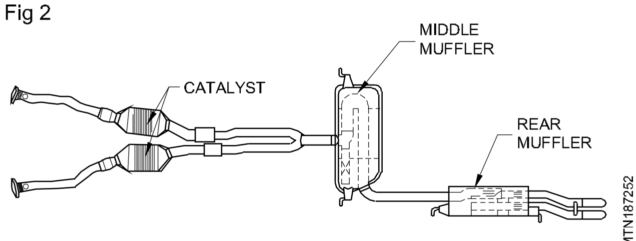


Fig 2



Absorption mufflers in exhaust system

This type of mufflers are almost indispenable element of modern exhaust systems. The absorption material is just modern exhaust systems. The absorption material is just as important as a calculation method for designing the mufflers in order to ensure that they are optimally used.

Absorption

Automotive exhaust noise can be attenuated is several ways. A distinction is generally made between active and passive attenuation. The modern engine exhaust system consist of more than one absorption muffler to reduce the noise and pollution. The absorption mufflers are disspate the sound energy through the use of porous materials.

Noise absorption components

Reactive / abosorption silencers in single package unit

Ceramic coatings

Ceramic coating is capable of withstanding of high temperature and it has very good chemical and corrosion resistance and possess excellent thermal barrier characteristics, providing a dramatic reduction in radiated heat. It is self-cleaning properties last for upto 5 years.

Ceramic coatings contain the gaseous heat with in exhaust pipes. The causes the gasses to heat up and expand as a result exhaust flow is boosted.

Catalytic converter: The catalytic converter looks like a muffler. It is located in the exhaust system a head of the muffler. Inside convertor are pellets or a honeycomb made of platinum or palladium The platinum or palladium are used as a catalyst (a catalyst is a substance used to speed up a chemical process). Catalyst is chemically oxidized or converted to carbon dioxide and water. This convertor works to clean the (exhaust) unburned hydrocarbons before they fly out the tail pipe.

Diesel Particulate Filters (DPF)

Objectives: At the end of this lesson you shall be able to
- **state the purpose of diesel particulate filters**
- **describe the working principle of diesel particulate filters**
- **state the importance of regeneration of diesel particulate filters**
- **describe the working principle of active regeneration of DPF**
- **describe the working principle of passive regeneration of DPF.**

Purpose of Diesel particulate filters

Diesel particulate filters (DPF) also called as 'particulate traps' have been developed to filter out PM from the diesel exhaust gases to meet very stringent emission limits.

During combustion of the fuel and air mix a variety of pollutant particles generically classified as diesel particulate matter is produced due to incomplete combustion.

Working principle of diesel particulate filters

Alumina coated wire mesh, ceramic fiber, porous ceramic monoliths etc., have been studied as filtration media. Presently, ceramic monolith of honeycomb type structure is used to trap the particulate matter as the gas flows through its porous walls. These filters are also termed as 'ceramic wall flow filters'.

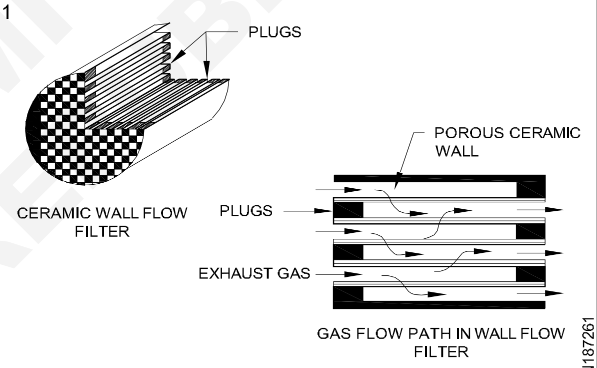
A ceramic honeycomb type particular filter is shown in Fig 1. In this cellular structure, alternate cells are plugged at one end and open at the opposite end. The exhaust gas enters the cells that are open at the upstream end and flows through the porous walls to the adjacent cells. The adjacent cells are open at the downstream end from where the filtered gas exits to the atmosphere. Flow path of gas through walls of the filter is also shown on Fig 1

Regeneration of DPF

It is relatively easy to filter and collect the particulate matter in the trap but the soot is to be burned in-suitable i.e., 'regenerate' the trap so that pressure drop across the filter is kept always at an acceptable level.

Burning of soot particles begins at about 540º C. Such high exhaust gas temperatures do not occur during engine operation for sufficiently long periods of time. The diesel exhaust gas temperatures in the exhaust pipe typically reach to about 300ºC only.

Fig 1



CERAMIC WALL FLOW FILTER FOR DIESEL PARTICULATE

Two types of regeneration systems have been investigated and a few developed for employment on production vehicles

Active regeneration

Passive regeneration

Active DPF Regeneration

In the active regeneration systems, sensors are used to monitor pressure drop across the trap. On receiving the signal from the sensor, the exhaust gas temperature is increased above 500º C by any one of the following techniques

Engine throttling - Throttling of air reduces airflow that results in decrease of overall air-fuel ratio, which increases the combustion and exhaust temperatures.

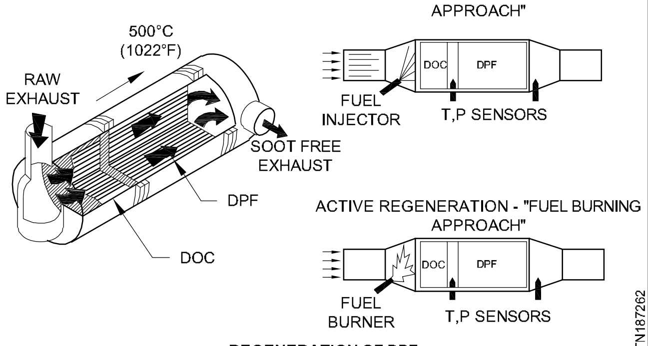
Use of electric heater upstream of filter - power to the electric heater is supplied by the engine alternator. A typical truck DPF regeneration system may require a 3 kw heater.

Use of burner upstream of filter - A diesel fuel burner is placed in the exhaust in front of the filter to regenerate the diesel particulate filter.

Passive regeneration

The passive regeneration systems (Fig. 2) employ catalysts to reduce soot oxidation temperatures to the levels that lie within the normal exhaust gas temperature range . The catalyst is either added to diesel added to diesel fuel in the form of additives or is impregnated on the surface of the filter substrate. Another approach for passive regeneration uses a special oxidation catalyst in the front of the ceramic wall flow particulate filter to promote soot oxidation. This system is known as the continuously regeneration trap (CRT).

Fig 2



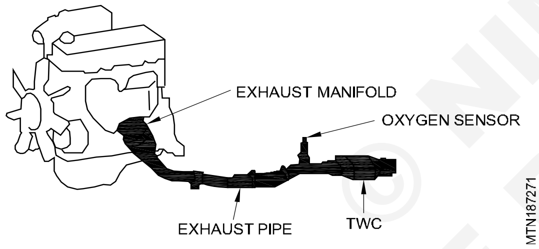
REGENERATION OF DPF

Catalytic converter

Objectives: At the end of this lesson you shall be able to
- **state the purpose of Catalytic converter**
- **explain the conversion principle of Catalytic converter**
- **describe the EVAP system components.**

Passenger cars and light trucks have been equipped with catalytic converters. A Catalytic converter is located (Fig 1) within the exhaust system and converts to convert harmful emissions as HC, CO, NOx, produced by an internal combustion engine, to less-harmful elements: H_2O (Water), CO_2(Carbon Dioxide), and N2 (Nitrogen)

Fig 1



Block Diagram of three-way catalytic converters (TWC) (Fig 3)

Modern vehicles are fitted with three-way catalytic converters (TWC). The term 'three-way' is in relation to the three regulated emissions the converter is designed to reduce:

- Unburnt Hydrocarbons are oxidized into water/steam.
- Carbon monoxide is oxidized into carbon Dioxide
- Oxides are converted into Nitrogen and Oxygen

The converter uses two different types of catalysts to reduce the pollutants: a reduction catalyst and an oxidation catalyst.

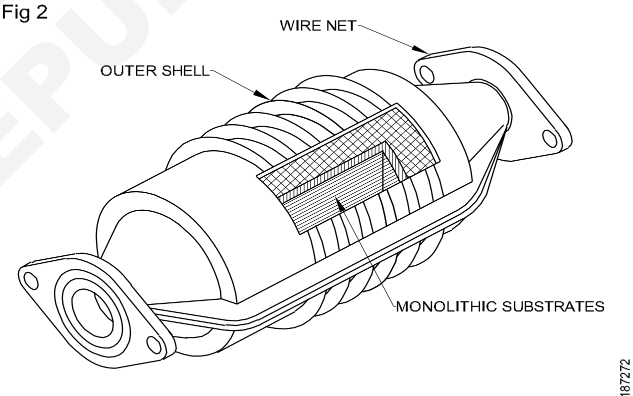
A honeycomb structure (Fig.2) as either ceramic or metallic is treated with a wash-coat of precious metals usually platinum, palladium and rhodium through which the exhaust gasses flow. The Surface of the honeycomb material has a rough finish such that it allows the maximum contacts are available to the exhaust gasses.

The exhaust gases first pass over the reduction catalyst in the converter. The platinum and rhodium coating helps to reduce the oxides of nitrogen, together known as 'NOX' emission.

The three - way Catalyst, which is responsible for performing the actual feed gas conversion, formed by coating the internal substrate with the following type materials.

The electronic control unit, or ECU, monitors the air-fuel ratio by using an exhaust gas oxygen, or EGO, sensor,

Fig 2



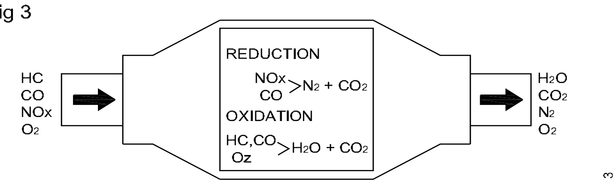
TWC - HONEYCOMB CATALYST ELEMENT

Material	Conversion for
Platinum/palladium	Oxidizing catalysts for HC and CO
Rhodium	Reducing catalyst for NOx
Cerium	Promotes oxygen storage to improve oxidation efficiency

also known as a lambda sensor. This sensor tells the engine computer how much oxygen is in the exhaust and uses this information via the ECU to control the fuel injection system.

The ECU can increase or decrease the amount of oxygen in the exhaust by adjusting the air-to-fuel ratio. The system ensures that the engine runs at close to the stoichiometric point in normal driving conditions. It also ensures that there is always sufficient oxygen in the exhaust system to allow the oxidization catalyst to deal with unburned hydrocarbons and carbon monoxide. (Fig 3)

Fig 3



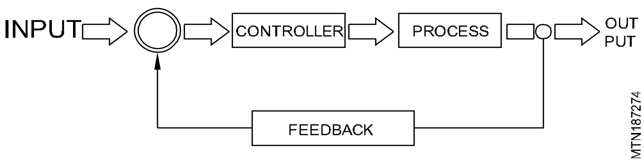
3-WAY CATALYTIC CONVENTER

OXIDATION AND REDUCTION PROCESS

Closed loop control system (Fig 4)

Control system in which the output has an effect on the input quantity in such a manner that the input quantity will adjust itself based on the output generated.

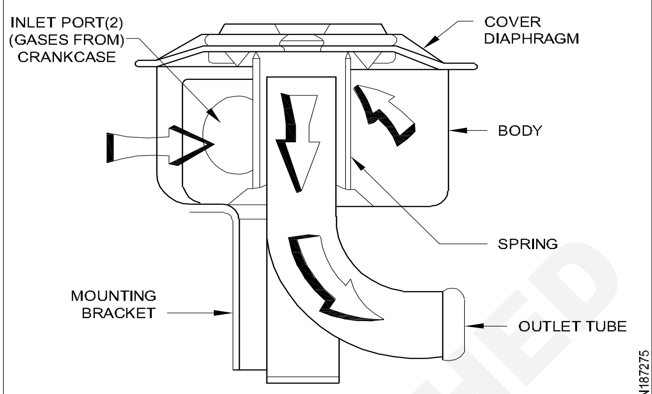
Fig 4



In this way closed loop control system is called automatic control system.

The diaphragm away from the top of the outlet tube allowing more gases into the main fold. The diesel crankcase ventilation system should be cleaned and inspected every 15,000 miles (24,000 km) or at 12 month intervals. **(Fig 5)**

Fig 5



THE CRANKCASE DEPRESSION REGULATOR VALVE

Exhaust Gas Recirculation (EGR) valve

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

- **state the purpose of exhaust gas recirculation (EGR) system**
- **describe the working principle of EGR valve**
- **describe the working principle of linear electronic EGR valve**
- **describe the working principle EGR system in diesel engines.**

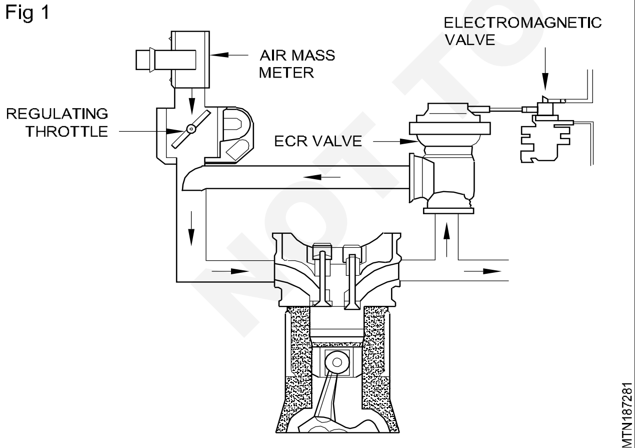
Purpose of exhaust gas recirculation (EGR) system

Purpose of exhaust gas recirculation (EGR) system's purpose is to reduce NOx emissions that contribute to air pollution.

Working principle of EGR valve

Exhaust gas recirculation reduces the formation of NOX and engine knock control. By re-circulating a allowing a small amount of exhaust gas into the intake air-fuel mixture on intake manifold as shown in Fig 1.

Fig 1



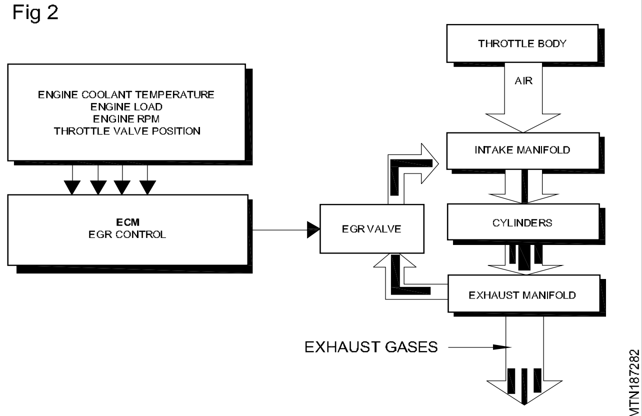
EGR, valve, connected between the exhaust port, or manifold, and the intake system.

If engine conditions are likely to produce oxides of nitrogen, the EGR valve opens, letting some gases is (only about 6 to 10% of the total) pass from the exhaust, into the intake system. During combustion, these exhaust gases absorb heat from the burning air and fuel. This lowers peak combustion temperatures (below 1500 degrees c) to reduce the reaction between the reaction between nitrogen and oxygen that forms NOx.

Older EGR systems use a vacuum regulated EGR valve while newer vehicles tend to have an electronic EGR valve to control exhaust gas recirculation.

When the engine is idling, the EGR valve is closed and there is no EGR flow into the manifold. The EGR valve remains closed until the engine is warm and is operating under load. As the load increase and combustion temperatures start to rise, the EGR valve opens and starts to leak exhaust back into intake manifold (Fig 2) This has a quenching effect that lowers combustion temperatures and reduces the formation of NOx.

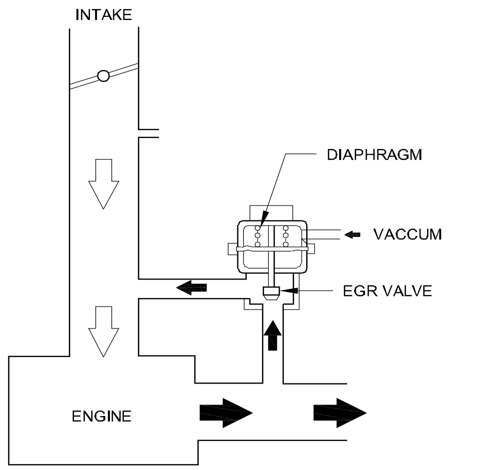
Fig 2



The EGR valve opens and closed the passage between the exhaust manifold and intake manifold. Vacuum is remove EGR valves.

Inside the vacuum actuated EGR (Fig 3) valve is a valve, diaphragm and spring. When vacuum is applied to diaphragm lifts the valve off its seat allowing exahust gases into the intake air stream. When vacuum is removed the spring forces the diaphragm and valve downward closing the exhaust passage.

Fig 3



Current technology of EGR valve

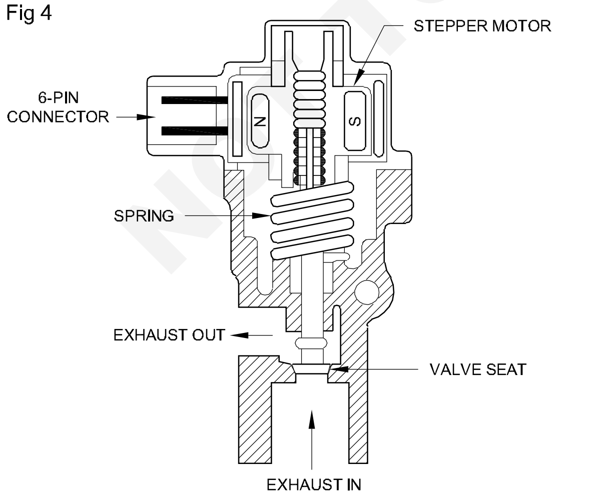
Linear electronic EGR valves

Electronic EGR valve is the"linear" EGR valve. (Fig 4) This type uses a small computer - controlled stepper motor to open and close the EGR valve instead of vacuum.

The advantage of this approach is that the EGR valve operates totally independent of engine vacuum. It is electrically operated and can be opened in various increments depending on what the engine control module determines the engine needs at any given moment in time.

Liner EGR valves may also be equipped with an EGR valve position sensor (EVP) to keep the computer informed about what the EGR valve is doing. (Fig 4)

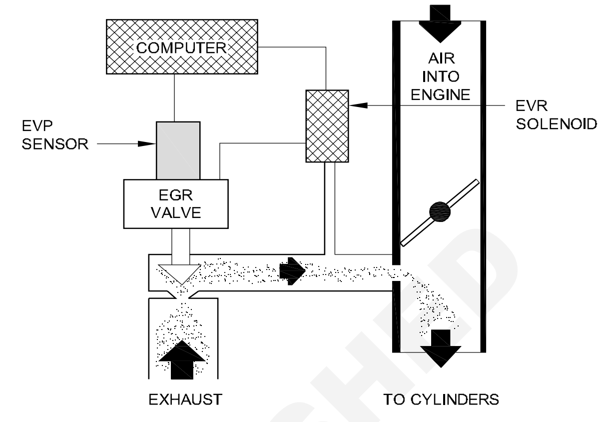
Fig 4



LINEAR EGR VALVE

The EVP sensor (Fig 5) also helps with self - diagnostics because the computer looks for an indication of movement from the sensor when the it commands the EGR valve to open or close. The sensor works like a throttle position sensor and charges resistance. The voltage signal typically varies from 0.3 (closed) to 5 volts (open).

Fig 5



LINEAR EGR SYSTEM CIRCUIT

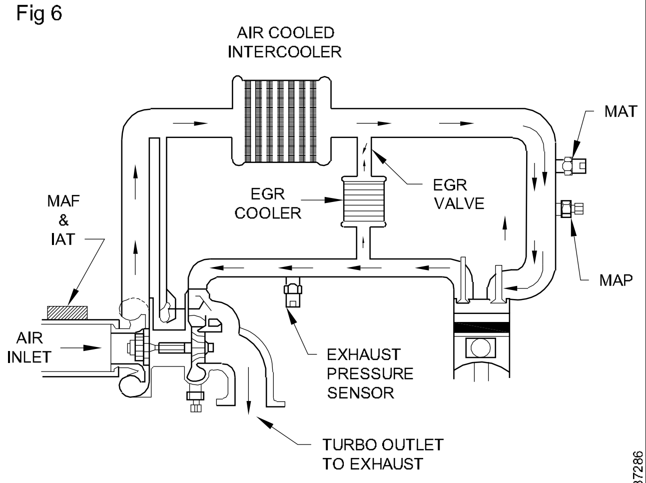
EGR system in diesel engines

The EGR systems (Fig 6) are quite the same as those used in gasoline engines, which means a sample of exhaust introduced into combustion chambers to reduce combustion temperatures. One of the main different is that most manufactures cool the incoming EGR gases before introducing them into the cylinders. This reduces the temperature of combustion and therefore reduces the amount of NOx emitted by the exhaust as shown in Fig 3.

Most systems with EGR coolers use engine coolant that passes through a separate circuit to cool the recirculated exhaust gases.

The ECU/PCM operates and monitors the EGR system, EGR flow is controlled by the ECU/PCM through a digital EGR valve. EGR flow will occur only when the engine is at a predetermined level and conditions are.

Fig 6



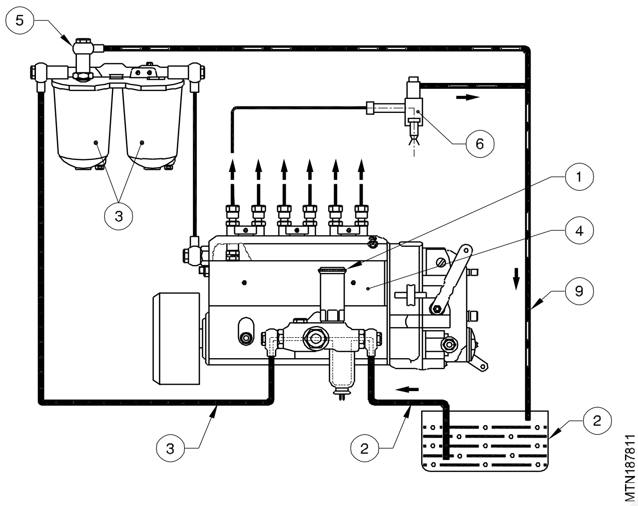
INTAKE EGR SYSTEM IN DIESEL ENGINE

Diesel fuel system

Objectives: At the end of this lesson you shall be able to
- **explain the layout of the fuel system**
- **explain the different types of fuels**
- **explain the specification and characteristics of fuel.**

Layout of the fuel system (Diesel) (Fig.1)

Fig 1



In a vehicle, fuel is sucked by the fuel feed pump (1) from the fuel tank (2). The fuel from the feed pump is supplied to the fuel filter (3). From the fuel filter (3) fuel is supplied in the fuel injection pump (4). The excess fuel from the filter is sent back to the fuel tank through the air flow valve (5). From the fuel injection pump the fuel is supplied to the injectors (6) at high pressure. The injector (6) atomises the fuel and sprays the fuel to in cylinder at a set time.

Function of fuel injection system

In this system diesel fuel is injected into the combustion chamber at the end of compression stroke in diesel engine.

If the amount and rate of fuel being injected is not measured, will result in uneven running of engine and it leading to vibrations and loss of power. The diesel fuel injection should be fully atomized into fine particles for it spreads one immediately in the combustion chamber to mix up with hot compressed air for high combustion. The injection should take place at the correct time, according firing order of the engine.

Fuel system must fulfil the following requirement

- Time the fuel injection and distribute the fuel properly in the combustion chamber.
- Measure the correct quantity of fuel injected.
- Control the rate of fuel injection.
- Fully atomize the fuel.
- Develop pressures well in excess of the combustion chamber pressure.

An engine converts heat energy of fuel into mechanical energy. The engine fuel may be solid, liquid or gas. Solid fuel (coal) is used in external combustion engine. e.g. steam engine. Liquid gases and fuel are used in internal combustion Engines.

Octane number

It is a measure to determine the burning quality of the gasoline which has a tendency to resist knocking in an engine. The higher the octane number the lesser the tendency to knock.

Volatility

Volatility is the ability of the gas online to evaporate, so that its vapour will adequately mix with air for combustion. Vapourised fuel will burn easily.

Viscosity

This is a physical property. This indicates the quality of fuel to flow. A lower viscosity fuel will flow more easily than that of higher viscosity.

Sulphur content

Diesel and gasoline contain some sulphur. Sulphur present in the fuel increases the corrosion of the engine and, therefore, it is reduced at the refinery to the maximum possible extent.

Additives

Several chemical additives are mixed with the fuel to improve combustion and control harmful deposits and to increase the anti-freezing quality of the fuel.

Detergents are also added to keep clean certain critical components inside the engine.

Diesel fuel

Diesel engine fuel is highly refined distillate fuel obtained from fraction distillation of crude oils.

There are light medium and heavy types of diesel fuel available in the market, which are used as per the recommendations of the engine manufacturers.

The diesel fuel should be light and have a very low viscosity. In general a high octane number implies a low cetane number.

Detonation (Abnormal combustion)

Normal combustion occurs gradually in each cylinder. The flame advances smoothly across the combustion chamber until all the air/fuel mixture is burnt. When the flame fails to reach a portion of the mixture before its temperature reaches the point of self-ignition, detonation occurs. Due to detonation a knocking sound is heard in the engine. This causes power loss.

Concept of quiet diesel technology

Technology for quieter, smoother diesel

The combustion pressure in diesel engine cylinder rises intensely and the maximum pressure is extremely high compared with a petrol engine, because of the differences in the combustion method. As a result, diesel engines generally produce more noise, vibration and harshness than petrol engines, and this is a major complaint among diesel users. Efforts to reduce the NVH to the level of petrol engines by making full use of the latest technology.

Pilot injection system to reduce combustion pressure

The sudden rise in combustion pressure is a major source of diesel engine noise. By the development of the common rail high-pressure injection system and electronic fuel injection, flexible and precise control over the injection timing and amount made possible. The fuel pressure rise controlled by smoothing the combustion process by pilot injection, a method in which a small amount of fuel is injected and ignited just before the main fuel injection process. This is known as pilot injection control process.

Increased rigidity of engine structure

The maximum cylinder pressure in diesel engine is considerably high and the pressure rise during combustion is very rapid, causing the engine vibration and noise. Also, diesel engine components such as the piston are solidly built in order to endure the high pressure and pressure increase ratio. The extra weight of these components translates into increased inertia, the scale of vibration. it is possible to control noise generation by reforming the engine structure to absorb vibration and to reduce the overall level of vibration. Moreover, vibration travels from the piston to the connecting rod, crankshaft and engine block. This form of vibration attenuated by employing a ladder frame structure with a more rigid crankshaft bearing.

Other technologies used to reduce NVH (Noise vibration and harshness)

A secondary balancer is use to help smooth out the vibrations characteristic of four-cylinder engines.

pairs of gears or scissors gears, working side by side with the same numbers of teeth, help to reduce mechanical engine noise by reducing the gear play.

The two sides of the flywheel, which face the engine and the transmission respectively, are each fitted with a spring and damper to absorb vibration caused during changes in speed.

Clean diesel technology

Clean diesel is a new generation of diesel made up of a three part system.

1 Advanced engines
  Highly efficient diesel engines
2 Cleaner diesel fuel
  Ultra-low sulfur diesel
3 Effective emissions controls
  Advanced emissions control

This new system ensures that advanced diesel engines will continue to play an important role in the transport of people and goods in the future, while helping meet greenhouse gas and clean air objectives in the world.

Technical innovation has helped progressively to lower vehicle emissions - over the last 15 years, nitrogen oxides (NOx) limits for diesel car engines have been reduced by 84% and particulates (PM) by 90%.

15% less CO_2 Emissions than equivalent petrol-powered vehicles. Diesel vehicles contribute to reducing CO_2 emissions from road transport and therefore to reduce climate change. Clean diesel fuel technology is involved with diesel fuel, engine & emission control.

Fuel tank and fuel pipes

Objectives: At the end of this lesson you shall be able to
- **explain the function of the fuel tank**
- **explain the function of each part of fuel tank**
- **explain the function of fuel pipes.**

Fuel tank

The Fuel tank is provided for storing diesel required for running the engine. It is constructed of either pressed sheet metal with welded seams and special coating to prevent corrosion or fiber glass reinforced plastic materials.

It may be round or rectangular in shape. It is mounted above the engine assembly.

Parts of the fuel tank
Filler neck and cap
Baffle
Fuel gauge sensing unit (Float)
Filter
Sediment bowl and drain plug

Filler neck is provided for pumping diesel into the fuel tank. A cap is provided for closing the tank tightly. A vent hole is provided either in filler neck or in cap to maintain atmospheric pressure in the tank above the fuel.

Baffles are provided in the fuel tank to minimize the sloshing of fuel due to movement inside the tank.

Fuel gauge sensing unit is provided to know the level of fuel available in tank. It consists of a float resting on the surface of the diesel in the tank. The float with the help of the electrical sensing system indicates the level of the fuel available in the tank, on the dash board fuel-gauge.

Filter is provided at the lower end of the suction pipe. It filters heavy foreign particles.

At the bottom of the fuel tank a drain plug is provided to collect sediments and drain it out of the tank.

Fuel pipe

Fuel pipe between the fuel tank and the feed pump is called suction pipe, the pipes between F.I.P. and the injectors are called high pressure pipes. An over flow pipe is provided on fuel filter bowl and injectors to supply excess fuel back to fuel tank.

Fuel filter

Objectives: At the end of this lesson you shall be able to
- **state the need of a fuel filter**
- **explain the types of fuel filter systems**
- **explain the need for bleeding the fuel system**
- **state the function of water separator.**

Need of fuel filter

Effective filtering of fuel, oil is most important for long trouble free functioning of the engine. Diesel fuel while transporting and handling has chances of getting contaminated by water, dirt, bacteria and wax crystals. Dirt is the worst enemy of the fuel injection equipment. Dirt contamination can be the result of careless filling of the fuel tank. When fuel tank is not filled, moist air condenses inside the metal wall of the fuel tank resulting in water contamination of the fuel.

For these reasons a very efficient filtering system is required to remove these impurities.

Types of fuel filter system

There are two types of fuel filtering system.

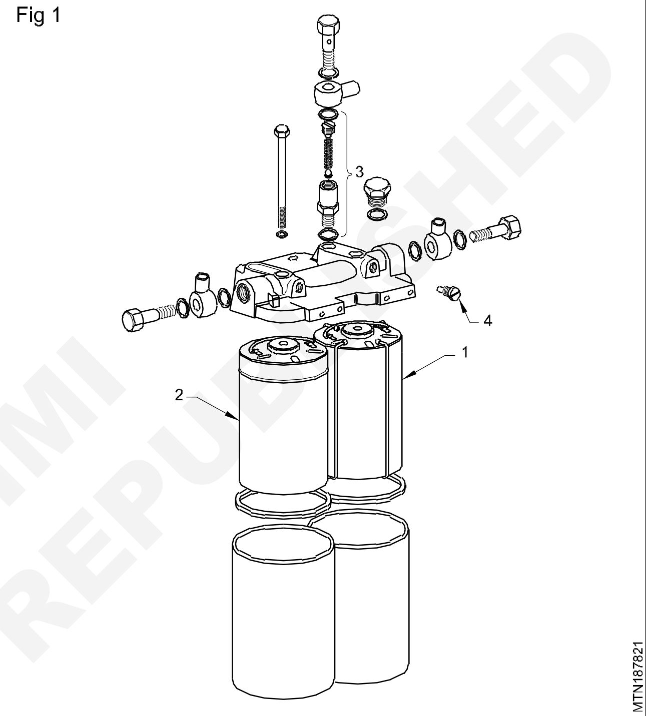
Single filter system

Two stage filter system

In a single filtering system one single filter assembly is used in between feed pump and fuel pump. The single filter in this system is capable of separating dirt from fuel. It should be replaced periodically as per the recommendations of the manufacturers.

In a two stage filter system, primary filter (1) (Fig 1) is used for filtering large solid contaminants and most of the water in the fuel is also removed by this filter. The secondary filter (2) is made of a paper element. This filter controls the size of the particles allowed to pass into the fuel injectors. It also separates any water that might have passed through the primary filter. An overflow valve assembly (3) is used to send back excess fuel to fuel tank. A bleeding screw (4) is provided to bleed the air from fuel system.

Fig 1



Fuel filter element

A paper element is most suitable because important properties which determine filter quality such as pore size and pore distribution can be effectively maintained. Generally paper filter elements are used at the secondary stage filtration process.

Coil type paper filter inserts are wound around a tube and neighbouring layers are glued together at the top and bottom. This forms a pocket with the openings at the top.

In the star type paper filter inserts, the fuel flows radially from outside to inside. The paper folds are sealed at the top and bottom by end covers.

Cloth type filter inserts are used for primary stage filtration. In this the fuel flows radially from outside to inside. The cloth is wound over a perforated tube whose ends are sealed at the top and bottom by end covers.

Bleeding of the fuel system

Bleeding is the process by which air, which is present in the fuel system, is removed. Air locking in the fuel system will result in erratic running of the engine and may result in stopping of the engine. Bleeding is carried out by priming the filter. A slight loosening of the bleeding screw allows locked air to escape as bubbles along with the fuel. When locked air escapes and the system is free of air, the screw is tightened finally.

Diesel fuel water separator

A fuel water separator is device that works to ensure clean fuel is delivered to the engine.

The fuel water seperator is a small filtering device used to remove water from the diesel fuel before it reaches to the sensitive partsof the engine. Water and contaminants have a direct impact on the service life and performance of diesel engines.

Besides being abrasive to engine components and cylinder walls, water and combination displaces diesel fuels lubricative coating on precision injector components, causing tolerance erosion, surface fitting, fuel loss and poor performance.

The first stage of the fuel water separator uses a plated paper element to change water particles into large enough droplets that will fall by gravity to a water sump at bottom of the filter. The second stage is made of silicone treated nylon that acts as a safety device to prevent small particles of water that avoid the first stage from passing into the engine. To remove the water from the fuel water separator, open the valve to drain the water from filter if the water separator fails, water in the fuel can wear away lubricants on the diesel fuel injectors, so that fuel water separator is important part of fuel system.

Components of Fuel Water Separator Filter (FWSF) components

Fuel water, separater filter provide a better way to filter fuel and it have twist fuel filter water separating system.

- Filter
- Water collection bowl
- Water drain valve with WIF sensor or threaded port

Benefits

- Protect the engine components
- Extend the equipments life

Features

- It is easy to switch over water from fuel
- Water separating fuel filter with standard twist & drain.
- Water collection bowel for easy visual inspection.
- Alternative twist and drain valve with water in fuel (WIF) sensor or threaded port.

Bleeding of the fuel system

Diesel fuel bleeding is the process by which air removing from the diesel fuel system is called the bleeding.

Presence of air in the fuel system will make the erratic running and loading to engine vibration or stop the engine. Hence air is to be removed from the diesel fuel system. Bleeding is carried out by hand the pump build up fuel pressure in fuel line and slight loosening of the bleeding screw of filter allows locked air to escape as bubbles along with fuel. Ensure complete air escapes and the system is free of air, the screw is tightened finally.

Fuel feed pump

Objectives: At the end of this lesson you shall be able to
- **explain the function of a feed pump**
- **explain the construction of a feed pump**
- **explain the working of a feed pump.**

Function

A feed pump is usually mounted on the F.I.P. and is driven by the camshaft of F.I.P. It sucks fuel from fuel tank and supplies it to fuel filters.

Construction

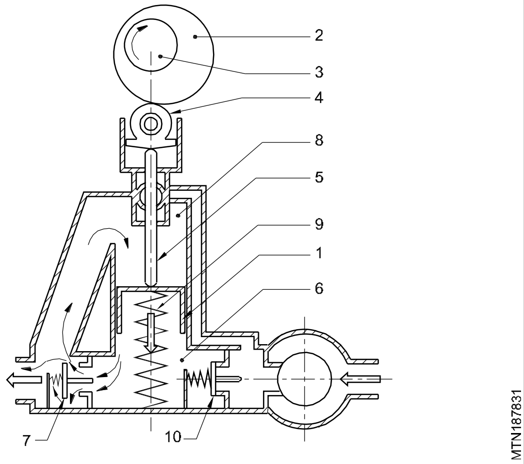
The fuel feed pump consists of a barrel, a plunger, a plunger return spring, spindle, roller tappet, suction and delivery valves, hand primer and pre-filter.

Working

The feed pump plunger (1) (Fig 1 & Fig 2) is driven by the cam (2) provided on the F.I.P. camshaft (3). When the plunger moves "downwards" by means of roller tappet (4) and pressure spindle (5) a portion of the fuel present in the suction chamber (6) is delivered through the pressure valve (7) to the pressure chamber (8) and the plunger spring (9) compressed in an intermediate stroke. Towards the end of this stroke the spring loaded pressure valve closes again.

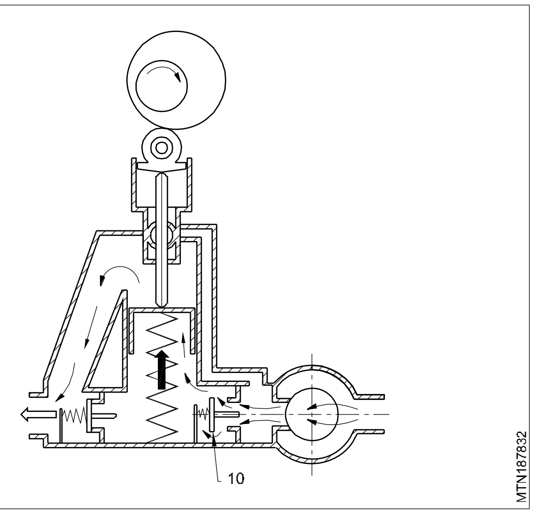
As soon as the cam or eccentric has passed its maximum stroke, plunger, pressure spindle and roller tappet move "upward" due to the pressure exercised by the plunger spring. A portion of the fuel present in the pressure chamber is thereby delivered to the fuel injection pump through filter. However, fuel is sucked simultaneously from the fuel tank to the suction chamber through the primary filter provided in the feed pump and suction valve (10).

Fig 1



When the pressure in the feed pipe exceeds a specified, pressure the plunger spring lifts the plunger only partially. The quantity of fuel delivered per stroke in this is comparatively smaller. When the fuel pipe line is full and the F.I.P. does not need further fuel the feed pump should be put out of action. Due to the excess fuel in the fuel outlet line the pressure in the pressure chamber, holds the plunger in the top position putting the feed pump out of action. During this period only spindle works. The moment the pressure falls down the spring forces the plunger down and the pumping action is resumed. This action during which fuel is not supplied by feed pump is known as idling of feed pump.

Fig 2



Hand priming device

The hand priming device is screwed into the feed pump above the suction valve. When the engine is at rest, with the aid of the hand priming device fuel can be pumped from the fuel tank through the filter to the F.I.P. In order to operate the primer the knurled knob is screwed out until the plunger can be pulled upwards causing the suction valve to open for fuel to flow into the suction chamber.

When the plunger is pressed down the suction valve closes while the pressure valve opens and fuel flows through the feed pipe and the filter to the F.I.P. After the use it is essential to screw the knob again in its original position.

Preliminary strainer

The preliminary strainer is usually attached to the feed pump. The function of the preliminary strainer is to prevent the coarser impurities at a very early stage. It consists of a housing with a nylon/wire gauge insert or a wire mesh sieve.

Fuel injection pump

Objectives: At the end of this lesson you shall be able to
- **explain function of F.I.P.**
- **explain constructional features of F.I.P.**
- **state the need of calibration**
- **list out types of fuel injection system**
- **explain air injection and airless injection**
- **state the need of a governor**
- **list out different types of governors**
- **explain constructional features of governors**
- **explain operation of governor.**

Function of the F.I.P.

Fuel Injection Pumps are designed to deliver specific quantity of fuel to the combustion chamber through an injector at a specific time.

Types of F.I.P.

There are two types of F.I.P.

Inline pump

Distributor or rotary type pump.

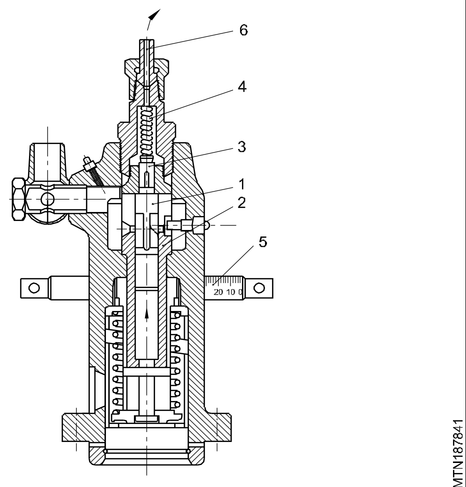
The inline pump has a plunger and barrel assembly for each cylinder of the engine. The assemblies are grouped together in one housing that resembles cylinders of an engine block.

Distributor or rotary type of fuel injection pump has a single pumping element, which supplies fuel to all the cylinders. Distribution to the individual injector is effected by a rotor having a single inlet and delivery, in turn to the appropriate number of outlets. This is done with the help of rotor. Cylindrical plungers and drilled holes in the bore.

Working of a F.I.P.

When the plunger (1) (Fig 1) is at its bottom position fuel enters through the barrel's (2) inlet port from the feed pump, fills the space above the plunger in the barrel and excess fuel flows out through the spill port. In a primed system, the barrel(2), all the pipes and the entire system is filled with the fuel. As the plunger rises up due to cam operation,

Fig 1



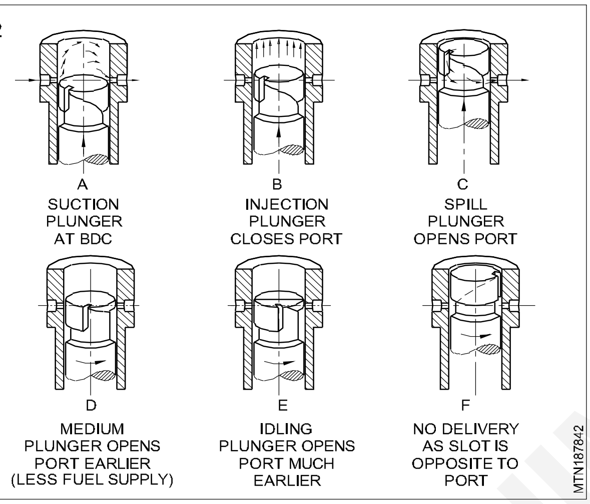
certain amount of fuel is pushed out of the barrel through the ports. As soon as the ports are closed by the plunger, the flow of fuel is stopped and the fuel above the plunger in the barrel is trapped and is pressurized. The pressure increases to as high as 400 to 700 bar (kgf/cm²) .

This pressure lifts the fuel delivery valve (3) and the fuel enters the fuel line (6) which is connected to the injector. As the pipe is already full of fuel the extra fuel which is being pumped causes a rise in the pressure throughout the line and lifts the injector valve. This permits the fuel to be sprayed into the combustion chamber in a fine mist form.

It continues until the lower edge of the helical groove in the plunger uncovers the port in the barrel. As soon as the port is uncovered, the fuel by passes downwards through the vertical slot and flows to the port. This causes a drop in pressure and delivery valve closes under its springs (4) pressure. With the consequent drop in the fuel line the injector valve also closes and cuts off the fuel injection.

The plunger stroke is always constant. But by rotation of the plunger in the barrel, it is possible to deliver the fuel earlier or later in the stroke and control the quantity of fuel sprayed. (Fig.2) The rotation of the plunger is obtained by operating the control rack (5), which is in turn connected to the governor.

Fig 2



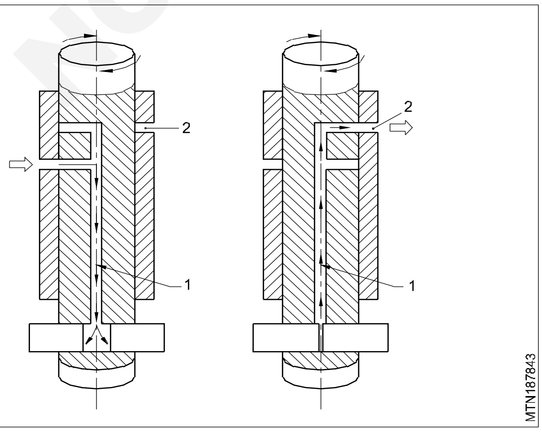
The governor controls all engine speeds upto a maximum, according to pedal pressed by driver. Different positions of the plunger and the fuel flow is given in the figure.

Constructional features of distributor type F.I.P.

It has a single pumping element which supplies fuel to all cylinders. The distribution to the individual injector is effected by a rotor having a single inlet and delivery equal to the number of cylinders. This ensures in built and uniform delivery to all injectors.

The pumping element consists of two plain opposed cylindrical plungers in a diametrical hole in the rotor head, an extension of which forms the distributor. An axial hole (1) (Fig 3) drilled in this extension connects the pumping chamber with a racked hole which registers in turn with racked delivery ports (2) due for each cylinder of the engine.

Fig 3



Need for calibration

In a multi cylinder engine it is necessary that equal and specified quantity of fuel is supplied to each cylinder by fuel injection pump at specified time. The measurement of fuel delivered by each plunger with the control rod in a fixed position and its comparison is called calibration of F.I.P. The adjustment for varying the fuel delivery can be done by altering the position of the control sleeve of each plunger. It is achieved by calibrating the F.I.P. on a test bench by a correct chart as recommended by the manufacturer.

Phasing is the process of testing the pump for the accuracy of their supplying fuel at correct intervals.

Cooling and lubrication

The single-plunger injection pump can be mounted in any position. In operation, its interior is completely filled with Diesel fuel under slight pressure in order to prevent intrusion of air and dust; and also to prevent rust formation caused by condensation. Excess fuel is recirculated within the pump to provide adequate cooling and lubrication.

Types of fuel injection system

There are two types of fuel injection system for diesel engines.

Air blast injection.

Mechanical injection.

Air blast injection

In the air blast injection system, a high pressure air blast drives the fuel at a very high velocity into the cylinder where it is mixed with the compressed air in the cylinder and ignites.

Mechanical injection

In mechanical fuel injection system, fuel is forced in from a mechanical fuel injection pump through injectors. These are of two types -

Low pressure fuel supply system.

Metering injection system.

All fuel supply systems use the same components, although the components vary in size and location within the system.

Low pressure fuel supply system

The low pressure fuel supply system consists of one or more fuel tanks, a feed pump, fuel filters, hand priming pump, overflow valve and a return orifice.

Metering injection system

It consists primarily of injection pump and injector and categorized as below, depending on the metering system.

(i) Pump controlled system

This is operated with a high pressure plunger and metering mechanism

(ii) Unit injectors system

This system is similar to the pump controlled system except that the high pressure pumping and metering mechanism are an integral part of the fuel injector.

(iii) Common rail system

This type of system uses a high pressure fuel pump that is connected to a common fuel rail. Each cylinder's fuel injector is connected to the common fuel rail.

Governors

The governor is a device for holding any speed steady between idling and maximum speed. The fuel injection pump operates in conjunction with a governor, which is required to control the injected quantity of fuel so that the engine neither stalls when idling nor exceeds the maximum speed for which it is designed.

Following Types of Governors are used

Mechanical

Pneumatic

Servo

Hydraulic

Mechanical Governor

Mechanical governors have speed measuring mechanism and fuel controlling mechanism actuated by mechanical arrangement. Two fly weights (Fig 4) (1) are mounted to the governor's drive gear or directly fastened to the camshaft. The centrifugal force of the fly weights actuates the fuel control mechanism.

Pneumatic Governor

In this type of governors the fuel control rack (1) (Fig.5) is actuated by joint effort of the atmospheric pressure, governor spring and allow pressure chamber (2) connected through a tube to the auxiliary venturi.

Servo Governor

In servo type of Governors the fuel controlling mechanism is actuated by hydraulication. This of governor reduced the effort required to move the fuel control device since a small force is necessary to move governor control mechanism.

Fig 4

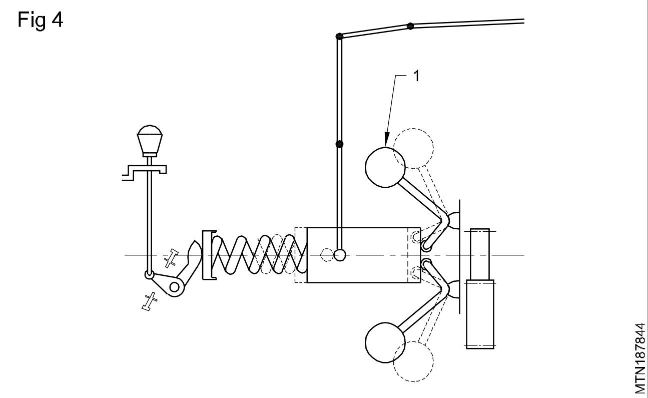
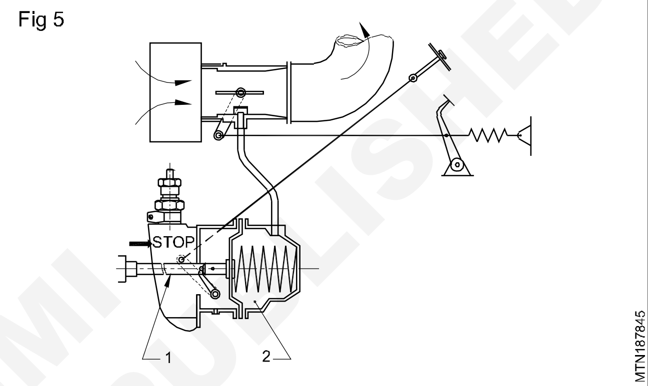


Fig 5



Hydraulic Governor

In this type of Governors the fuel controlling mechanism is actuated by hydraulic action. This of governor reduces the effort required to move the fuel control device since a small force is necessary to move governor control mechanism.

Nozzles

Objectives: At the end of this lesson you shall be able to
- **explain function of injectors**
- **list out different types of injectors**
- **explain special features of various types of nozzles**
- **explain specification of nozzle and nozzle holder.**
- **explain cumming & detroit diesel injection**
- **state the function of glow plug.**

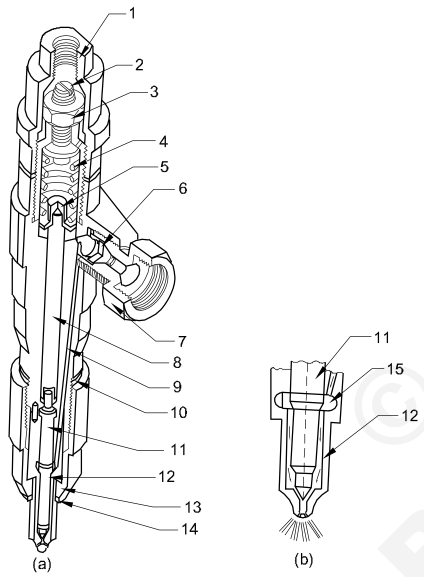
Fuel Injectors Fig 1

The function of the fuel injector is to deliver finely atomized fuel under high pressure to the combustion chamber for the engine. All component parts of the injector are carried in nozzle holder(10.) The main part of the injector is the nozzle comprising nozzle body (12) and nozzle valve (11)The nozzle body and needle valve are fabricated from alloy steel. They are thoroughly machined and have high surface harness necessary for operation in condition of high temperatures and elevated pressures. The bore in the nozzle body and the nozzle needle valve are lapped to a close tolerance and are a matched set, so that neither the nozzle body nor the needle valve may be replaced individually. The needle valve is pressed against a conical seat in the nozzle body by spring (4) acting through the intermediary of stem 8. The spring pressure is adjusted by adjusting screw (2). The adjusting screw is screwed in the bottom of the injector spring cap nut which in turn is screwed in the nozzle holder. Lock nut (3) is used to prevent the adjusting screw from unscrewing spontaneously. The screw is covered by nozzle holder cap nut (1) provided with a threaded hole to connect the leak-off pipe through which the leak-off fuel (used to lubricate the nozzle valve) filling the pressure spring and adjusting screw area is returned to the fuel tank or the secondary fuel filter.

In operation, fuel from the injection pump enters pressure chamber (gallery) (15) in the nozzle body through supply passage (9) and a high-pressure pipe. When the fuel pressure in the pressure chamber becomes so high that the force acting on the pressure taper of the needle valve from below exceeds the set spring force on the stem, the needle valve lifts off its seat and comes to rest with its upper shoulder against the face of the nozzle holder. Fuel is then forced out of the nozzle spray holes into the combustion chamber in a spray pattern which depends on the type of nozzle used.

After the injection of fuel has been ended, the fuel delivery from the injection pump ceases, the pressure in pressure chamber 15 of the nozzle drops instantly, and the pressure spring snaps the needle valve onto its seat, preventing unpressurized fuel from leaving the nozzle. The fuel injector is installed in a brass injector tube, or sleeve, which is fitted in a hole in the cylinder head, and is held in place by a special clamp.

Fig 1



(a) Construction :
(b) Illustrating the operation of the injector :
1-Cap nut.
2-Adjusting screw.
3-Lock nut.
4-Spring.
5-Spring nut
6-Screen filter.
7-Inlet fitting.
8-Spindle.
9-Fuel passage.
10-Nozzle holder.
11-Nozzle needle valve.
12-Nozzle body.
13-Nozzle cap nut.
14-Washer.
15-Nozzle pressure chamber (gallery)

FUEL INJECTOR

MTN187851

Injectors are provided to atomise the fuel into engine cylinder. This is done to achieve complete combustion.

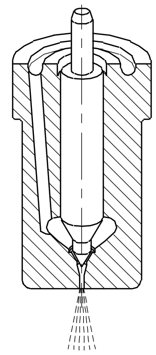
Following types of nozzles are used in engine.

- Single hole type (Fig 2)
- Multihole type (Fig 3)
- Longstem type (Fig 4)
- Pintle type (Fig 5)
- Delay nozzle (Fig 6)
- Pintaux nozzle (Fig 7)

Single hole type (Fig.2)

In this type, one hole is drilled centrally or in an angle through its body which is closed by nozzle valve.

Fig 2



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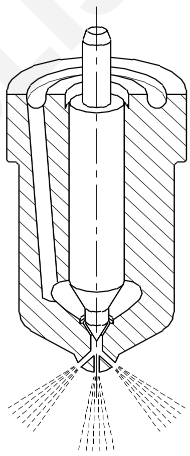
Multihole type (Fig.3)

In this type varying number of holes are drilled at the end of the body. The actual number of holes depend upon the engine requirement.

Fig 3



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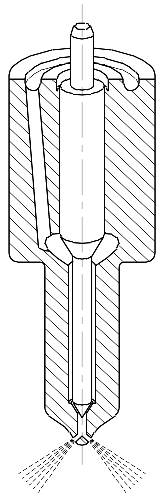
Longstem type (Fig.4)

For providing adequate cooling for the standard short stem nozzle, a different type of nozzle with a small diameter extension has been developed. This is called long stem nozzle.

Fig 4



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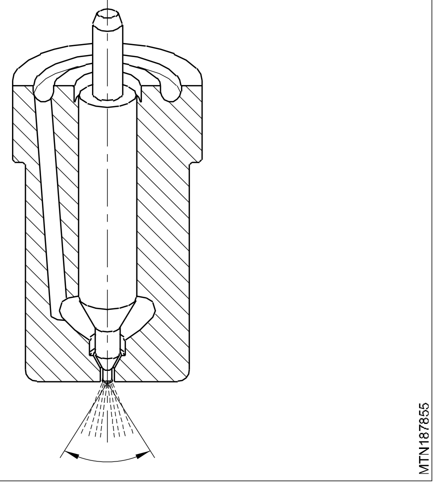
Pintle type (Fig.5)

In this type the valve stem is extended to form a pin or pintle which protrudes through the month of the nozzle body.

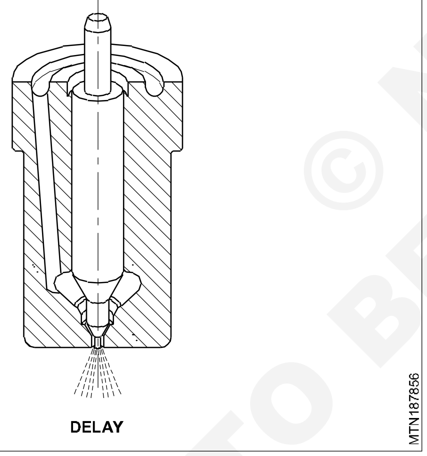
Fig 5



Delay nozzle (Fig.6)

In this type spray pattern is controlled by the modification in pintle design. This will reduce the amount of fuel in combustion chamber, when the combustion begins. This modified nozzle is known as delay nozzle.

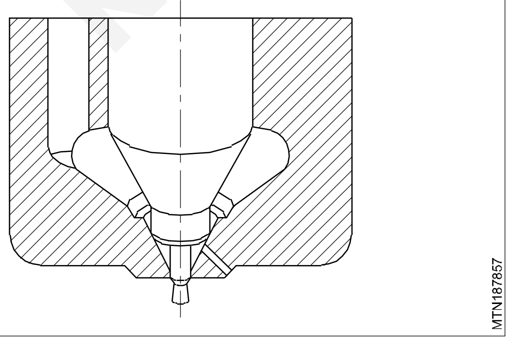
Fig 6



Pintaux nozzle (Fig.7)

This is the further development of pintle type nozzle, having an auxillary spray hole to assist easy starting under cold condition.

Fig 7



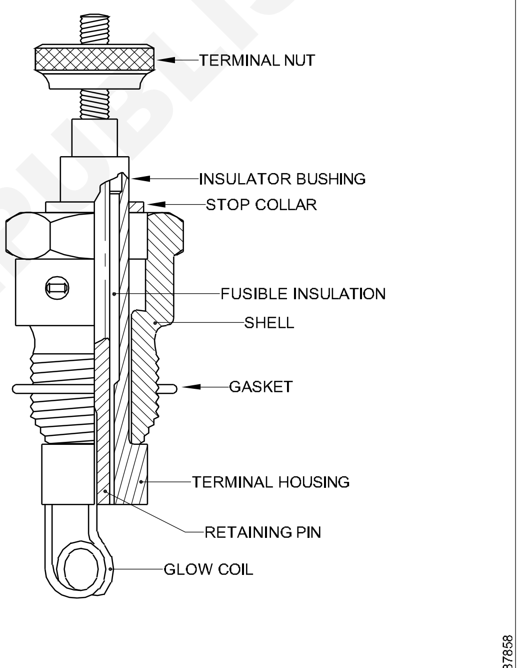
Need of a glow plug

A heater plug or glow plug is used in a Diesel engine having a pre-combustion chamber for igniting the diesel fuel spray. This arrangement makes for an easy starting of a diesel engine in cold weather. Most diesel engines use heater plugs. Figure 8 shows parts of a heater or glow plug.

Description of a glow plug (Fig 8)

The glow plug consists of a heating element (glowing coil) and is provided with an insulator shell and other parts. One such glow plug is shown in Fig 9. In a multi-cylinder engine the number of glow plugs depends on the number of cylinders. They are connected in series (Fig 10), parallel with the battery, through a glow plug switch, (control switch) a resistor and a red indicator light and they are provided on the dashboard (panel) of the vehicle. The glow control switch is a three-way one, connecting to the starter also for starting purposes. The glow control switch serves to connect and disconnect the battery with the glow plug as and when required. The red indicator light indicates to the driver, the working of the glow plug or its failure.

Fig 8

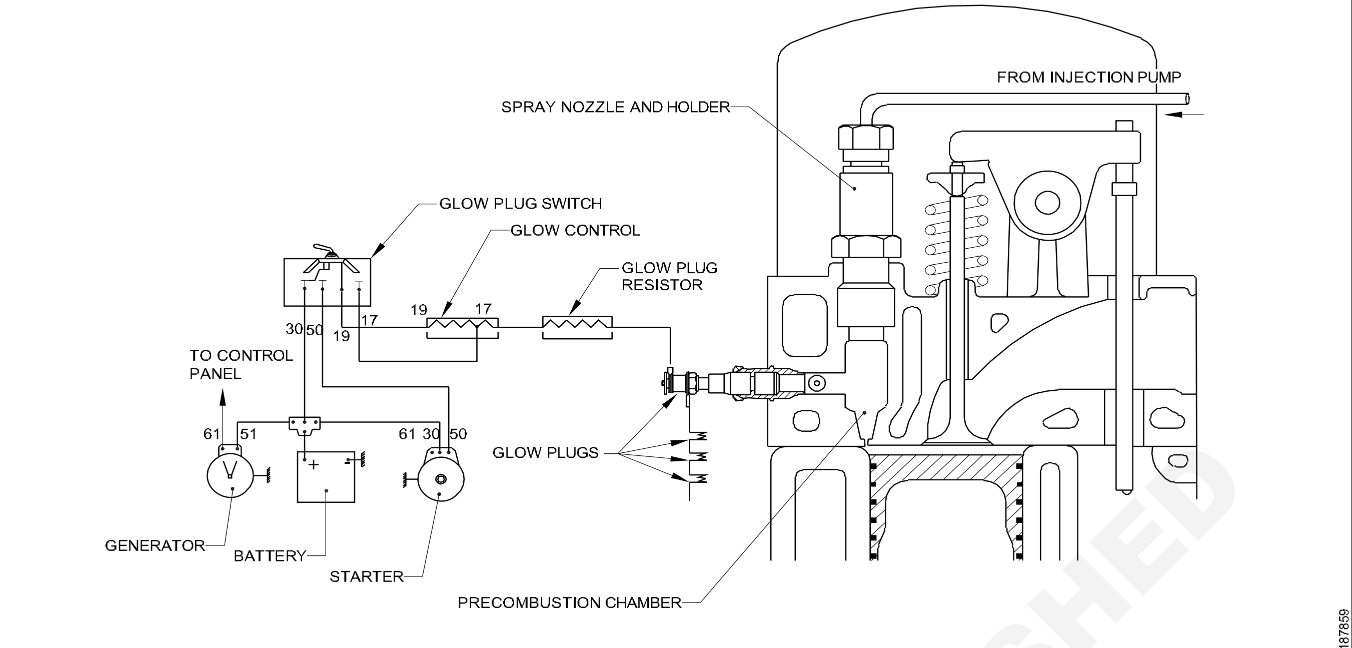


CONSTRUCTION OF THE DUAL - POLE GLOW PLUG

Working of the circuit (Fig 9)

When the switch is closed, the heating element becomes very hot due to the passage of current from the battery, and the surrounding air is heated up. When the engine is cranked heated air is drawn into the cylinder giving the compressed air a higher temperature for ignition. The fuel particles, which happen to be very near the hot air, will be ignited directly, thus initiating combustion. After combustion begins, the burning air-fuel mixture comes out of the pre-combustion chamber and enters into the main chamber. There it gets mixed up with the combustion chamber air and thus combustion is completed.

Fig 9



IGNITION CIRCUIT DIAGRAM OF GLOW PLUG SYSTEM IN A DIESEL ENGINE

Precautions

- After the engine is started the glow plug is to be cut off from the circuit. Otherwise the glow coil will be heated up additionally and gets burnt up eventually, resulting in the replacement of the glow plug.
- The glow plug switch should not be operated for more than three seconds.
- The glow coil is having low electrical resistance and hence it will be very hot when connected to the circuit. Do not touch it, when it is hot.

Detroit diesel cummins diesel

Detroit diesel cummins diesel well known for favouring unit injectors, in which the high-pressure pump is contained within the injector itself. This leads to the development of the modern unit injector.

Cummins PT (pressure-time) is a form of unit injection where the fuel injectors are on a common rail feed by a low-pressure pump and the injectors are actuated by a third lobe on the camshaft. The pressure determines how much fuel the injectors get and the cam determines the time.

Design of the unit injector eliminates the need for high-pressure fuel pipes, and with that their associated failures, as well as allowing for much higher injection pressure to occur. The unit injector system allows accurate injection timing, and amount control as in the common rail system.

The unit injector fitted into the engine cylinder head, where the fuel supplied via integral ducts machined directly into the cylinder head. Each injector has its own pumping element, and in the case of electronic control, a fuel solenoid valve as well. The fuel system is divided into the low pressure <5 bar fuel supply system, and the high-pressure injection system <2000 bar.

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 (Fig 1 to 2) is a diesel engine fuel injection control system for the precise metering and delivery of fuel into the combustion chamber of modern diesel engines used in trucks and cars.

The electronic control, the system which provides greater ability for precise measuring, data processing environment flexibility and analysis to ensure efficient diesel engine operation.

- It receives the information from sensor, analyze/ calculate it and sends the instructions to the acturators.
- It converts information from analog to digital.
- It consists of microprocessors to process the information from sensor to ECM and ECM to actuators.
- Number of microprocessors are 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.

Fig 1

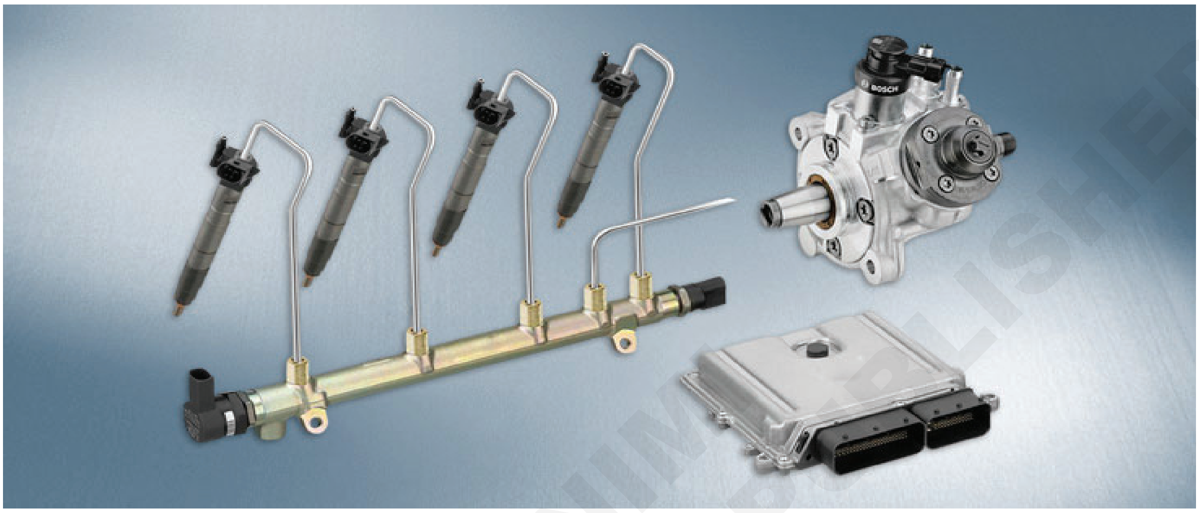
MDN2511411

Move the below figure under the common rail direct injection system (Fig.2)

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.

Fig 2



COMMON RAIL WITH FUEL INJECTORS

MDN2511412

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 positon **CKP** (for RPM and firing order)

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 **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

(ECM) Electronic Control Module (or) system

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 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.

Common Rail Diesel Injection (CRDI)

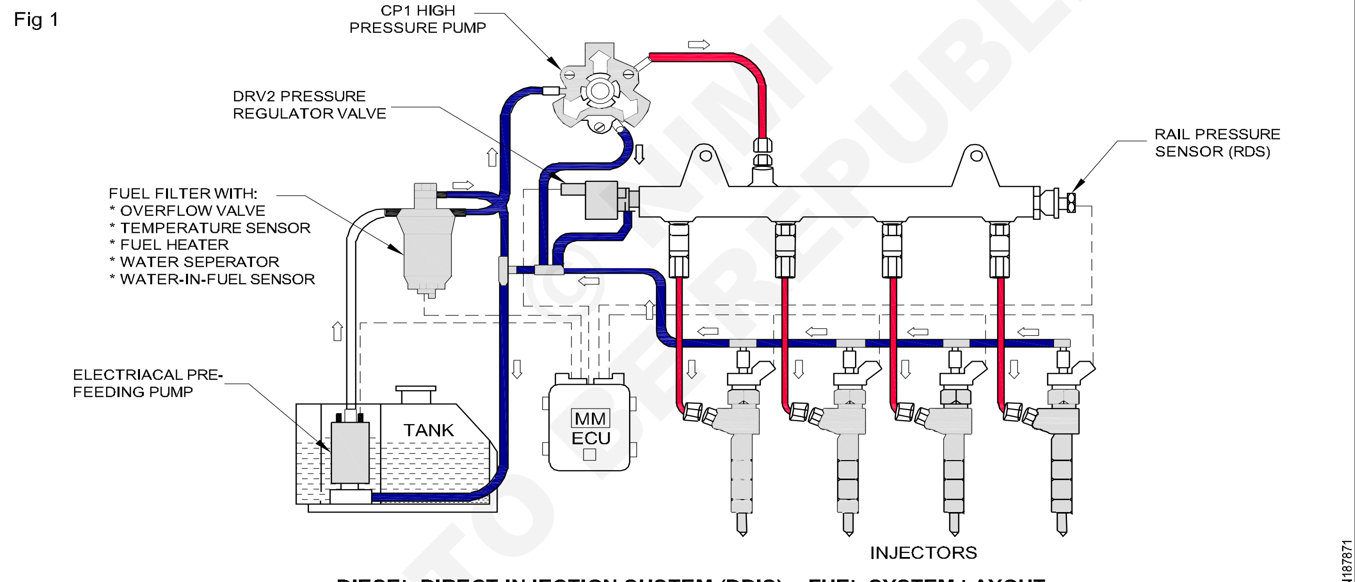
Objectives: At the end of this lesson you shall be able to
- **describe the construction of CRDI**
- **explain the working of the CRDI**
- **list out the merits and demerits of the CRDI.**

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 ($\leq$ 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.

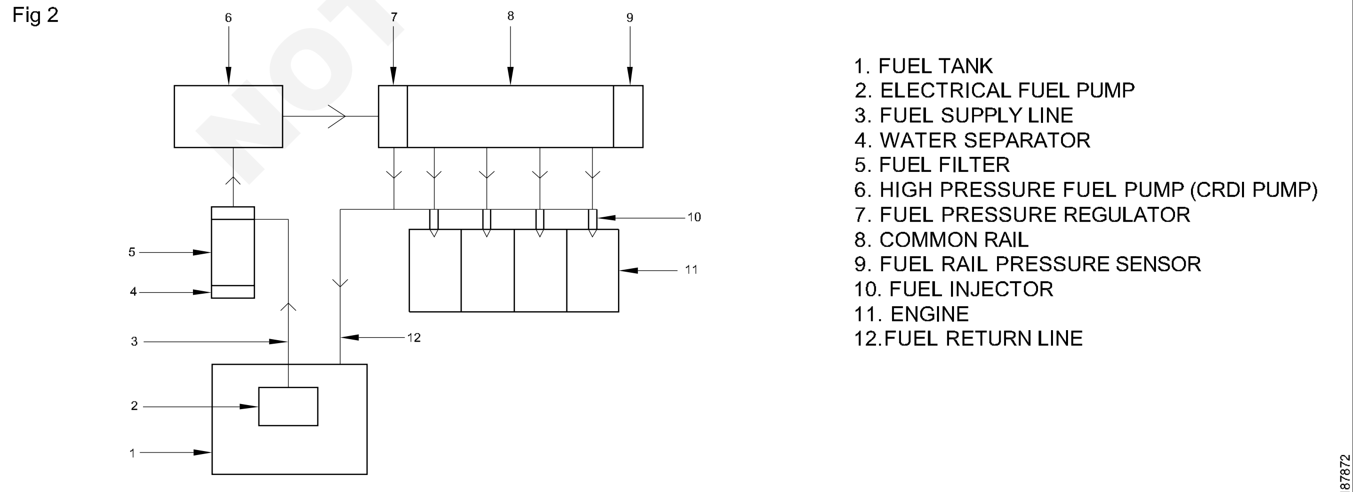
Diesel Direct injection system (Fig.1)

Fig 1



DIESEL DIRECT INJECTION SUSTEM (DDIS) -- FUEL SYSTEM LAYOUT

Fig 2



COMMON RAIL DIRECT INJECTION SYSTEM (CRDI) FUEL SUPPLY SYSTEM

Clutch

Objectives: At the end of this lesson you shall be able to
- **state the need for a clutch in a tractor**
- **list out different types of clutch**
- **state the function of the clutch**
- **state the adjustment of the clutch**
- **discuss the trouble shooting of clutch.**

Depending upon the implement used with the tractor different loads are imposed on the tractor requiring change of speed to match the rated power available in the tractor. Tractor speed can be changed by shifting gears.

While shifting gears, the speed of the sliding sleeve and the respective gear on the main shaft should be synchronised to avoid gear collision noise. This is achieved by disconnecting the transmission of power from the engine flywheel to the gear box shaft with the help of the clutch. Thus, clutch is used to connect and disconnect transmission of power from the engine flywheel to the gear box drive shaft.

Clutch requirements

– The clutch should connect the power from the engine to transmission smoothly gradually without affecting the other components.

– It should damp vibrations and shocks during operation.

– It should not slip under high torque transmission.

Torque transmission by clutch depends upon the:

– contact area of the clutch plate.

– co-efficient of friction of lining material.

– spring pressure.

– number of clutch plate used.

Types of clutches: Different type of clutches used in tractor can be classified into following categories.

– Dry & wet clutches

– Friction and positive clutches

– Others - Fluid couplings & diaphragm clutches

Friction clutches are those clutch in which transmission of power is through the use of friction plates. These have further been categorised into following sub-categories.

– Single plate Vs multi plate clutches.

– Single plate Vs dual plate clutches.

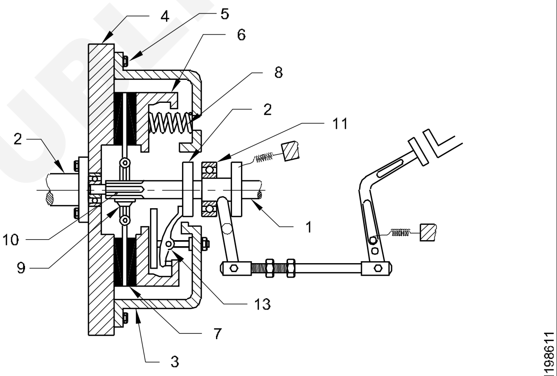
– Cone clutches.

– Dog clutches.

All different types of clutches are explained briefly in the following section.

Single plate clutch (Fig 1)**:** A clutch consists of driven (1) and driving shafts (2). A clutch cover (3) is mounted on the flywheel (4) by a set of screws (5). A pressure plate (6) presses the clutch plate (7) against the flywheel by the pressure of springs (8). The clutch plate hub (9) is splined (10) on the gear box drive shaft. The clutch plate rotates along with flywheel and power is transmitted to the drive shaft. When the clutch pedal is pressed, the release bearing (11) pushes the thrust plate (12) through the linkages.

Fig 1



WORKING OF SINGLE PLATE CLUTCH

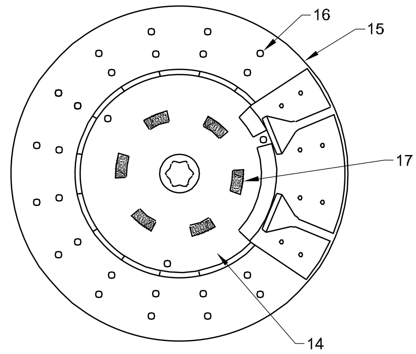
The thrust plate pushes the clutch finger (13), the clutch finger swivels and moves the pressure plate away from the flywheel. When the springs are compressed, the pressure plate does not exert pressure on the clutch plate and in turn the clutch plate does not transmit power from the flywheel to the drive shaft.

The clutch plate (Fig 2) consists of a torque plate (14) and clutch lining (15) made of frictional material fixed on the torque plate by reverts (16). Damper spring (17) are fixed in the torque plate to dampen shocks and vibrations during clutch operation.

The tractor with a single dry plate clutch pressure plate spring force becomes difficult to operate the clutch pedal during long travel of tractor. Mechanic hydraulic system is added with tractor clutch operating system to minimise the human physical effort on clutch pedal operation.

When the clutch pedal is pressed, hydraulic fluid pressure build up in master cylinder, the pressurised fluid passes through check valve and it reaches to the slave cylinder. As the fluid is under pressure it actuates the slave cylinder piston and clutch release bearing operating fork, there by disengaging the transmission with less human effort.

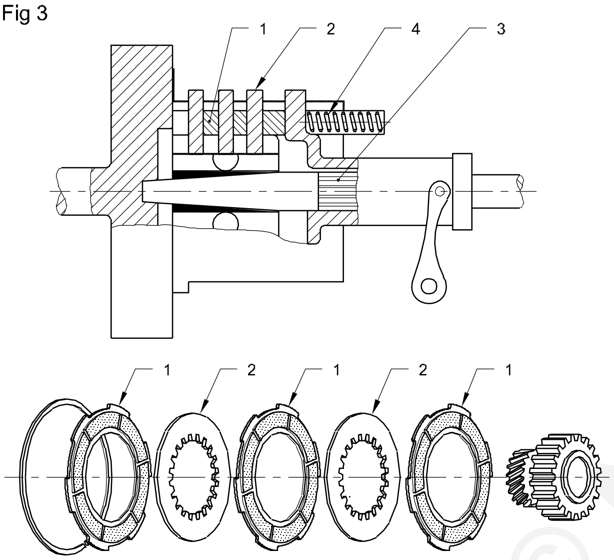
Fig 2



CLUTCH PLATE

Multi-plate clutch (Fig 3)

Fig 3

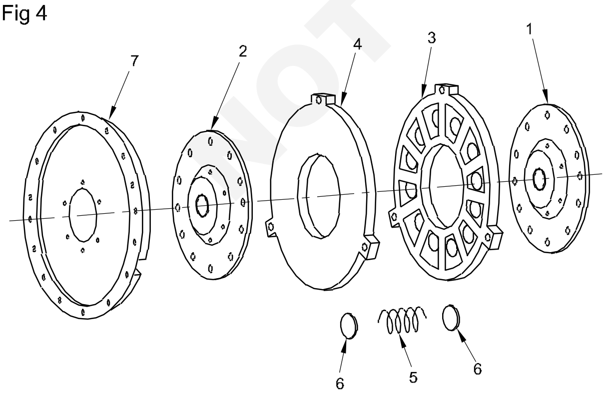


MULTI-PLATE CLUTCH

To transmit more torque, more contact area is necessary. Instead of using a larger diameter clutch plate, two or three small clutch discs are used to increase in frictional area. The pressure plates (2) and clutch plates (1) are alternatively arranged on the clutch shaft (3) and compressed by a number of pressure springs (4). This type works in the same way as a single plate clutch does.

Dual clutch (Fig 4)

Fig 4



EXPLODED VIEW OF DUAL CLUTCH SYSTEM

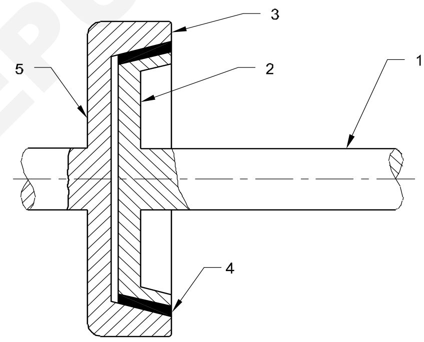
Dual clutches are combination of the primary master clutch (1) transmitting torque to the driving wheel and secondary P.T.O clutch (2) to drive P.T.O shaft. Dual clutch is mounted into the flywheel with primary pressure ring plate (3) and PTO pressure ring plate (4) (Fig.4) Disc spring (5), inserted in between two pressure rings, through insulating pad (6), pressing on both plates with there outer friction surface is the pressure element. Clutch guard (7) is mounted on the flywheel for safety reason. When clutch pedal is pressed partially , it disengages gearbox, while when pressed completely P.T.O drive is cut off.

Dry and wet clutches: These clutches may be dry or wet. When the clutch is operated dry without oil, it is called a dry clutch, but where the oil is used in the clutch it is called a wet clutch. Oil is used to cool the friction plate. The wet clutches are generally used along with or as a part of automatic transmission. These types of clutches are mostly used in heavy tractor and earth moving machineries.

Cone clutch (Fig 5)

In this case friction plates are in the shape of a cone. When the clutch is engaged the friction surfaces (4) of the male cone (2) on the clutch shaft (1) engage with the female cone (3) on the flywheel (5) due to the force of the spring. When the clutch pedal is pressed the male cone slides on the splines of the clutch shaft against the spring force. It gives more frictional area and is simple in construction. It is practically absolute and the same principle/device is used in the synchroniser unit in a synchro-mesh gear box.

Fig 5

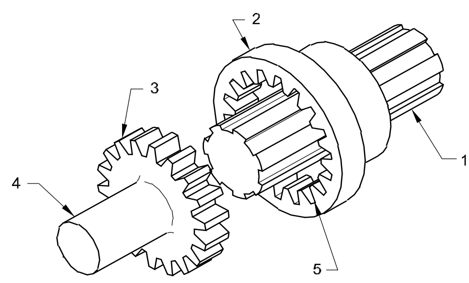


CONE CLUTCH

Dog clutch (Fig 6)

This type of clutch is used to lock two shafts together or to lock a gear to a shaft. When the sleeve (2) slides on a splined shaft (1) its internal teeth (5) match with the dog clutch (3) teeth of the driving shaft (4) and the clutch is engaged in this type there is no possibility of a slip as both the shafts revolve exactly at the same speed.

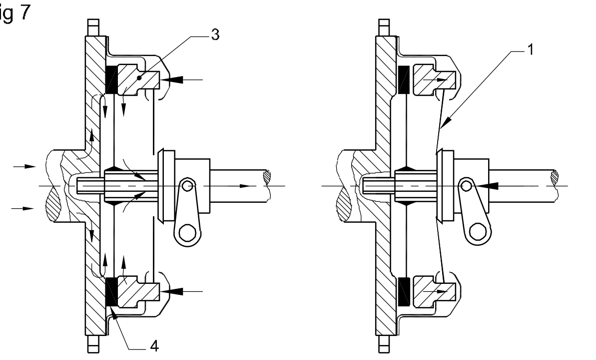
Fig 6



DOG CLUTCH

Diaphragm spring type clutch (Fig 7)

Fig 7

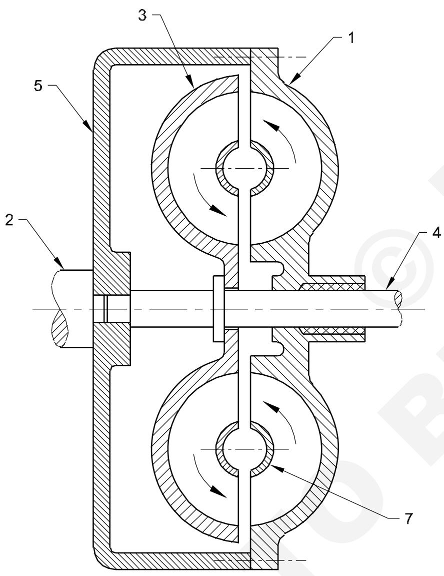


DIAPHRAGM SPRING CLUTCHES

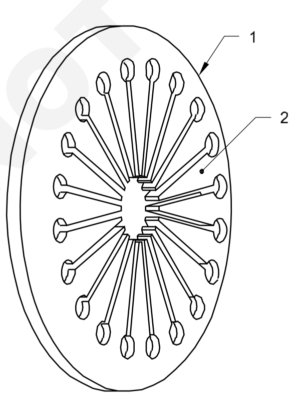
In some tractor, instead of using coil spring a conical dish shaped steel plate diaphragm spring (1) is used. It exerts force on the pressure plate (3) to press the clutch plate (4) firmly for engaging the clutch. It does not have release levers. The slots start from the centre of the diaphragm to form a number of release fingers (2). It requires very little pedal effort to disengage the clutch and it works noise free.

Fluid coupling (Fig 8)

Fig 8



FLUID COUPLING



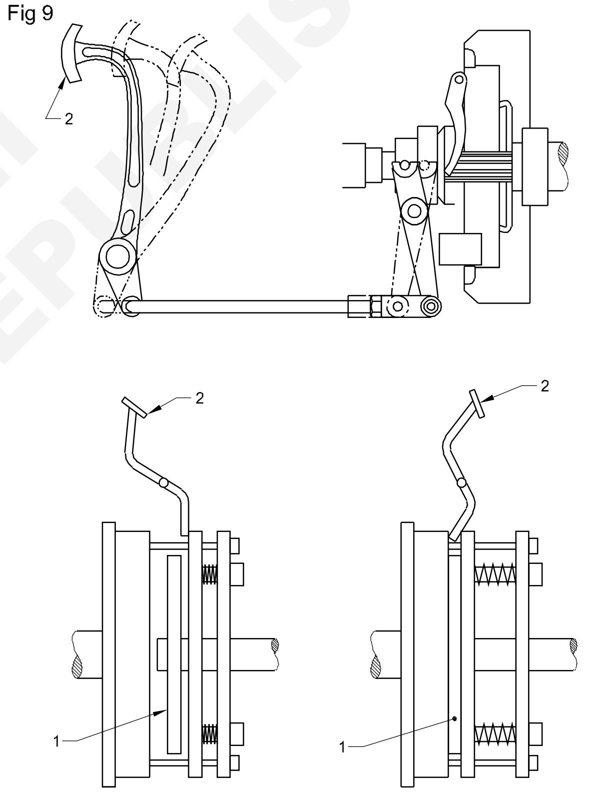
DIAPHRAGM SPRING TYPE CLUTCH

Fluid coupling consists of two half shells fitted with interior fins (7) which rotate from the hubs. These unit are mounted very close to each other with their open ends. So that they can turn independently without touching each other. A housing (5) surrounds both units to make a complete assembly inside, the assembly is fitted with 80% of fluid. The driving unit impeller (1) is linked to the crankshaft (2) rotates. The driven impeller (3) is mounted on the driven shaft (4) due to the movement of the oil, the impeller (3) rotates and transmits torque to the driven shaft (4).

Fluid coupling enables the driver to use the clutch and gear with less skill and fatigue than the conventional clutch. Wrong clutch engagements or selection of improper gear will not produce any of noise or sound. Any sudden load is also cushioned and absorbed by the fluid coupling. Dynamic stresses or breakages of the gear teeth of the mechanism and final drive are reduced to minimal. Fluid coupling is used with the epicyclic gear box as the output shaft (drive shaft) is always in motion.

Clutch adjustments (Fig 9)

Fig 9



Owing to the normal wear of clutch friction linings (1) the free movement of the clutch pedal (2) gradually diminishes. Therefore it must be restored to normal as a part of the clutch periodical maintenance. The clutch free play is related with the clearance between the release bearing and fingers. On some tractors, this clearance is adjusted by the linkage, where as on others it is adjusted by moving the clutch release shaft.

The linkage has an adjustable rod with U-shaped ends known as the elevis. Increasing the length will give greater free play. Clutch pedal free play should be 18 mm to 30 mm.

Clutch Actuation

Type	Mechanical actuation	Hydraulic actuation
Features	Pedal effort is transmitted by linkage	Pedal effort is transmitted by fluid to release bearing to release bearing.
Advantages	Little maintenance is required. Easy to repair	Little pedal effort is required to disengage the clutch.

Troubleshooting of Clutch

Trouble	Possible causes	Remedies
Clutch drags (when pedal is depressed to disengage the system, even then driven plate rotates)	• Dirt or other foreign material in the clutch plate	Clean
	• Improper pedal adjustment	Adjust clutch pedal
	• Warped clutch plate	Replace new lining
	• Damaged pressure plate or clutch cover	Install new parts
	• Splines of the shaft tight or burred	Clean and smear with grease
Clutch slippage (lack of firm contact between flywheel, pressure plate and clutch is known as 'Slip' and will result in dis-proportionate rise in vehicle speed when engine speed goes suddenly high.	• Oil or grease on the lining or replace lining	Clean with petrol
	• Glazed surfaces of lining caused due constant rubbing of dust particles	Replace new lining
	• Bent or tight release shaft	Straighten and free the shaft
	• Lack of clutch free play	Adjust
	• Worn-out lining	Replace
	• Uneven adjustment of release levers(fingers)	Adjust properly
	• Weak pressure spring	Fit new set of springs
Clutch grabs (during engagement of the clutch the vehicle moves with a series of jerks) plate	• Oil or grease on the lining	Clean
	• Glazed lining	Replace
	• Damaged pressure	Replace
	• Splines of the shaft or clutch-plate hub tight or burred	Clean up & smear with grease
	• Bent or tight release shaft	Straighten and free
Clutch noises	• Weak or broken pressure springs	Replace affected springs
	• Excessive worn splines on the shaft and clutch plate	Replace affected parts
	• Worn or dry release bearings/ pilot bearings	Replace affected parts
Abnormal lining wear	• Insufficient pedal free play	Adjust
	• Overriding of the clutch pedal	Caution the operator to avoid this
	• Weak or broken pressure spring incapable of pressing pressure plate against clutch plate	Replace
	• Warped pressure plate	Replace
	• Incorrect adjustment of clutch fingers	Adjust properly

Gear box (Sliding mesh and constant mesh)

Objectives: At the end of this lesson you shall be able to
- **state the need for a gear box**
- **state the various resistances in vehicle motion**
- **calculate gear ratios**
- **state the different types of gear boxes**
- **describe the various components and their functions in a sliding mesh gear box**
- **describe the various components and their functions in a constant mesh gear box and its advantages**
- **state reasons for gear noise**
- **state the different types of gears**
- **describe epic cyclic and auxiliary gear box.**

Introduction

Every automobile truck/car or tractor has a gear box (or Transmission Unit) to enable the drive ratio between the engine and final drive to be varied by selecting most suitable speed or gear ratios provided in the Gear Box Mechanism to accommodate different gradients and load.

The I.C.engines operate between minimum and maximum speed (maximum BHP production), the performance of a vehicle lies within this limit only. It may noted that the engine should not run below or above the rpm specified by the makers, irrespective of different loads being carried by the vehicle and also vehicle being driven in gradients. Hence selection of speed ratios becomes an important factor. While starting from standstill (rest point) and accelerating on a gradient, more power is required at the road wheels, and the engine delivery of Torque must be higher than driving at a steady speed on level roads. Hence a gear box provided in all vehicles and tractors.

Need or object of a gearbox

Gearbox: A gear box is used to get different torques and speeds which are required to overcome the following resistances.

- Road resistance
- Air resistance
- Gradient resistance
- Load on vehicle

By engaging different gears, engine torque is increased while speed is decreased. In the top gear the rpm and torque of the engine and gear box remain the same.

Speed ratios or gear ratios (Fig 1)

Some fundamentals: When a small gear (1) drives the bigger gear (2) the speed is reduced in proportion of the gear tooth. For example: Gear (1) is having 10 teeth and gear (2) is having 20 teeth. Assuming gear (1) rotates at 50 rpm.

$$\text{Gear ratio} = \frac{T_1}{T_2} = \frac{10}{20} = \frac{1}{2} = 1:2$$

linear velocity 'V' remains the same for both the gears.

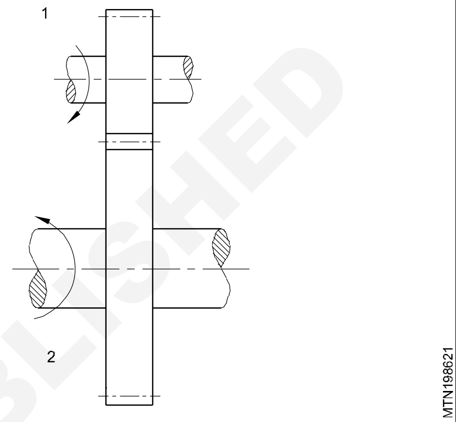
$$\text{So, } T_1 \times N_1 = T_2 \times N_2$$

$$N_2 = T_1 \times \frac{N_1}{T_2} = 10 \times \frac{50}{20} = 25$$

Here the rpm of gear (2) is half of gear (1). So torque will be double.

It means in higher gear the torque is less and in lower gear the torque is more.

Fig 1



Different sets of gears are used in the gear box to achieve different speeds and torques.

The speed ratios in a Tractor Transmission are generally divided into 3 groups. They are as below.

Main speed ratios: These are used for tractor land speeds required by majority of field tasks.

For modern tractors, the speeds range from 1.4 to 4.2 m/sec (5 to 15 km/hr).

Transport speed ratios: The ratios are used in tractors for carrying goods by Tractor - Trailer combinations and also in ferry trips.

In wheeled tractors, these speed ratios provide for land speeds in the range of 4.2 to 9.5 m/sec and in Crawler Tractors (Chain Drive System) 4.2 m/s.

For some field tasks (Transplanting and root crop harvesting)

These speeds are in the range of 0.4 to 0.16 m/sec.

A comparison with automobiles' transmission: Automobile transmission have smaller number of speeds, since the scope of work for automobile being limited to certain areas.

The automobile transmission provides low speed ratios that are used for

- Starting from rest
- Acceleration
- For negotiating difficult road sections.

High speed ratios are used when cruising under good road conditions.

Comparison of reverse speed: The automobile transmissions have only one reverse speed whereas tractors have several reverse speeds. When teaming the tractor with drags or rakes.

Some tractors can be reversed in any gear.

Hence the gear train arrangements in Automobile Transmission are generally simple in arrangement.

From the above discussion we have understood that any Transmission has two jobs to do.

– Select speed ratios

– Reverse the vehicle

Mechanical transmission used in tractors are of 3 major types

– Sliding mesh gear box

– Constant mesh gear box

– Synchromesh gear box

Let us study each one briefly.

Sliding gear transmission: This transmission is used still in some smaller farm tractors.

Two basic designs are used

– input and output shafts parallel

– input and output shafts in line

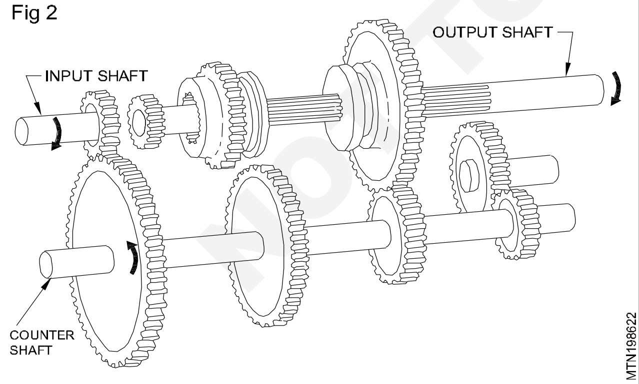
Inline shaft arrangement (Fig 2)**:** In this gear box, the gears are mounted directly on the main shaft. The gear is slided on the main shaft with the help of the shifter yoke mechanism to engage with the countershaft gear. The gears on the clutch shaft and countershaft are fixed. The idler gear is always in mesh with the countershaft's gear.

To achieve reverse speed, the main shaft's gear is slided on the main shaft, to engage with the idler gear.

To slide the gear on the shaft the shifter forks directly sit on the main shaft's (1) gear. The shifter forks are connected to the gear shift lever through the selector rods.

In this type of gear box, spur gears are always used, because the gear is slided on the shaft to engage with the countershaft gear.

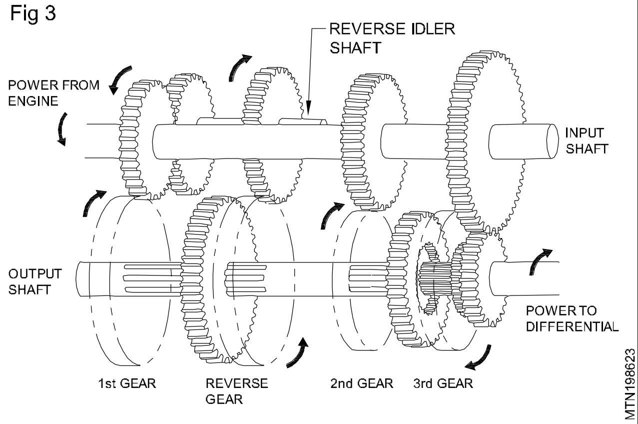
Fig 2



Parallel shaft arrangement of power line (Fig 3)**:** The input shaft drives the output shaft which transmits the power. There is a third shaft to get reverse gear or vary the power flow. All 3 shafts are parallel and intersect through the shifting of gears.

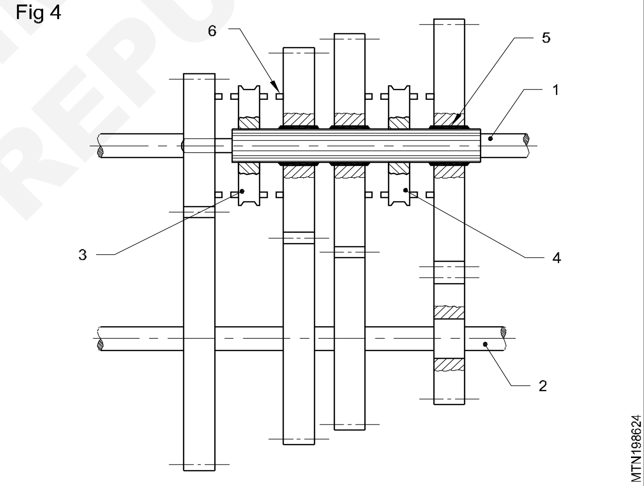
Constant mesh gear box (Fig 4)**:** In this gear box the gears of the main shaft (1) are always in mesh with the corresponding gears of the countershaft (2). But power is not transmitted unless the dog clutch (3) or (4) engages with the particular gear on the main shaft (1). The main shaft is splined. In between the splined main shaft and gears, bushes (5) are provided.

Fig 3



The fixed dog clutch (6) is splined on the main shaft gear (1). Therefore the gear and the fixed dog clutch both rotate freely without transmitting power. The dog clutch can slide along and revolve with the main shaft. When the sliding dog clutch (3 or 4) is engaged with the respective gears fixed dog clutch, power is transmitted from the gear to the main shaft through the sliding dog clutch (4) and fixed dog clutch (6).

Fig 4



In this type of gear box, helical gears are used.

Advantages: The power transmission is smooth when helical gears are engaged because more than one tooth are in contact at a time.

Easy to engage: Less wear of gears in comparison to the sliding mesh gear box because gears are always in mesh and gear shifting is done through the sliding dog clutch.

Gear box troubles

Gear noise: The following are the causes for noise in the gear box.

– Wrong adjustment of gear shifting fork.

– Misalignment between gear box and engine.

– Gear box not lubricated.

– Excessive backlash between gears/worn out gears.

– Gear box bearings damaged.

Synchromesh gear box

Objectives: At the end of this lesson you shall be able to
- **explain the need of synchromesh action in a gear box**
- **list out the different types of synchromesh gear boxes**
- **explain each type of synchromesh gear box**
- **explain the function of a synchromesh unit**
- **explain power flow in different gear positions**
- **explain the advantages of a synchromesh gear box over-sliding mesh and constant mesh gear boxes.**

Introduction

The modern automobiles (trucks/cars) are equipped with inertia type. Synchronisers (Synchromesh devices) that synchronise the rotation of the gears which are to be meshed during gear shifting when the vehicle is in motion.

The synchromesh devices are largely used in Automobile Transmissions.

Example

A four speed Transmission of an Automobile uses a high Gear Synchroniser between III & IV gear engagement. Even though a number of Types of Synchromesh devices are in use the most popularly used in Tractor Transmission is Baulk Ring Type (Blocking ring) Synchroniser.

Let us now try to understand the synchronising action and proceed to discuss Balk Ring Type Synchroniser, used in Tractors.

Synchroniser and its action (Basic principle) (Figs 1, 2 & 3)**:** Synchronisers are used for easy gear shifting when a vehicle is in motion.

Fig 1

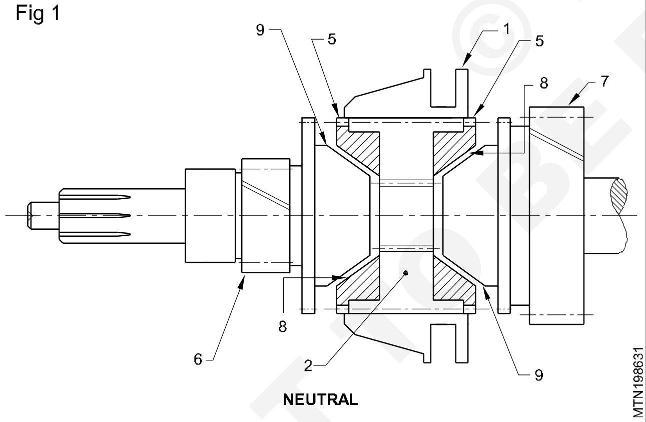


Fig 2

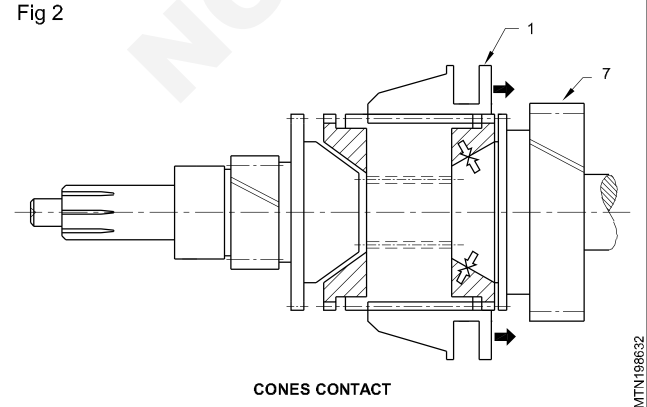
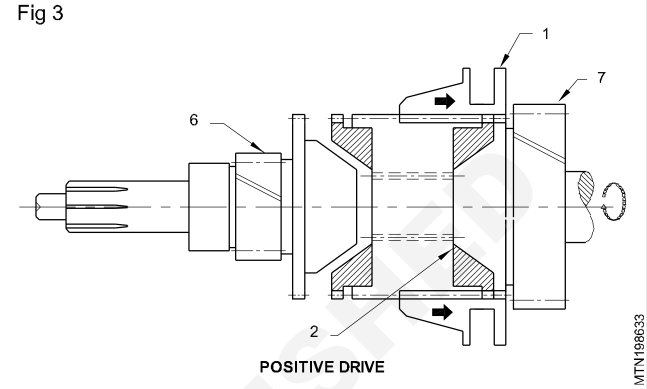


Fig 3



With Synchronising action, gears can be changed without using double declutching. An unskilled driver can also change gears with less danger of gear clashing as in the case of in-sliding mesh and constant mesh gear boxes.

A synchroniser unit has a synchroniser sleeve (1), hub (2), a set of blocking rings (5), and a conical cup (8) provided on the blocking ring. Correspondingly a cone 99) shape is provided on gears (6) and (7) to suit the matching of the cup (8) and cone 99). Gears (6) and (7) rotate in mesh with the countershaft gear whereas the hub (1) rotates at the main shaft's speed.

Whenever any particular gear is to be engaged, the sleeve (1) is pushed towards the gear, and it further pushes up (8). The first cup (8) makes contact with the cone (9) of the gear (7) and due to friction between the cone and the cup's blocking ring (5) and gear (7) start rotating at the same speed. Further movement of the sleeve (1) engages the dog teeth of the sleeve (1) with the dog teeth of the blocking ring (5) and gear 97). As at this stage the blocking ring and gear are rotating at the same speed. This engagement is carried out smoothly without double declutching and without causing any clashing noise.

Types of synchromesh gear boxes

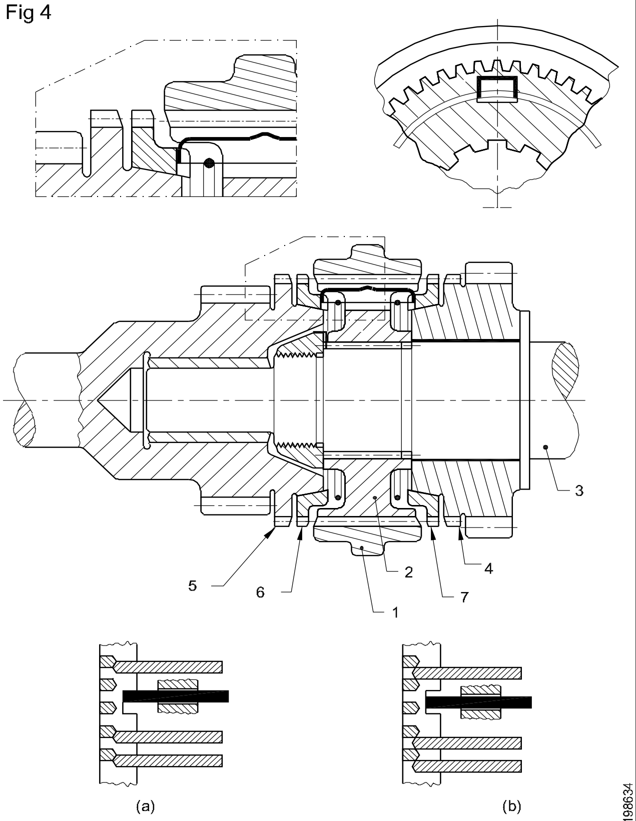
The various types of synchromesh gear boxes are given below:

- baulk type
- baulk ring type
- multi and double cone type
- porche type

Let us study the principle of **baulk ring type** synchromesh type in the following para.

Baulk ring type synchromesh device (Fig 4)**:** This type of synchroniser unit is mostly used to engage the IV gear from III and vice versa.

Fig 4



BAULK RING TYPE SYNCHROMESH DEVICE

In this the dog clutch sleeve (1) is free to slide on the splines on the hub. The hub (2) is fixed to the main shaft; when the clutch sleeve is moved to the right its internal splines engage the dog teeth of the 3rd gear (4), and when it is moved to the left its splines engage with the dog teeth of the 4th gear (5). The synchronising action is provided by the baulk rings (6&7) which are having internal cones to engage with the external cones formed on gears.

The synchromesh gear box and power flow in different gears

Introduction: A 3 speed all helical gear, synchromesh gear box (transmission) of a passenger car is shown in Fig.1.

It has 3 forward speed and one reverse speed for selection. This is closed as manually operated selective type because the driver can select the required gear ratio by shifting the gear by the operation of the gear shift lever.

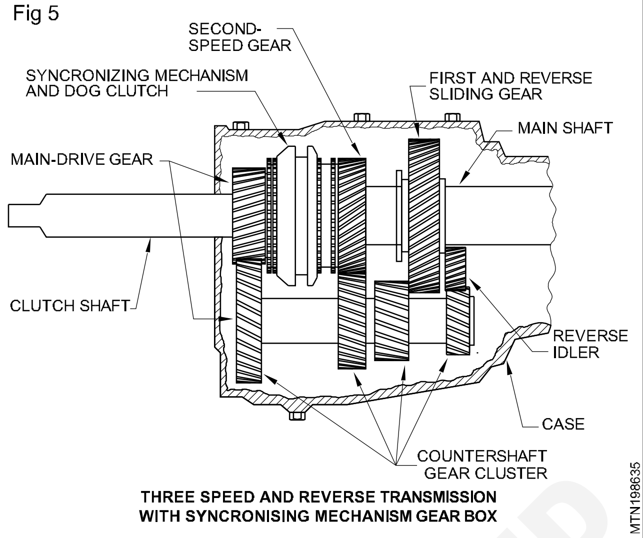
The gear box in Fig 5 here consists of the following main parts.

- Case and extension of housing
- Rotating parts including bearings
- Shift mechanism

Details

- The case houses all parts of the gear box and serves as a container for the gear oil.
- The rotating parts consist of the main and lay shafts, its bearings, gears, dog clutches and synchroniser mechanism.
- The case cover carries a selector and shifter mechanism and seals the gear box housing against water and dirt.

Fig 5



THREE SPEED AND REVERSE TRANSMISSION
WITH SYNCRONISING MECHANISM GEAR BOX

Gear ratios	Jeep vehicle
I gear	2.798 : 1
II gear	1.151 : 1
Top or III gear	1 : 1
Reverse gear	3.798 : 1

Power flow in different gear positions is shown by figures below and also briefly discussed.

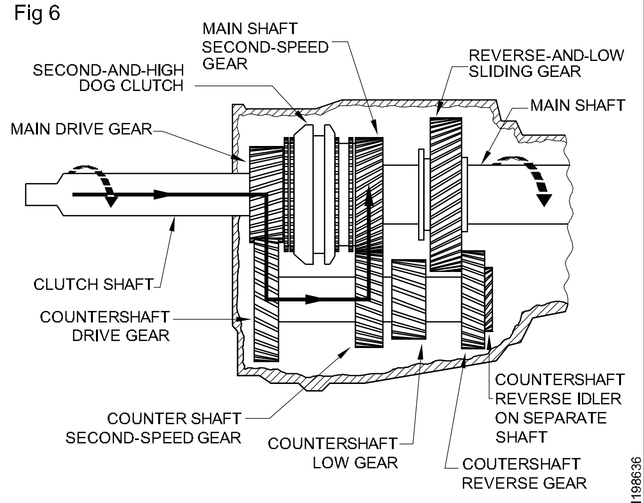
Power flow in neutral

Neutral position (Fig 6)**:** In the neutral position there is no flow of power from engine - clutch primary shaft transmitted to the gear box main shaft. This condition helps to start the engine and run it without movement of the vehicle.

Secondly, the main shaft and lay shaft second speed gears are in constant mesh but the second speed and high speed dog clutch is not engaged. Also the main shaft second speed gear is not splined or keyed to the main shaft but it simply rotates on it without transferring any power.

The back line with arrow shows the power flow from the clutch shaft to the countershaft through the main drive gear and countershaft gears which are in constant mesh.

Fig 6



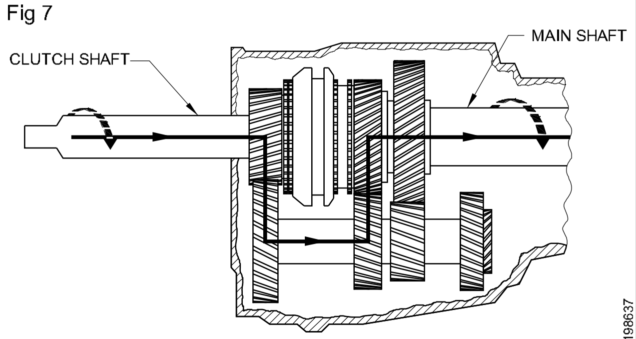
FLOW OF POWER IN NEUTRAL

All gears are revolving but no power but no power is being transmitted.

Power flow in first or low gear

First or low gear (Fig 7)**:** The power flow in first or low gear is shown in the figure.

Fig 7



FLOW OF POWER IN LOW GEAR

By shifting the reverse and low sliding gear towards the left and making it mesh with countershaft (Lay shaft Low gear, First gear position is obtained. The ratio is 2.798:1. The clutch primary shaft drives the countershaft through the main drive gear and countershaft drive gear.

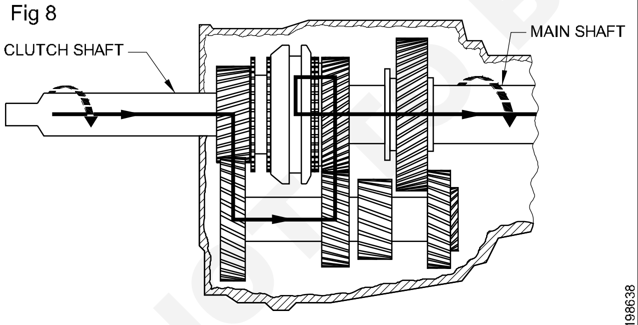
The flow of power (shown in black line arrow) goes from the countershaft to the main shaft, through countershaft low gear to the reverse and slow sliding gear (I gear) which is splined to the gear box main shaft and then to the U-joints and to the rear wheels.

Speed of main shaft = 1/2.798 of clutch shaft speed

All forward shifting is accomplished by action of the mechanism synchroniser.

Second gear position (Fig 8)**:** The first gear engagement is released out by shifting the first and reverse sliding gear out of mesh and bringing the system to neutral position.

Fig 8



FLOW OF POWER IN SECOND GEAR

The synchroniser sleeve is then moved to the right so that its teeth are meshed with the teeth on the hub of the second gear after synchronisation. The synchroniser hub is internally splined to the main shaft. Hence the power flows through clutch shaft main drive gear to the counter shaft drive gear, through the counter shaft to the countershaft second speed gear, and then to the main shaft second speed gear which turns the main shaft.

$$\text{Speed of main shaft} = \frac{1}{1.151} \text{ of clutch shaft speed.}$$

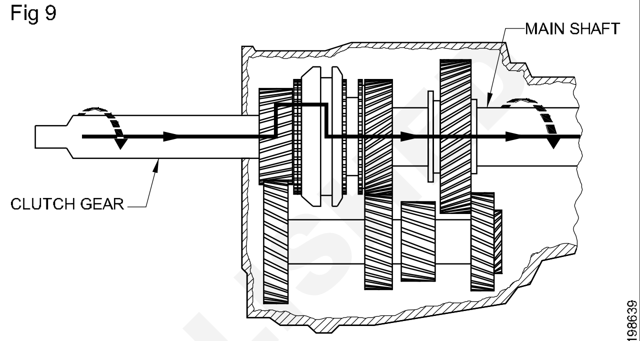
Top gear or high gear position (Fig 9)**:** Power flow in the top gear is shown in the figure. The synchroniser sleeve is moved to the left so that its teeth could mesh with the teeth on the hub of the main drive gear after the second speed gear is released out of engagement. Now a direct drive engagement takes place locking the main shaft to the clutch shaft.

Speed of main shaft = speed of clutch = 1.1 shaft

No power is transmitted through the other revolving gears in the system.

The power flow line (arrow) shows the direct drive through the synchroniser mechanism to the gear box main shaft.

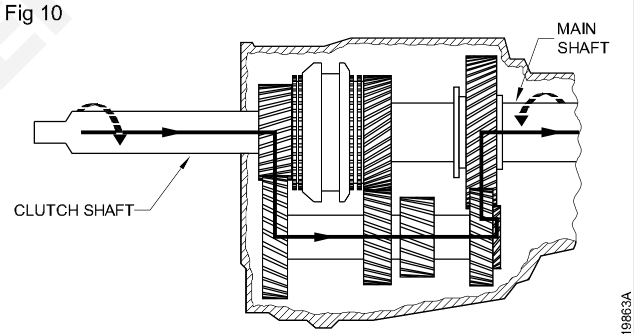
Fig 9



FLOW OF POWER IN HIGH GEAR (TOP GEAR)

Reverse gear position (Fig 10)**:** In this gear, the synchroniser mechanism stands in neutral position. The clutch shaft and the main shaft are separated from the drive.

Fig 10



FLOW OF POWER IN REVERSE

By operating the gear shift lever the reverse and low sliding gear is moved to the right and is engaged with the reverse idler gear. This engagement causes the change of direction of rotation of the reverse gear which in turn transfers the drive to the main shaft. Now the main shaft rotates in the reverse direction. The drive is then transmitted to the road wheels at the rear through U-joints and propeller shafts and differential. So the vehicle moves in the reverse direction. The power flow is from the clutch shaft main gear, countershaft gears, the reverse idler and then to reverse and low sliding gear and then to the main shaft.

$$\text{Speed of main shaft} = \frac{1}{3.798} \text{ of clutch shaft.}$$

Advantages of synchromesh gear box over sliding and constant mesh gearboxes: It requires less force to change the gears.

In sliding mesh gear boxes, the gear wheels themselves move on the shaft to mesh with each other which is eliminated in the synchromesh gear boxes, thereby increasing the life of the gears.

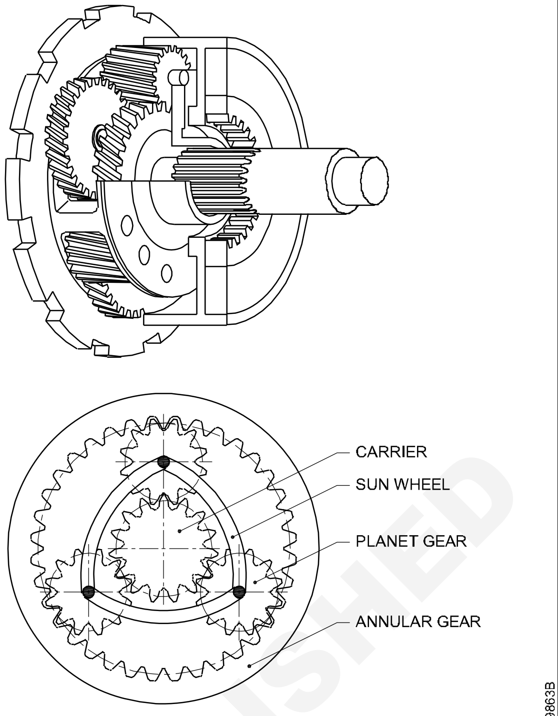
The constant mesh and sliding mesh gear box requires double declutching while changing the gears which is not needed in a synchromesh gear boxes.

An unskilled driver can operate the synchromesh gear box more easily than the sliding mesh and constant mesh gear box.

Overall fuel efficiency is higher in synchromesh gear boxes as compared to constant mesh and sliding mesh gear boxes since double declutching is not required for this.

Epicyclic gearbox (Fig 11)**:** The system is smaller and compact. It is more durable under heavy loads since torque loads are spread more evenly over several gears.

Fig 11



EPICYCLIC GEARBOX

Torque converter

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**
- **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

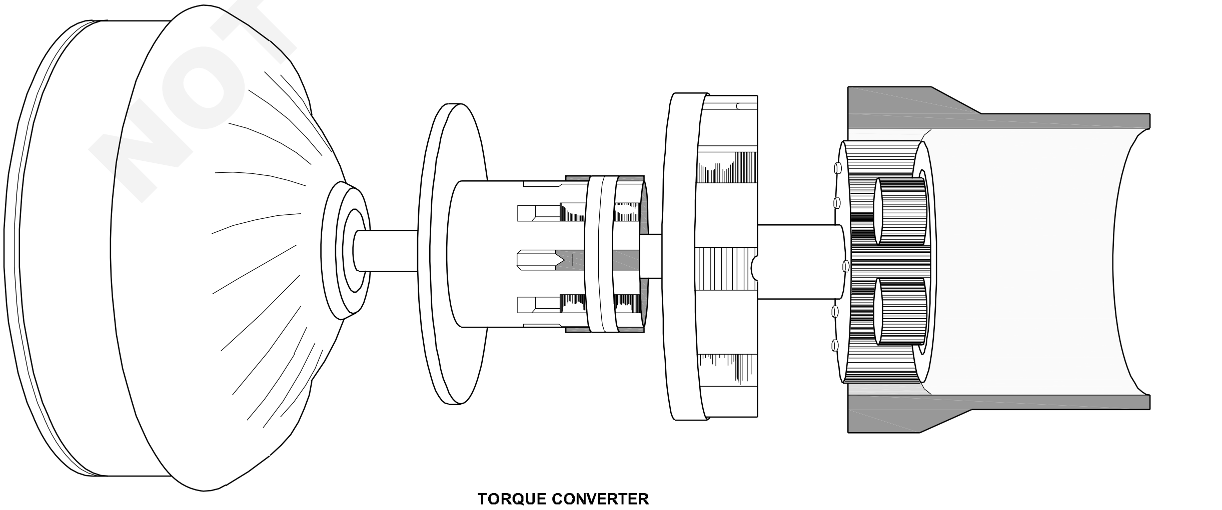
The main controlling variables are

- Selector lever position
- Driving speed
- Engine load (accelerator pedal position)

Major automatic transmission components

- Torque converter (Fig 1)
- Planetary gear unit
- Electro hydraulic control

Fig 1



TORQUE CONVERTER

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

The impeller, turbine wheel and stator are designed as curved blade wheels and operate in an enclosed housing which is filled with hydraulic fluid.

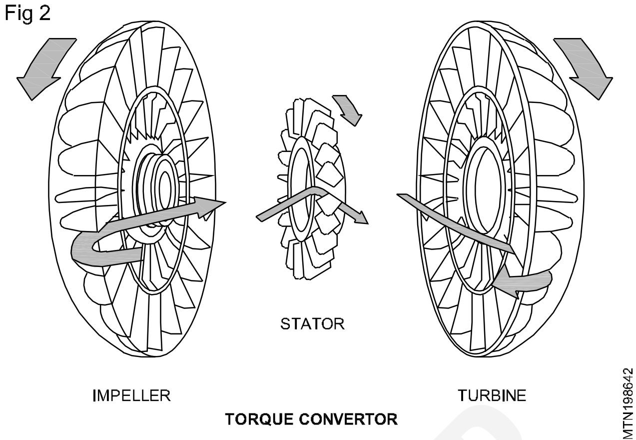
The impeller is driven by the engine flywheel. Guide rings are provided on the inner edges of the vanes to provide smooth fluid flow. When the impeller is driven by the engine, the centrifugal force causes the fluid to flow outward towards the turbine.

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)

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.

Fig 2



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

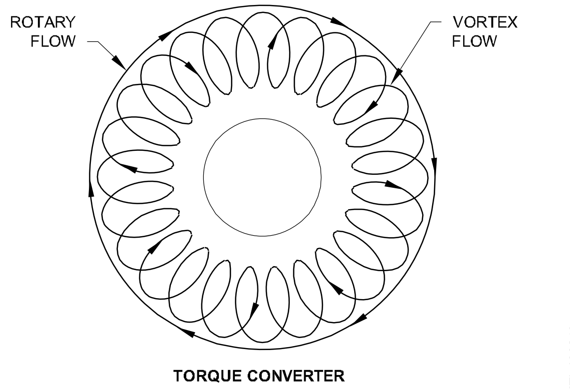
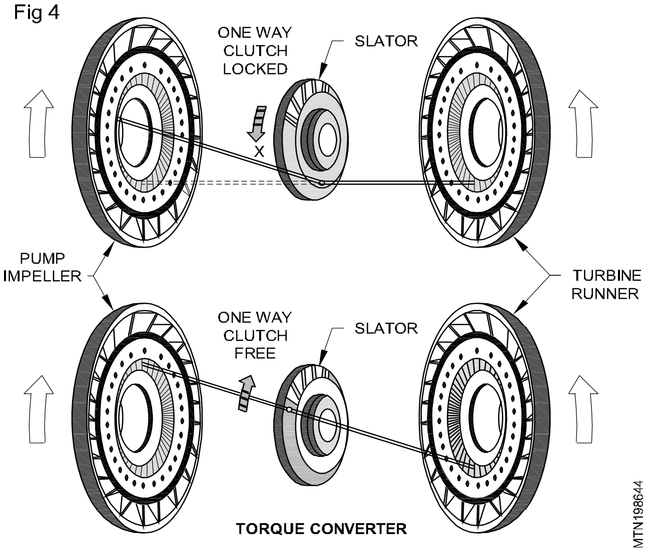


Fig 4



TORQUE CONVERTER

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 (Figs 4, 5 & 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.

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

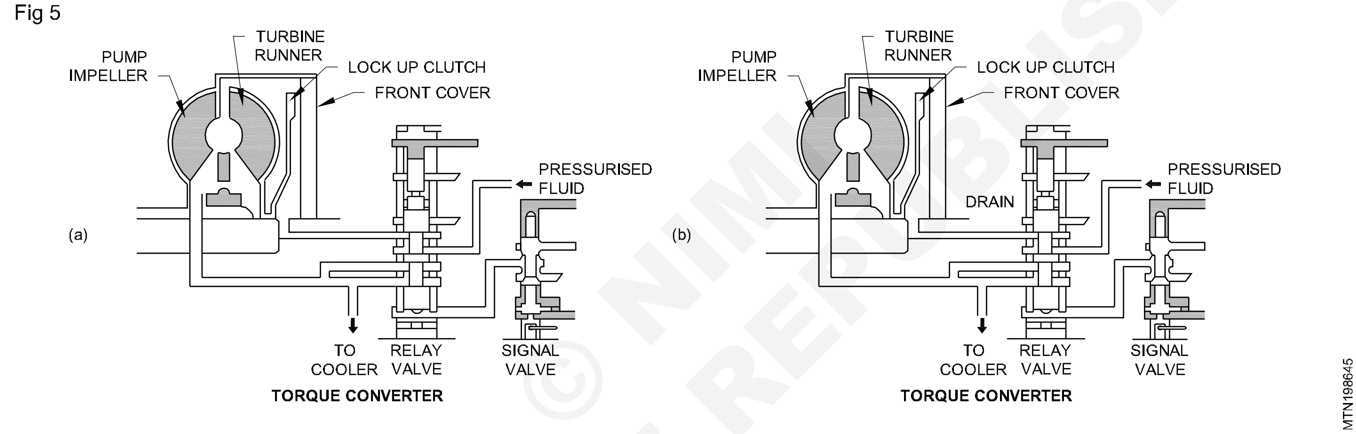
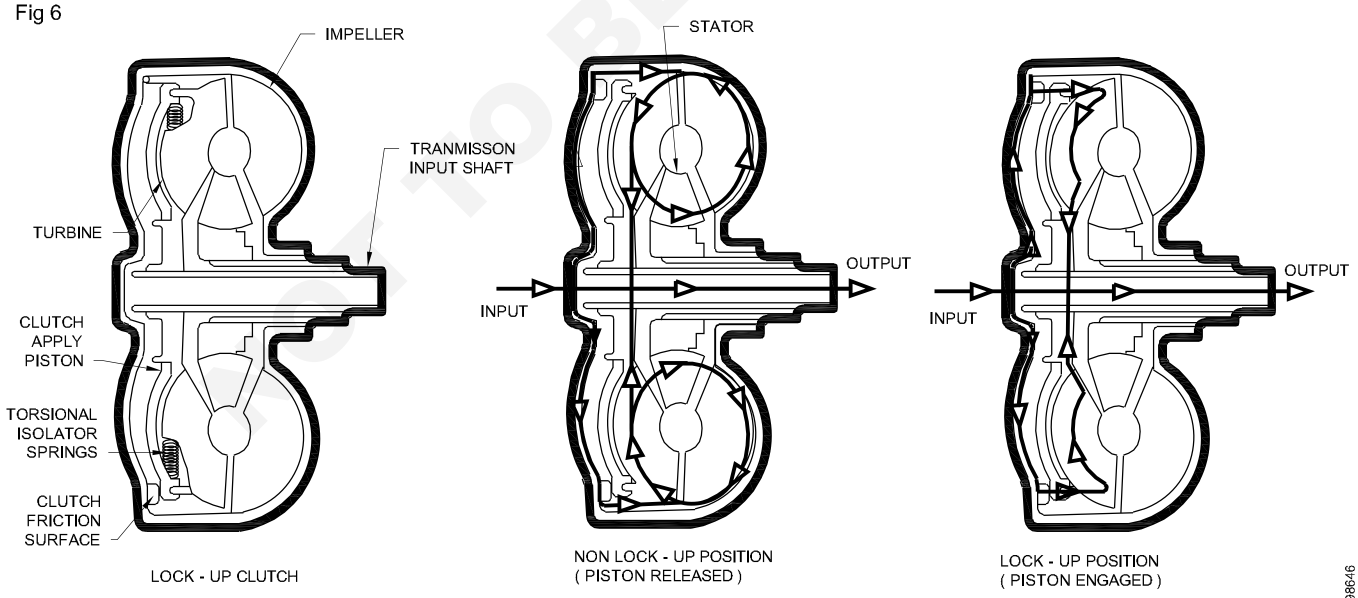


Fig 6



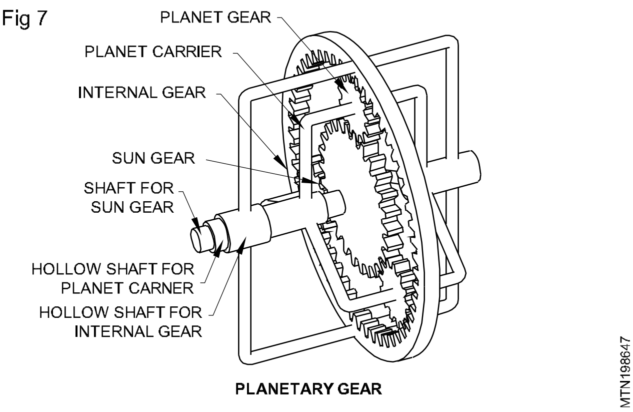
OPERATION OF ONE TYPE OF LOCK - UP CONVERTER

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

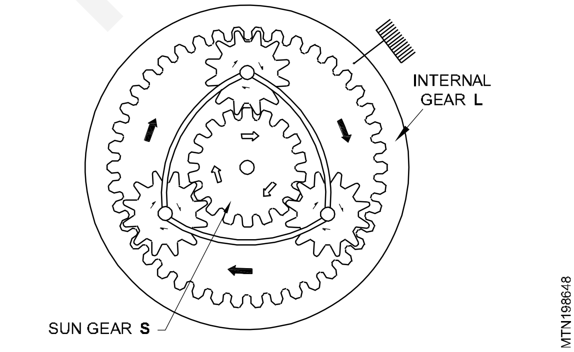
The planet gears are supported with their axis in the planet carrier. The planet gears circulate on the internal teeth of the ring gear and the outer teeth of the sun gear. All gears are constantly meshed. The sun gear, planet carrier and ring gear are driven and braked. Output is effective through the 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)

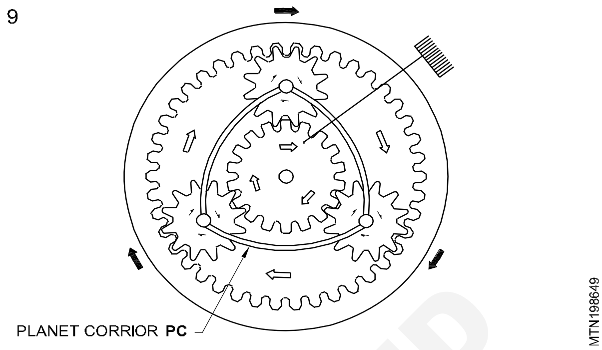
Fig 8



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.

2nd gear (Fig 9)

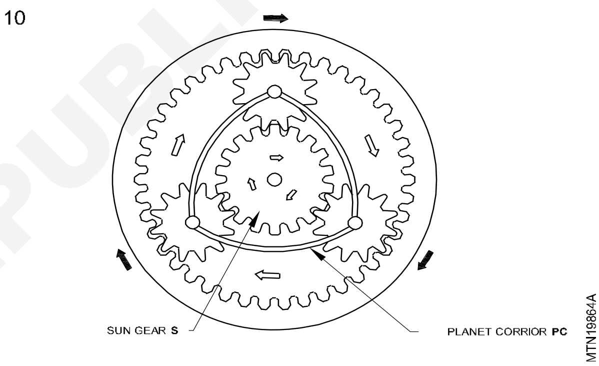
Fig 9



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.

3rd gear (Fig 10)

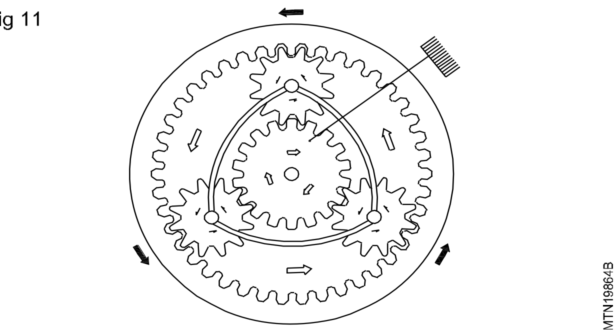
Fig 10



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.

Reverse gear (Fig 11)

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	

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

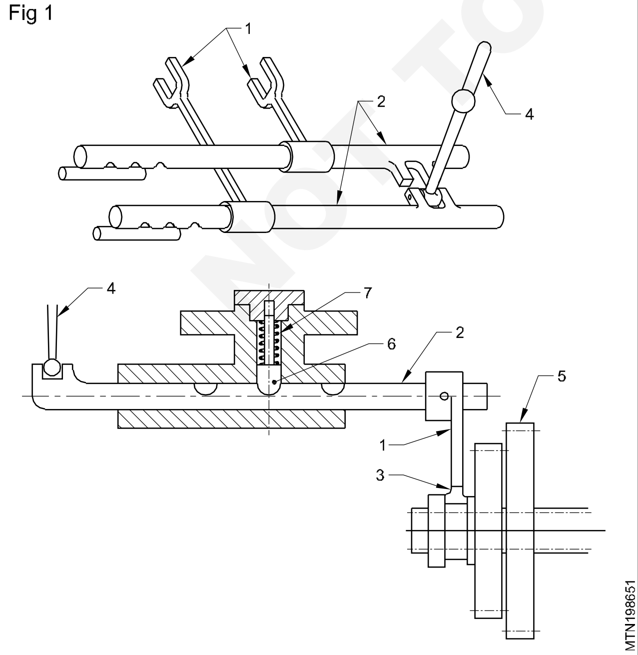
These are used to lock the sun gear, planet carrier or ring gear. These are all actuated by the electronic gear box control unit. By operating this, any one of the planet gear set component can be braked.

Gear shifting mechanism and gear shifting arrangements in tractors

Objectives: At the end of this lesson you shall be able to
- **state the various types of gear shift mechanism**
- **know the gear shifting arrangement in sliding mesh gear boxes**
- **discuss the gear shifting arrangement in synchromesh gear boxes**
- **to study the shifter systems used in tractor transmission**
- **to discuss the lubrication of gear boxes and hydraulic transmission**
- **to study the planetary gear system and in tractor transmission and drive arrangement and gear selection.**

The gear shift lever is located either on the steering column or on the floor board. (Fig 1)

Fig 1



To engage the gear, the gear shift lever (4) moves the selector rods (2). The gear shift forks (1) are fixed on the selector rod. The shifting forks (1) or (4) sit in the slot of the sliding dog clutch of the gear. When the selector rod moves, the shifting fork also moves and pushes the respective sliding dog clutch (3) into the gear to engage the respective gear (5).

When the selector shaft (2) is moved, it forces the pin (6) into a groove cut in the opposite rail and the lock or spring loaded ball (7) hold selector shaft in locking position.

Sliding mesh gearboxes

Gear shift arrangements: Two stages of transmission shifting to be studied. In the sliding mesh gear box in Tractors as many as 10 speed ratios are provided for gear selection. This is done in 2 stages.

Ist stage: Selection of I, II, III, IV & 5th forward speed ratios and 1st reverse speed ratios.

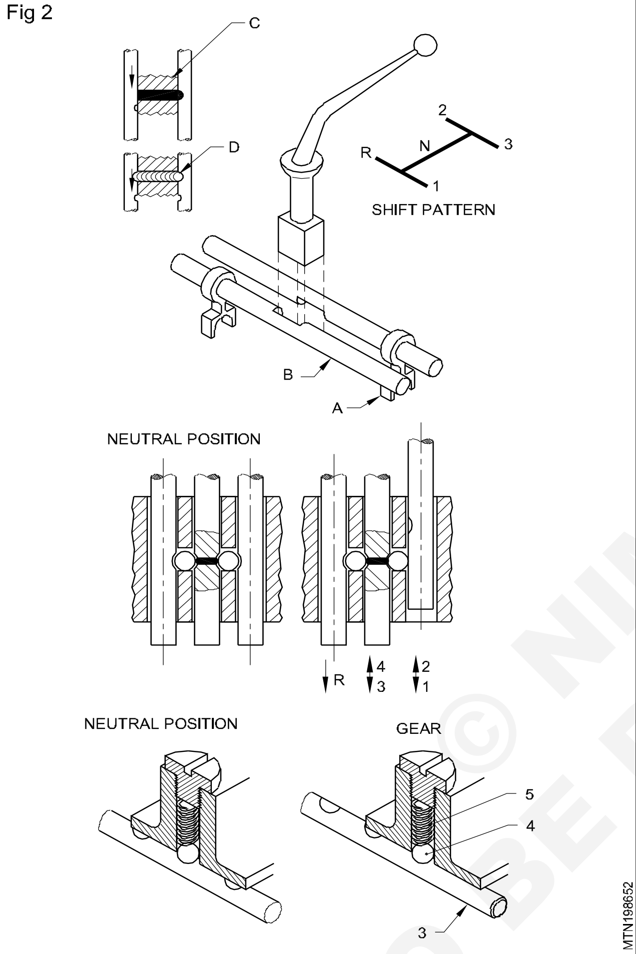
IInd stage: Selection of 6th, 7th, 8th & 9th & 10th forward speed ratios plus 2nd reverse speed ratio.

Shifter mechanism part and working

Parts: This consists of

– Shifter rails
– Shifter forks
– A gate
– Inter lock shaft
– Shifter locks
– A gear shift lever

Fig 2



Working (Fig 2)**:** The gear shift lever is located either on the steering column or on the floor board.

To engage the gear, the gear shift lever moves the selector rods (1) & (2). The gear shift forks (3) & (4) are fixed on the selector rod. The shifting forks (3) & (4) sit in the slot of the sliding dog clutch or gear. When the selector rod moves, the shifting fork also moves and pushes the respective sliding dog clutch or gear to engage the respective gear.

When the selector shaft is moved, it forces the pin (6) into a groove cut in the opposite rail and the lock or spring loaded ball (7) hold selector shaft in locking position. This system is mostly used in automobiles.

Gear slip: The following are the reasons for the gear to slip.

– Wrong adjustment of gear lever/selector rod.
– Weak lock spring
– Worn out locking ball/pin
– Excessive end float of gear

In the shifter mechanism also two types are used. They are as below

For sliding mesh and constant mesh gear boxes: Gears or collars are moved by a shifter fork, that fits in a groove in a collar or gear. This fork is connected to gear shift lever by linkages and operates in response to movement of gear shift lever.

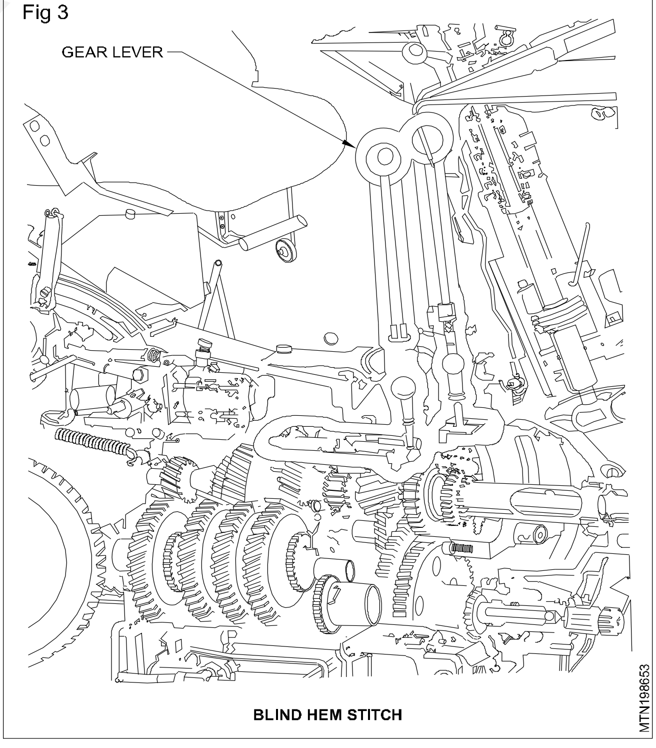
For synchromesh gearboxes: The synchromesh transmission is primarily a constant mesh collar shift transmission only, but used with a synchroniser mechanism to equalise the sped of meshing gears before they engage. The synchromesh is used in all manual shift automatic transmission and has become very popular now-a-days.

The collar shift transmission basic parts are shown in the figure here.

– Shifter collar with internal splines.
– Shifter gear splined to shaft.
– Driven gear revolves free on shaft
– Shaft with long splines and machined shaft portion.

Principle of working (Fig 3)**:** The driving gear is permanently attached to the shaft. The driven gear (3) is free to turn on its shaft. The driven gear (3) can also be locked to its shaft by shifting the collar so that its internal splines are engaged with external splines on the driven gear and the shifter gear. Because it is a constant mesh with a synchronising device. One gear in each pair must be so arranged so that it can be locked to its shaft for engagement. But allowed to free wheel on its shaft for disengagement. The collar acts like a coupling device.

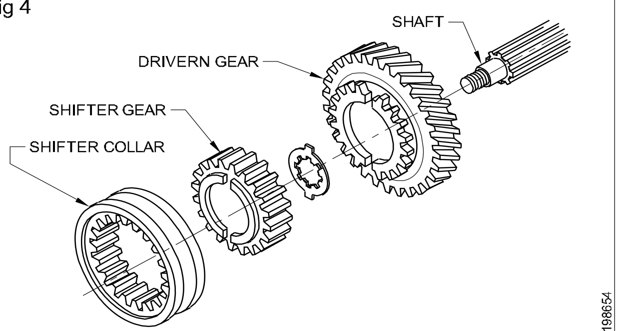
Fig 3



Shifter systems used in tractors

Direct type shifter arrangement (Fig 4)**:** In this system, the gear shift lever (provided in driver cabin) projects into the transmission case.

Fig 4

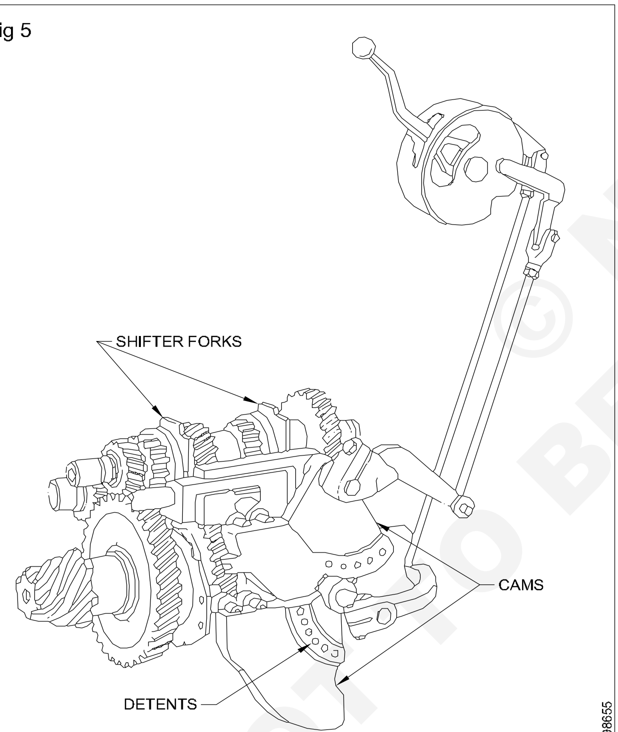


COLLAR SHIFT TRANSMISSION

The shifter (which slides the collars of gears) are connected to the gear shift rails or shafts. To swivel the gear lever to various shift position. A ball and socket is used in the top of the transmission cover. By moving the lever, the finger at the lower end selects and moves one of the rails, its forks and a gear or a collar.

Cam type shifter system (Fig 5)**:** Two cams are used to move the shifter forks and these cams are connected to shift lever by linkages and the movement takes place about a pivoting point.

Fig 5



CAM TYPE SHIFTER

The shifter cam is made out of a plate with two irregular grooves. Rollers on the rail and fork assembly slide in these grooves.

When the cam pivots, the rollers sliding in the irregular grooves, move the forks to engage the selected gear. Thus gear engagement is made.

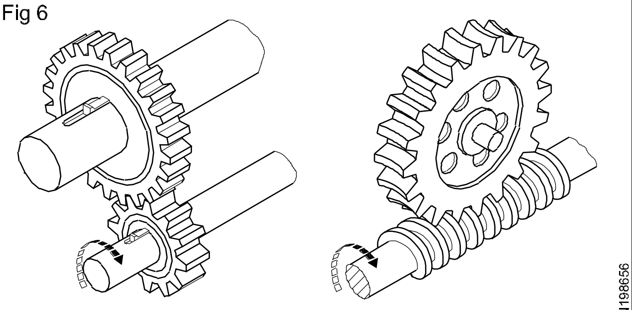
Lubrication of gearbox

Lubrication: Gear oils for correct viscosity must be used in gear boxes. Makers of vehicle specify the grade of lubricants for their gear boxes. Kindly refer to Maker's Service Manual for details.

Gear lubrication

General points (Fig 6)

Fig 6



- In a simple gear system where tooth pressures are not very high a relatively light and simple gear oil will serve the purpose.
- spiral bevel and worm gears have high tooth pressures. Hence require special type of gear oil. They are called "Extreme Pressure Lubricant or Hypoid Lubricants".
- Viscosity of oil
  – The viscosity of oil are graded by Society of Automotive Engineer's by SAENOS. The numbers indicate the viscosity above and do not specify any other qualities of oil. Eg. SAE 50, SAE 80, SAE 140 EP.
  – Multi-grade oils are also available from supplies under SAE Nos.75/80, SAE 80/90/140.
  – Some Maker's suggest the use of engine oil for transmission and some other maker's suggest the use of SAE 50 oil. Hence the containers are marked as SAE 50-90.

A.P.I. oil service classification: The American Petroleum Institute designates the Lubricants by service for which they are used.

Eg. API-GL-1 oil - Lowest services and adequate for lower gear speeds and pressure.

API-GL-6 Oil - For Hand Service.

Latest developments

Transmission hydraulic fluids: The farm and Industrial Manufacturers have developed a special fluid to be used in a common reservoir from where it is supplied to gear trains, differentials, hydraulic clutches and disc brakes as well as hydraulic system and power steering.

Some of the fluids developed for Multiple Service work is given below.

– John Deere 303 special purpose fluid

– All is chalmers A - 26 fluid

– Ford M2C41-A-Fluid

– International harvester Hy-Tran-B-6 fluid.

These fluids are referred to as four way oils. Their key properties are given below:

– High oxidation stability for lay life.

– Low pour point for L.T.service (cold starting)

– High viscosity Index (under different temperature)

– Extreme pressure additives

– Rust and corrosion inhibitors

– Comparability with all kind of seals

– Foam suppressors

Always use oil recommended by the manufacturers.

Gear shift systems in tractor transmission

Objectives: At the end of this lesson you shall be able to
- **types of shift system in tractor transmission.**

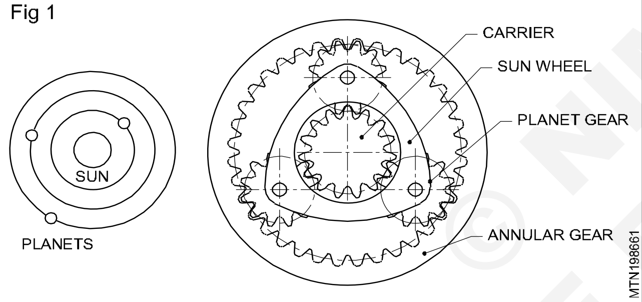
Types of shift system in tractor transmission

On the GO (Power) shift type tractor transmission

Introduction (Fig 1)**:** In modern tractor design, latest developments are used in Transmission system. i.e the transmission can be shifted to any gear while power is being transmitted. Such Transmission is named as "ON-the-Go" or "Power Shift Transmission".

In some latest models of tractors this shift system is assisted by hydraulic controls. Hence called as "hydraulic assist transmission". In the arrangement two or more hydraulic clutches control the flow of power through gears that are kept in constant mesh. Let us discuss about the same briefly.

Fig 1



Discussion: The parts work together as below:

– Hydraulic clutches - control the power flow

– Gear trains - transmit the power flow

Description

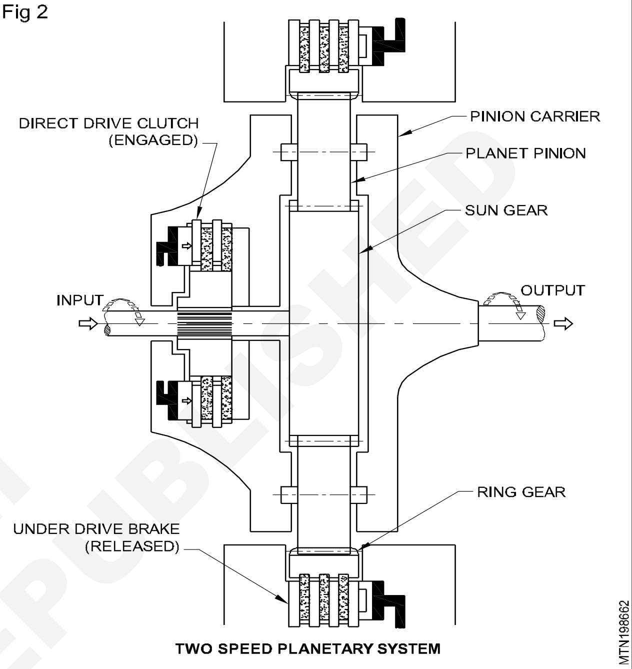
Hydraulically controlled clutches (Fig 2)**:** These are housed in pairs in 2 drums which are splined to transmission output shaft. When gear shift lever is moved the pressurised hydraulic fluid engages the clutches, that route the power to selected gears.

The hydraulic clutch consists of a pack of friction discs and plates arranged in alternate layers or stages. (multiplate disc clutch).

The disks are splined to the input drum and the plates are splined to the output hub. For engaging the clutch, the hydraulic fluid pressure pushes the piston against the discs and plates, thus clamping them together.

At the release of the fluid pressure the piston moves away from the clutch pack, disengaging the clutch. A spring is provided on the opposite side of the piston, helps to release the discs and plates quickly.

Fig 2



Gear train arrangements: The gear trains, employing the hydraulic transmission control, usually uses two systems of arrangement.

– Planetary gearing system

– Counter shaft gearing system

Countershaft transmission: This makes it possible to shift one set of gears without disturbing the other gear ratios in the transmission unit. It has two hydraulic clutches and four gears in mesh.

This is accommodated in the clutch housing in front of the transmission case and allows the speed ratio to be reduced by a factor of 1:3. Whenever one clutch is engaged, the other is disengaged.

Drive arrangement

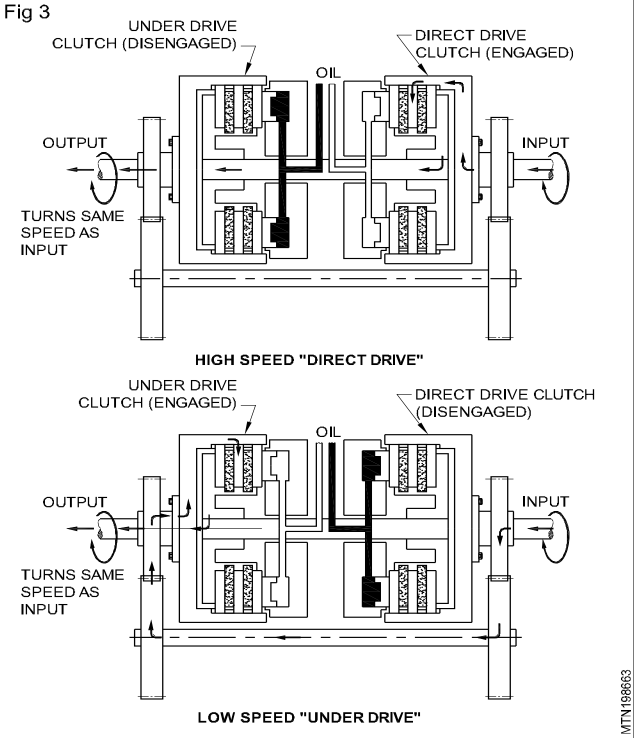
Direct drive (Fig 3)**:** The input and output shafts are locked together by the action of direct drive clutch. Hence they both rotate at the same speed.

Low speed: Direct drive clutch released - under drive clutch engaged - Power flows through the gears and the counter shaft output gears - The speed depends on ratio of gears engaged.

On-the-go-reversing capabilities of tractor

To get a reverse speed from the counter shaft gears another gear is used to make the counter shaft to rotate in the same direction as the input shaft.

Fig 3



Forward speed: To get this forward speed, the forward clutch is engaged, power flows straight through by passing the counter shaft.

Reverse motion on the go shift: To get the reverse motion, the reverse clutch is engaged and power is transmitted through counter shaft. The action makes the output shaft to rotate in the opposite direction of input shaft.

Planetary transmission system

– The system of gears arranged is a simple and compact unit.

– A planetary gear set can work as (a) direct drive coupling (b) a reduction gear unit and (c) a reversing gear unit.

– In this system the input and output shafts rotate on the same axis. The load is distributed to a number of gears. This eliminates transmission shocks and side loads.

– The gear ratios can be changed without engaging and disengaging the gears. There is no interruption of power flow when operator changes the gear.

Important note: No counter shaft is used in the system.

Arrangements of parts: Parts of a planetary system

– Sun gear - centre of the system

– Planet pinions and carrier - rotates around the sun gear

– Ring gear - surrounds the other gears

– Hydraulic clutches and brakes - To control the rotation of the parts.

Working

Two speed planetary gearing set: This has one clutch and one brake.

– **The clutch controls the direct drive (High speed).**

– **The brakes control the under drive (Low speed).**

– **Power is supplied to the sun gear shaft.**

– **The planet carrier carries the output shaft.**

Gear selection - Drive arrangements

High speed	Low speed	Neutral
Direct drive clutch is engaged. Sun gear locked to pinion carrier. **Result** Input and output shaft rotates as one unit.	Direct drive clutch is released Under drive brake applied to hold ring gear locked. The sun gear turns the planet pinions on the locked ring gear. Planet carried is forced to rotate. **Result** The pinion carrier rotates in the same direction as the sun gear at a reduced speed.	When all gears are revolving, the system is in neutral position. **Reverse** Planet carried will be the locked member. Reverse direction will be obtained.

– **To get additional speed ratio two planetary sets can be combined.**

– **For combination, the output shaft of first system is connected to the input of the second.**

– **Thus many more ratios can be obtained by this gearing system.**

– **This system is used in automatic transmission of automobiles.**

Four wheel drive (Transfer case)

Objectives: At the end of this lesson you shall be able to
- **explain the necessity of a four wheel drive**
- **explain the purpose of the transfer case**
- **explain the operations of a four wheel drive**
- **explain the shifting mechanism in the transfer case.**

In the four wheel drive mechanism, there is provision to supply power to all the four wheels, whenever it is needed. When the vehicle is moving on sand, slushy ground, traction between wheels and road is lost and the drive wheel tends to slip on the ground. In this condition, the vehicle cannot be pushed. Therefore, power is transmitted to other wheels also through the transfer case.

The transfer case is mounted in the back of the main transmission. It is sometimes called auxiliary gearbox.

The transfer case can transmit engine power either only to the rear wheels of the vehicle or to all the four wheels according to the driving requirements.

The transfer case can also provide low or high speed transmission.

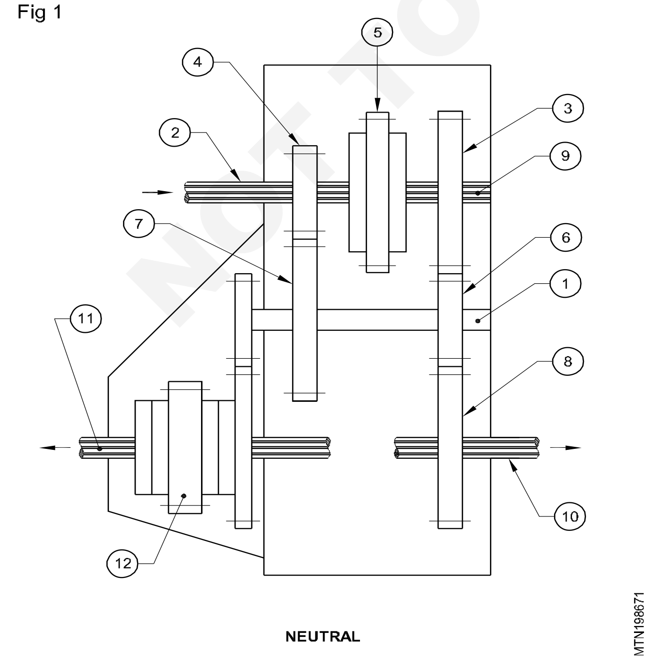
A low speed transmission drive is mostly used when moving with the heavy load requiring high traction torque.

Operation of transfer case (From wheel drive)

The transfer case consists of a main shaft (9) on which the low range gear (4) and the high range gear (3) are fixed. These gears rotate freely on bushes. The sliding gear (5) slides on the main shaft. An idler gear shaft (1) is fixed between the main shaft and the rear differential drive shaft (10) and the front differential drive shaft (11). A clutch locking drive gear (12) is fixed on the front differential drive shaft (11).

During neutral position, the sliding gear (5) and clutch drive gear (12) are not engaged with their respective gears and power is not supplied to the front and rear wheels. (Fig 1)

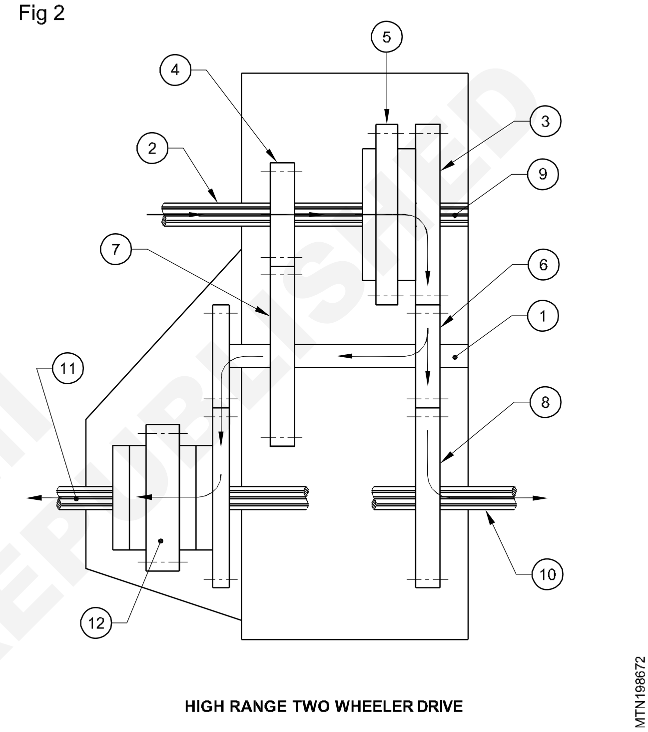
Fig 1



NEUTRAL

When power is to be supplied to the rear wheels only, the front drive clutch gear is kept in neutral position and the sliding gear (5) on the main shaft is engaged to low or high range gears (4) or (3), depending upon the requirements. In this condition, power flows only to the rear axle. (Fig 2)

Fig 2



HIGH RANGE TWO WHEELER DRIVE

When a vehicle is driven over slushy ground the drive wheels tend to spin without moving the vehicle.

In this position, the clutch drive gear to front wheels is engaged. Now power will be supplied to all the four wheels. (Fig 3)

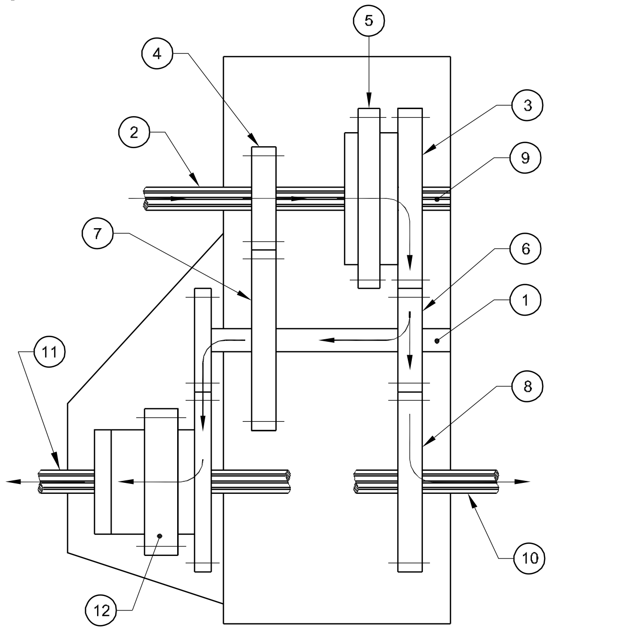
When the lever is shifted to engage a high range four wheel drive position, the drive from the primary gearbox shaft (2) goes to the main shaft (9). The main shaft's sliding gear (5) engages with the high range gear (3) and power is transmitted to the front wheel's drive output shaft (11) and the rear wheel's output shaft (10) through the idler gears.

When the lever is shifted to engage the low range four wheel drive position, the drive from the primary gear shaft (2) goes to the main shaft (9). The main shaft's sliding gear (5) engages with the low range gear (4) and transmits the drive to the output shafts of the front and rear drive shafts (10 & 11) through the idler gears. (Fig 4)

Shifting mechanism in four wheel drive

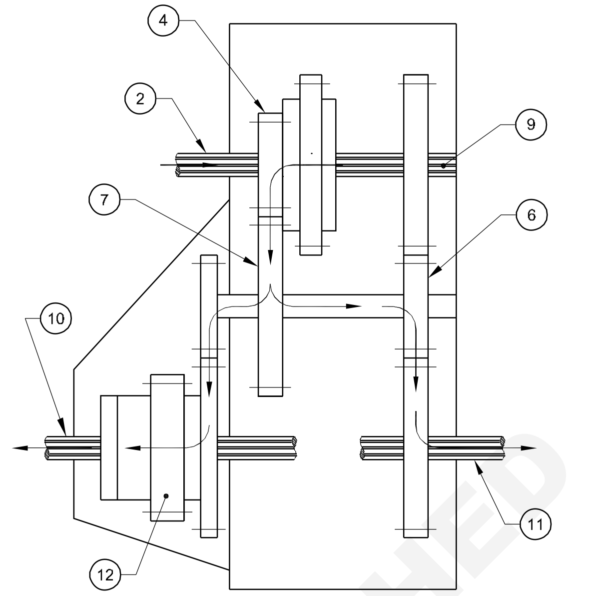
The transfer case is provided with a shift mechanism to operate the four-wheel drive mechanism.

Fig 3



HIGH RANGE FOUR WHEEL DRIVE

Fig 4



LOW RANGE FOUR WHEEL DRIVE

A gear shifting lever is provided in the driver's cabin and it is connected to a clutch locking drive gear of the first gear through a shifting rod and fork. Similarly another lever is provided to engage the sliding gear (5) with low range or high range gears, and is connected with the sliding gear through the shifting fork and rod.

Universal and slip joints

Objectives: At the end of this lesson you shall be able to
- **state the need for a universal joint**
- **state the function of a universal joint**
- **state the constructional features and function of the different types of universal joints**
- **state the need for a slip joint.**

Need and function of universal joint

In any vehicle the gearbox and the rear axle are at different levels. A universal joint provides a flexible connection. It allows the propeller shaft to transmit torque from the gearbox to the rear axle. Similarly due to the ups and downs on a road, the angle between the gearbox and the rear axle changes. The universal joint accommodates this variation in angle and permits smooth transmission of torque from the gearbox to the rear axle.

Types of universal joints

- Cross-type or spider and two yoke type
- Ball and trunnion type
- Constant velocity type

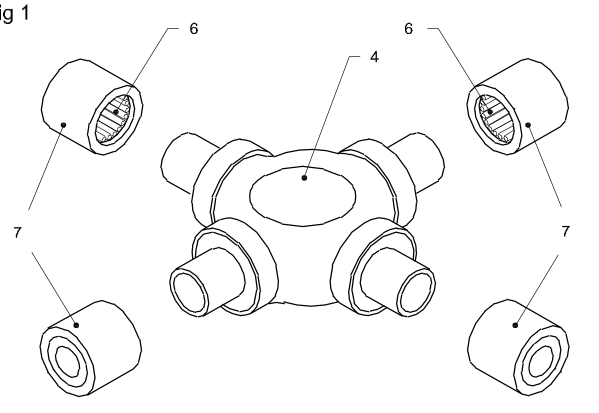
Cross-type universal joint (Figs 1&2)

A cross-type universal joint has a spider (4). At the four ends of this, needle roller bearings (6) are fixed with bearing caps (7). Two yokes (1) and (2) at 90° to each other are pivoted to the spider (4).

Ball and trunnion type universal joint (Fig.3)

In this type of joint a ball head (1) is fixed at the end of the propeller shaft by a pin (2). At both the ends of the pin two steel balls (3) with roller bearings (4) are fixed. The centering button (5) and a button spring (6) keep the pin (2) in the centre. The propeller shaft and universal joint assembly is fixed to the companion flange (7). Whenever the angle between the gearbox and the rear axle changes, the ball accommodates this variation by moving in the 'U' channel.

Fig 1



Constant velocity joint (Fig.4)

This joint has the input of a half shaft (1). The shaft (1) is splined (4) at one end on which the inner spherical socket (2) sits. The inner spherical socket (2) and the outer spheri-

Fig 2

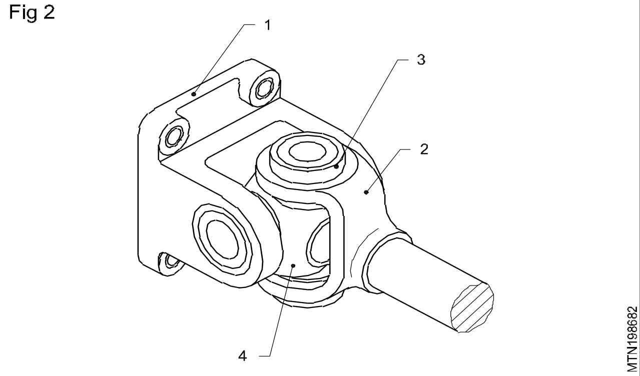
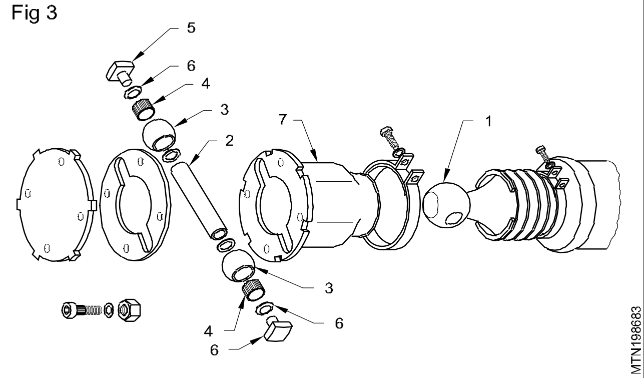


Fig 3



cal socket (3) have grooves in which balls (6) move. The outer spherical socket (3) is connected to the output shaft (5).

This arrangement provides equal speeds of input shaft (1) and output shaft (5), irrespective of the angle between them.

Slip joint (Fig.5)

When the vehicle is moving, the rear suspension spring compresses and expands because of the ups and downs on the road. As a result, the length and the angles be-

Fig 4

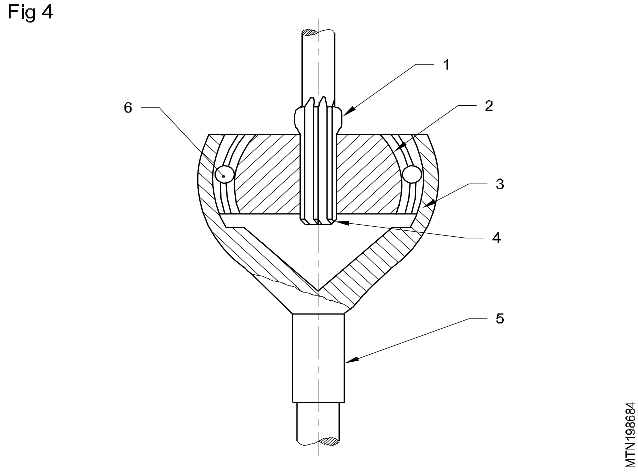
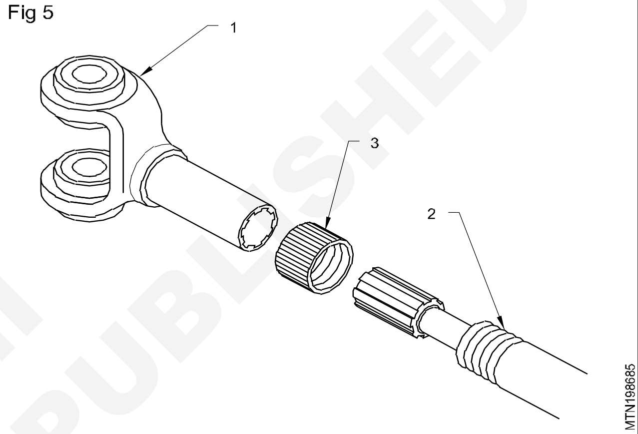


Fig 5



tween the gearbox and rear axle varies. To accommodate this change in length, slip joints are used.

The joint yoke (1) has internal splines matched with external splines of the propeller shaft (2). Whenever there is any change in length the joint yoke (1) moves on the shaft (2) and adjusts the length.

Propeller shaft

Objectives: At the end of this lesson you shall be able to
- **state the function of the propeller shaft**
- **state the need for centre bearing**
- **state the hotchkiss drive**
- **state the torque tube drive.**

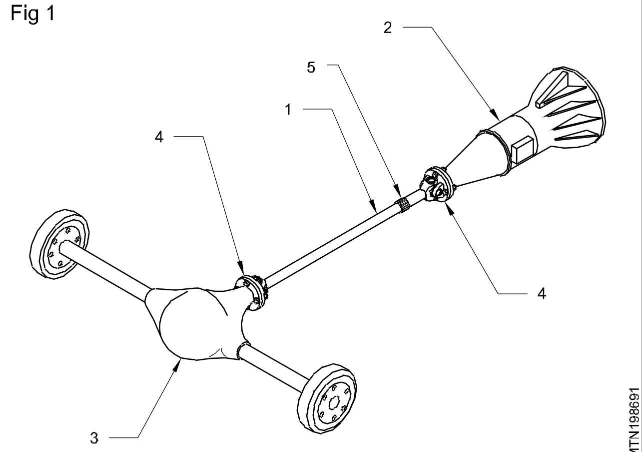
Functions of propeller shaft (Fig.1)

The propeller shaft (1) connects the gear box (2) and final drive(3). The pinion shaft of the differential is connected to the propeller shaft (1). One universal joint (4) is used in between the propeller shaft and the pinion shaft of the differential. Another universal joint (4) with one slip joint (5) is also used between the propeller shaft (1) and the gearbox (2).

The propeller shaft rotates at high speed and bears a heavy torque. So it is made of strong steel tube. In some vehicles a solid propeller shaft is also used. Vehicles having a larger wheel base use two propeller shafts.

Whenever the distance between gear box and rear axle is very large (example -passenger buses) more than one pro-

Fig 1



peller shaft is used for torque transmission. Centre bearing is used to connect the two propeller shafts.

Types of drives

Two types of drives are used.

- Hotchkiss drive
- Torque tube drive

Hotchkiss drive (Fig.2)

It has two longitudinal rear leaf springs (1). The front end of the spring (1) is connected to the frame with the pin and the rear end is connected to the frame by a bracket and shackles. The gearbox (2) and the rear axle (3) are connected by an open propeller shaft (4), through the universal joint and the slip joint. Whenever the torque resistance of the rear axle changes i.e. while driving fast or applying the brake, the springs get deflected and this helps to damp the shock. The slip joint accommodates variation in length between the gearbox (2) and the rear axle(3).

Torque tube drive (Fig.3)

In this type of drive the propeller shaft (1) is enclosed in the tube (2). The tube (2) is fastened to the differential housing (3). The other end of the tube (2) is connected to the gearbox by a flexible joint (4). Only one universal joint is used in this drive. To provide strength, brace rods are connected between the torque tube (2) and the differential housing (3). In this drive helical or torque bar springs can be used.

Fig 2

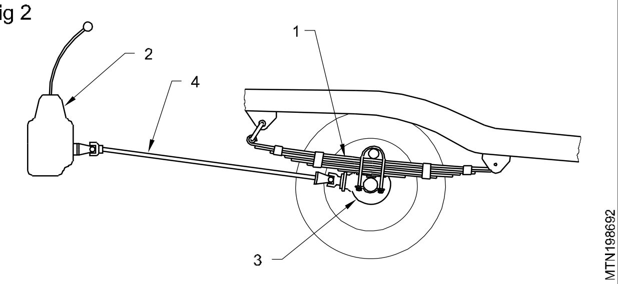
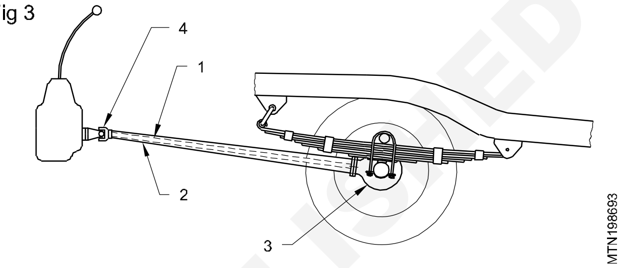


Fig 3



Layout of transmission system

Objectives: At the end of this lesson you shall be able to
- **draw a layout of the power transmission in a tractor.**

The need for transmission is.

– To increase the pull effort to the tractor loads.

– To run the tractor at different speeds. N.P. Engine unit produce the power at rated r.p.m. The torque is transmitted from the engine (1) to the gear box (3) through the clutch (2). The torque is increased in the gear box by engaging the different gears. This torque is transmitted to the wheels (6) through the differential gear (4) and reduction gear/ final drive (5). The bevel gear and crown wheel in the differential housing converts the drive by 90°. (Fig 1)

The mechanical drive power transmission has four basic components:

Clutch, rear box, differential and final drive.

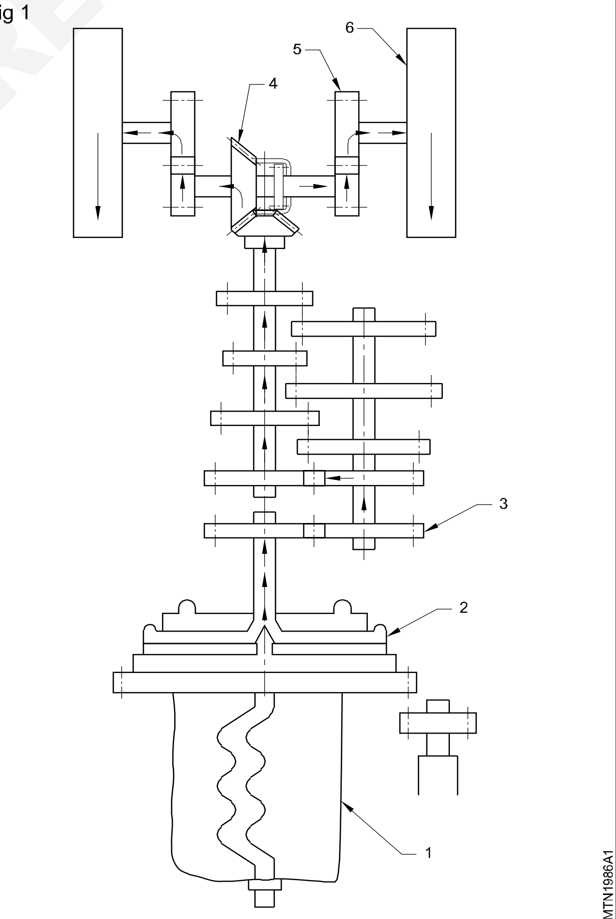
The clutch transmit power from engine to gear box and provides a means of starting and stopping power flow to gear box.

The gear box consists of a series of gears forward and reverse speeds of tractor can be obtained by combination of gears of main and lay shafts.

The differential transmits power from gear box to final drive. It also allows the driving wheel to run at different speeds during turning.

The final drive transmit power to rear wheels.

Fig 1



Differential

Objectives: At the end of this lesson you shall be able to
- **state the function of a differential**
- **know the arrangement of parts of a differential unit**
- **discuss the differential action**
- **discuss the use of differential locks.**

Function: The differential transmits power from transmission output shaft to the driving axles. It has mainly two functions to perform.

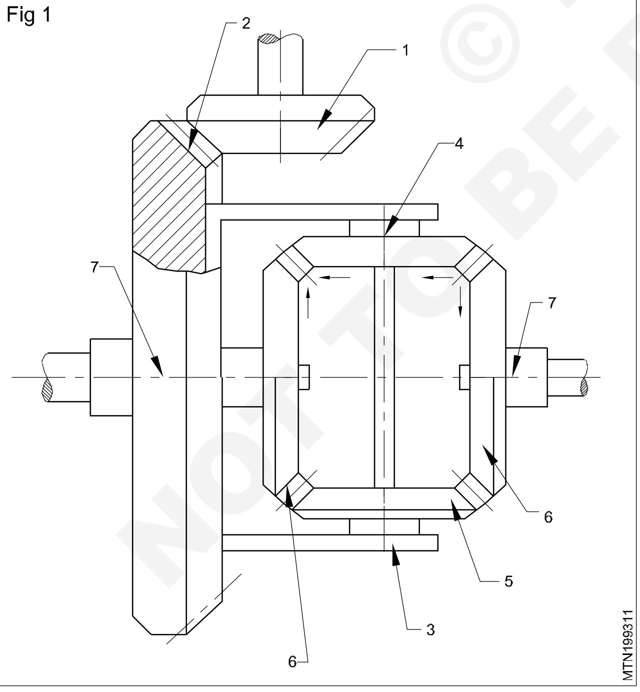
– It permits to transmit equal Torque on Axle shafts.
– It allows the two drive wheels to rotate at different speeds during cornering.

> – **The bevel pinions (1&2) provide differential action.**
>
> – **The ring gear and drive pinion gear (1 & 2) provide direct power to the axles.**

Arrangement of parts in a differential unit

Parts arrangement (Fig 1)**:** The differential is made up of a differential case (4), four differential bevel pinions, 2 bevel side gears on axle (5 & 6). The differential case is bolted in two parts and supported by 2 taper roller bearings installed in differential carrier.

Fig 1



Adjusting nuts are provided for adjustment of backlash between ring gear and drive pinion teeth and side bearing pre-load.

The differential ring gear is bolted to the differential case flange.

The axle pinion shaft is supported on two taper roller bearings and is placed on the differential carrier.

The position of drive pinion shaft relative to the centre line of axle is adjusted by the help of shims placed under the flange of drive pinion.

The pre-load of drive pinion is adjusted by use of shims placed under the cone of the front bearing.

The 'U' joint flange is provided at the front end of the drive pinion shaft.

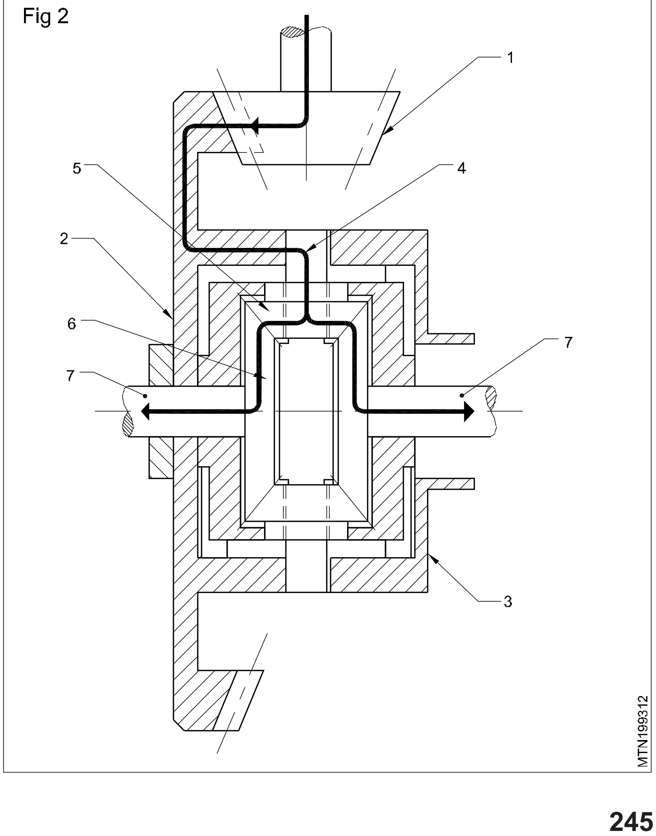
On the top of axle housings. Two spring pads are welded. Also, filler hole, drain plug hole and closing plugs are provided on the housing.

The rotating components are lubricated with transmission oil.

Operation (Differential action)

Straight ahead movement of the vehicle (Fig 2)**:** When the vehicle is moving in straight run, the power is transmitted from axle drive pinion (1) to the ring gear (2) and then to cage/case (3). When the case/cage (3) is rotating the spider (4) is also rotating with star gears (6). The sun gears

Fig 2



are pushed by star gears (5) and the power is transmitted to the axle shafts (7).

During the straight line run, the star gears (5) do not rotate on their axis.

During cornering of a vehicle: During cornering, the inner wheel has more grip on the road, than the outer wheel. So the respective inner sun gear offers more resistance. At the time the star gears rotate on their own axis and move the inner sun gear slowly and allow outer sun gear to rotate faster. So the outer wheel travels more distance in the same time.

During one revolution of ring gear the left hand bevel side gear makes two revolutions as below.

– One as a result and force applied by ring gear.

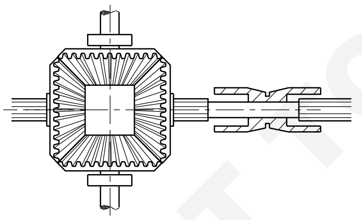
– The second as a result of bevel pinions walking around the right hand bevel gear.

Result: As a result when driving wheels (road wheels) come across unequal resistances the wheel with less resistance turns more. As one wheel turns faster, the other slows down by the same amount.

Differential locks (Fig 3)**:** Differential action may not be useful when resistance applied to one wheel decreases in a large measure, especially when vehicle is moving in straight ahead. When the resistance drops to zero, the wheel will spin and no power can be applied to the other wheel.

So, differential locks are employed to prevent such power loss. By locking out the differential, the locks direct power equally to both wheels. The advantage is that when one wheel is slipping, there will not be any power loss or loss

Fig 3



DIFFERENTIAL LOCK

of traction. When the lock is put sum and star pinions come to rigid position, power is equally transmitted to both the wheels.

Advantage of using differential locks

– getting stuck up in many cases is avoided.

– draw bar pull is increased.

– Tractor pulling straighter and making it easier to plant straight rows.

– during cultivation, steering the vehicle is easily done.

– side effect caused by some implements is reduced considerably.

Disadvantage: When there is a big difference in Rear Wheel Traction condition the front of the tractor is pushed towards the side of the least traction. Here the tractor operation must be careful during ploughing operations.

Types of differential locks: Three types of locks are normally used

– Limited slip differential

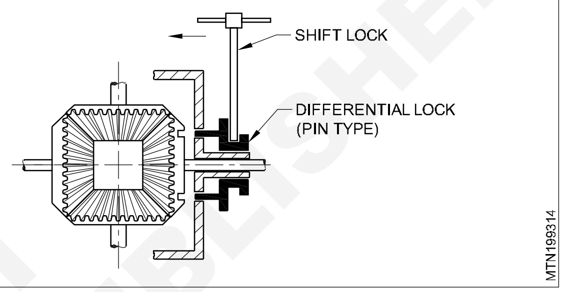
– Mechanical lock

– Hydraulic lock

Out of the three lock, the mechanical lock is simple and easy to operate.

Mechanical lock (Fig 4)**:** A foot operated jaw clutch that rigidly connects together both the axle shafts of the tractor.

Fig 4



Important note: To lock the differential, bring the steering to straight ahead position and depress the lock pedal until the lock is engaged - then release the pedal. This lock should be disengaged when rough terrain is encountered.

OR

When the operator moves a lever, it makes a fork to slide a collar on the splines of axle.

This engages the differential housing splines to the collar. Now the axle and the housing are forced to rotate as one unit. This action prevents the bevel gear on the axle from turning. Thus locks the differential. When the drive wheels have equal tractions, the lock disengages automatically because the collar is spring loaded. The pedal will also return to its original position.

If the pedal is slow in returning moment, depress the clutch pedal.

Hydraulic lock: To lock the differential, hydraulic oil is used. When pedal is depressed, a valve allows oil pressure to flow to the differential. The oil pressure presses the piston against disk clutch, compressing it against the housing. Because the disks are held by splines to the level gear and the plates are held by tangs to the housing, this locks up the bevel pinions and prevents differential action. Thus locking of differential is obtained.

Precaution on use off differential lock

- When one of the rear wheels is slipping, use the differential lock.
- Do not turn the tractor with the differential locked.
- Differential lock should not be applied for more than 2 minutes under normal condition.

Double reduction gearing: Double reduction gearing mechanism is used in huge automotives, where in the speed has to be reduced at a required level. For eg. If the input speed is 2000 rpm and the output speed desired is 300 rpm a reduction gearing mechanism, the reduction of speed takes place in steps. Initially the input shaft from the engine shaft has a pinion mounted on it through couplings. The pinion gear is first reduction gear. The gear is than connected to another low speed pinion on another shaft. This low speed pinion is connected to the second reduction gear, which is mounted on the propeller shaft. Which is the output.

In short double reduction gearing is used to reduce the speed in 2 states as explained above.

Front axle of tractor

Front axle is an important tractor part which facilitates the movements of agricultural machines on the field. It is attached to the front side of the tractor. Front axle is used in the process of steering the tractor right or left.

Function of front axle

- it is used to bear the full weight of front of a tractor.
- it has king pin, steering arms using which machine can be easily be steered.
- the machine is kept in a regular levelled position through its swinging action.
- the springs fitted inside the case absorbing the shocks.
- in a four wheel drive machine, the transmission of power to road wheels is also done using this tool.

Shape of front axle

1-I section, 2. Circular section 3. Oblong section 4. Square section

Types of front axle

- Rigid types
- Swinging type

Now a days the rigid type axle has been replaced by swinging type of axles. In the swinging type, the centre of axle is rested on the front side of the machine using a centre pin. Due to this alignment, the right on wheel can easily move up or down or swing in different directions.

Stub axles: In stub axle, wheel hub is attached using 2 taper roller bearing and maintained in position by washer and nut. Stub axle is fixed on axle beam which allows regular movement.

Rear driving axle - final drive

Objectives: At the end of this lesson you shall be able to
- **discuss about the rear driving axles and types used on tractors**
- **study the brake and steering arrangements on rear axles of tractors**
- **understand the types of final drive used in tractors and their operations**
- **know about the principle and parts and working of differential mechanism and its action.**

Introduction

All tractors have been provided with rear drive axle with a differential mechanism and final drive. All tractors include final drives in their power trains. But it may be seen that the rear axle and differential mechanism may appear to be similar to those used in automobile trucks. But in actual practice, they differ in constructional and mounting aspects to a large extent. Since the wheel base of the tractor is shorter than automobile truck. These two units are accommodated in a different way. However, the only similarity is that the principle of differential operation in tractor and automobile truck is the same. Also in tractors wheel hub reduction gears and brakes are employed along with rear driving axles, but in automobile truck, this system is not employed. Let us study the system of rear axle drives, brakes, differential and final drive arrangement in tractors in the following paras.

Rear driving axle (types and working)

Objectives: At the end of this lesson you shall be able to
- **list out the types of rear driving axles for tractors**
- **know about the constituents of each driving axle unit**
- **discuss the brakes provided on the drive axle unit of row crop tractors**
- **discuss the steering brakes on the crawler type tractors (chain drive).**

Types of rear driving axle for tractors

3 types are generally used on tractors

- driving axles for general purpose wheeled Tractors
- driving axles for row crop tractors
- driving axles for crawler tractors

The driving axles used in tractors consists of the following constituents assemblies

General purpose wheeled tractors

Each driving axle includes the following constituents

– a housing
– an axle drive
– a differential
– two axle shafts (half axles)

General purpose tractors have 4 wheels drive arrangement. They have two driving axles - front & rear. Both axles are same in construction. These two axle drives are interchangeable and contains a pair of spiral bevel gears.

The final drive may be arranged from spur gearing or planetary gearing system. They may be located at wheel hub or near to the differential.

Row crop tractors: These tractors have a single driving axle at the rear.

The rear axle comprises of the following units

– An axle (main) drive
– A differential
– Two final drives
– Two brakes
– A differential lock mechanism

The axle (main) drive contains a pair of spiral bevel gears.

The final drives are arranged by spiral gearing system on both sides of the rear axle

They may be located within the differential housing attached to the outer end of axle shafts are the driving wheels, tyre etc of the tractor.

Crawler tractors: The rear axle of this contain the following units.

– An axle (main) drive
– Planetary steering mechanism
– final drives

The axle (main drive) includes a pair of bevel gears. The constituents of rear axle are housed in a housing at the rear of transmission case which is made into 3 compartments i.e one compartment for housing axle wire and planetary gear sets of steering mechanism, the other two houses sun gear of steering mechanism and axle shaft (stopping) brakes.

The final drives are accommodated in a separate housing.

Row crop tractors - Driving axles

Brakes used in this system: The row crop tractors rear axle drive includes a brake system also.

Function: The brakes are used to stop the tractor quickly, if applied simultaneously (For 2 wheels). If applied separately, short turns are possible.

Arrangement of parts: These are dry friction disc type and consists of a housing, two steel brake discs, two CI pressure plates, Two brake pedals, brake rod with 2 brake links.

The brake housings are bolted, with bearing carriers (supports) of the final drive pinion shafts to the side walls of the rear axle housing.

The brake discs are lined on both sides with friction material and they are splined onto the outer ends of final drive pinion shafts.

The pressure plates are clamped with 3 springs between the pressure plates, are five balls that are accommodated in shaped grooves, in the inner end faces of the plates.

Working of brakes (Brake action)**:** During the movement of tractors, the brake discs rotate with final drive pinions. If one of the brake pedal is depressed, its connected brake links cause their pressure plates to turn in opposite directions.

When the plates turn, the balls clamped between the plates roll over the inclined surfaces of their sockets and cause the pressing of rotating brake discs against the stationary surfaces of brake housing and bearing carrier flange.

The above action causes the final drive pinion (hence the driving wheel of the tractor) to slow down and then to stop rotating completely.

Each of the brake pedal can be retained in the applied position by means of a latch.

Parking brakes: Next to the main brake, (right hand side) an emergency or parking brake is arranged. This brake could be controlled by a hand lever from driver's cabin.

Crawler tractors - Driving axles

The planetary steering mechanism: The planetary gear system of steering mechanism is made up of the following units.

• Planetary gear set
• Two brakes
  – Sun gear or steering brake
  – Axle shaft or stopping brake

The purpose this mechanism is to slow down or stop completely its connected track enabling the tractor to turn.

Arrangement of parts: The planet gear set is arranged inside the Internal gear which is also a part of it. The set includes planet carrier, 3 planet pinions and sun gear.

The hub of the planet carrier is having internal splines that mesh with splines on the inner end of axle shaft. The outer end of axle shaft having splines mesh with internal splines of final drive pinion.

The inner end of pinion shaft carries a stopping brake pulley. The sun gear brake pulley is bolted to the sun gear flange.

Both brake pulleys are surrounded by brake bands which carry friction material. They are made into two halves hinged at bottom. The operating mechanism is also provided on brake band.

Lubrication: The planetary gears are lubricated with oil poured into Central compartment of Rear Axle housing.

Operation of steering mechanism

Introduction: The steering and brake mechanism of this tractor are complicated ones. Hence it is explained in parts for easy understanding.

The control of crawler tractor includes steering levers and brake pedals arranged in cabin of the tractor.

The levers are linked with their associated brake mechanism in a rear axle housing by means of rods and levers.

Tractor moving in a straight line: The sun gears are held stationary by application of their brakes. But Axle shafts freely revolve.

The axle drive transmits rotation to the Internal Toothed ring gear, which drives the planet gears. The planet gear walk around the stationary sun gears since both are in mesh. The planet carrier also revolves. The planet carriers during its rotation, turn the axle shafts and final drive pinions.

There is a ratio between the speeds of revolving member gears.

Rotational speed of planet carriers when compared with sun gears is reduced by a **ratio 1:4**. But their torque is increased 4 times.

Turning the tractor to left or right: The driver has to pull the steering brake lever. The sun gear Brake will be released and the sun gear will revolve freely by the action of planet gears.

Now the track on the side of the released sun gear will slow down and tractor will turn smoothly.

To make a sharp turn: The driver has to pull back the steering lever and also operate the stopping brake pedal on the same side. This action will act on stopping brake pulley and the track will stop completely without any movement.

The tractor will now turn sharply in the direction of the stopped track.

Adjustment: The brake shoe clearance must be adjusted by use of adjusting screws and release springs.

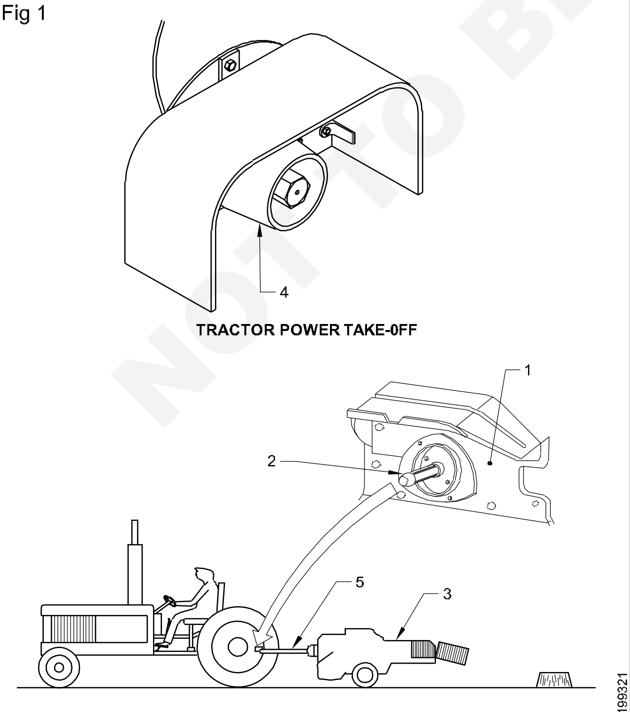
Kindly refer to the service manuals of tractors for brake and other adjustments.

Power take off (P.T.O)

Objectives: At the end of this lesson you shall be able to
- **state the purpose of P.T.O**
- **explain working of P.T.O**
- **state the need and use of telescopic shaft**
- **state the need and use of universal joint and slip joint.**

Power take off is a part of the tractor transmission system. It is provided with a gear box (1) consisting of standard shaft (2) at the rear of the tractor to operate the P.T.O operated machines like thrashers, mowers, forage harvester, combines etc. (Fig 1) The PTO shaft is always kept covered to avoid accidents during operation. PTO shaft can also attach with an additional gear unit and pulley (also known as PTO pulley) (4) to operate belt driven machines. When a PTO driven machine is connected to the tractor through a telescopic shaft (5) with a universal joint is placed in between as a coupler to take care of the angularity of the drive.

Fig 1



OLD STANDARD 540 RPM P.T.O. SHAFT

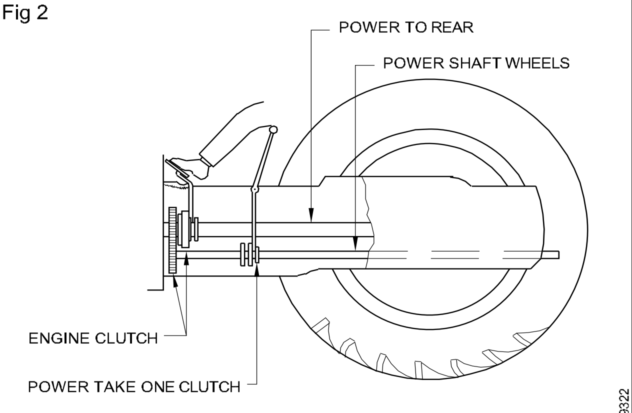
The PTO shaft get its drive either directly from the engine or from the transmission output shaft or both. When the drive is taken from the output shaft the speed of the PTO shaft is proportional to the forward speed of the tractor. In the other two types the speed of the PTO shaft is directly proportional to the engine speed and therefore the speed is controlled by the engine throttle. The existing ASAE and BIS standard for PTO specifications are given as follows.

– Speed = 540 rpm ± 10 rpm when operating under load or 1000 rpm ± 15 rpm when operating under load.

– Shaft diameter = 34.925 mm (1-3/8 inch) with 6 splines (Fig 2). However, PTO with 1000 rpm have 21 splines.

– **Location:** the vertical distance from the drawbar should be 20 cm (8 inch) within the limits of 7.5 cm (3 inch) to the right or left of the centre line of the tractor.

Fig 2



PTO SHAFT DRIVE - TRANSMISSION DRIVEN
CLUTCH FOR ENGAGING AND DISENGAGING

Drive for PTO shaft: Drive to PTO shaft given by 3 ways as under:-

– transmission drive

– independent drive

– continuous running

Transmission drive: Drive to PTO is provided through the main engine clutch that controls ground speed of tractor. With this arrangement PTO shaft operates whenever clutch is engaged. To drive the tractor PTO (Fig 2) engage shift lever.

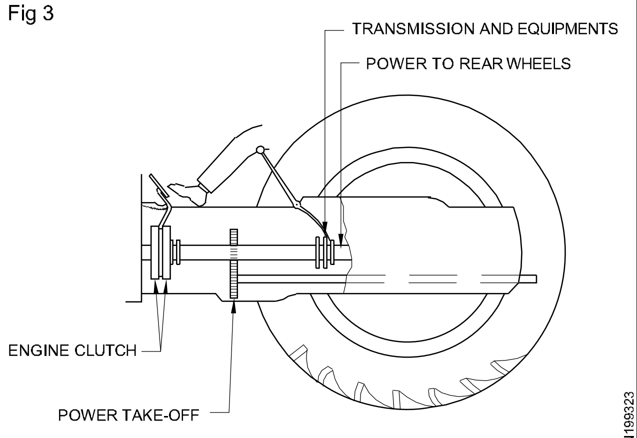
In this arrangement there is a disadvantage that when you stop the tractor or press the clutch, PTO shaft also stops. To operate machine without tractor operation, shift the gear in neutral and again re-engage the clutch by using clutch pedal.

Independent drive: In this case PTO continue to operate the attached machine even when the tractor is in motion or standing still. PTO drive in this case is controlled by means of a separate clutch such arrangement is shown in (Fig 2) PTO shaft drive is controlled by means of a separate clutch. Power to PTO can be engaged or disengaged through a lever by shifting the dog clutch.

Continuous running drive: In this arrangement dual clutch is used. PTO drive is controlled by means of separate clutch and machine can be operated whether the tractor is in motion or stand still or it is in the process of being started or stopped (Fig 3). When dual clutch is pressed partially PTO drive comes in operation and implement can operate or function.

Tractor pulley: It is not uncommon to use the tractor for operating stationery machines such as silage cutter, stationery thresher, centrifugal pump etc. These machines are driven by a tractor pulley located either on the left, right or rear side of the tractor.

Fig 3



CONTINUOUS RUNNING DRIVE P.T.O SHAFT

In practice the driven pulley usually rotates at lower speed than calculated due to slippage of belt. Belt slippage cannot be stopped all together but it can certainly be reduced.

Following are the reasons for belt slippage

– pulley too small or too narrow

– oil or grease on belt

– pulleys too far apart

Precautions to be taken while using belt pulley

– Belt pulley should be started up slowly and carefully working up to its full speed gradually.

– Tractor should be locked before starting by placing wooden wedges before and after all tyres.

– Belt should be driven in straight line with the driver and driven pulley.

– Never get a belt on or off a pulley with stick, stop the drive.

– Never jump or cross over running belt.

Transmission noise

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

• **explain the various noises and their causes in the transmission system.**

NOISE IN THE CLUTCH

Sl.No.	Noise	Symptom	Causes	Remedies
1	Noise in the clutch assembly	Noise heard while engaging the clutch.	(1) Insufficient pedal play (2) Improper clutch lever adjustment (3) Seizure of thrust bearing and release levers (4) Broken or weak fork lever return spring (5) Excessive clearance in driven plate hub and clutch shaft splines (6) Dry or dirty clutch linkages	Adjust. Readjust. Rectify or replace. Replace. Replace. Clean & lubricate.

2	Noise in the clutch assembly	Continues to make noise but noise disappears when the clutch is disengaged. (Noise in the engaged position)	(1) Misalignment of engine & transmission (2) Friction disc torsion springs weak/broken (3) Friction disc hub & clutch shaft splines worn out (4) Weak or broken pressure springs (5) Weak or broken anti-rattle spring (6) Pilot bushing in flywheel worn out (7) Cracked pressure plate or flywheel (8) Fulcrum of release bearing holder damaged	Realign. Replace clutch disc. Replace. Replace. Replace. Replace. Replace. Replace.
3	Noise in the clutch assembly	Continuous noise in both driven plate hub engaged and disengaged positions.	(1) Worn splines on clutch shaft (2) Friction disc damper springs broken or weak (3) Misalignment of engine and transmission (4) Worn or dry clutch release bearing (5) Release levers not properly adjusted (6) Pilot bearing in crankshaft worn or dry (7) Retracting spring (in a diaphragm spring clutch) worn out (8) Loose release fork mounting (9) Release levers striking clutch cover	Replace. Replace. Realign. Replace. Readjust. Replace. Replace. Tighten. Rectify defect.

NOISE IN THE GEARBOX

Sl.No.	Noise	Symptom	Causes	Remedies
1	Noise appearing in the gearbox neutral position	Noise is appearing in gear neutral position.	(1) Worm or dry clutch shaft bearing (spigot bearing). (2) Worn out gears. (3) Too much end play in countershaft or gears. (4) Worn out or dry countershaft bearings/gear. (5) Transmission misaligned with engine. (6) Too much backlash in driving gears (in between gear wheels). (7) Insufficient and wrong lubricant. type to level. (8) Gear shifting forks rubbing in grooves.	Replace. Replace. Adjust. Replace. Realign. Replace. Change oil of recommended Adjust.
2	Noise appearing in the gearbox	Noise is appearing when gear is engaged. (Particular gear)	(1) Worm, chipped or broken gears. (2) Lack of lubricant. (3) Countershaft gear worn out or damaged. (4) Gear loose on main shaft.	Replace. Top up/flush & refill with correct lubricant. Replace. Replace.

3	Noise appearing in the gearbox	Noise is appearing when gear is engaged. (Particular gear)	(1) Damaged/worn out synchnoniser ring gear. (2) Counter gear/bearing worn out or damaged.	Replace. Replace.
4	Noise appearing in the gearbox	Noise in all gears.	(1) Transmission misaligned with engine case. (2) Speedometer drive gear damaged. (3) Input shaft bearings worn out or damaged. (4) Low oil level. (5) Main shaft rear bearing worn out/ damaged or dry.	Realign. Replace. Replace. Top up. Replace.
5	Noise appearing in the gearbox	Noise while gear shifting.	(1) Clutch not disengaging (clutch pedal, free play excessive). (2) Idle speed excessive. (3) Shifter fork bent. (4) Gear shift linkage out of adjustment. (5) Idling speed of engine too high. (6) Incorrect lubricant. (7) Shaft splines & gear teeth worn out. (8) Inter-locking device linkage out of adjustment. (9) Shifter lock springs too strong.	Adjust. Adjust. Rectify. Adjust. Adjust. Replace. Replace. Readjust. Replace.

NOISE IN THE PROPELLER SHAFT & UNIVERSAL JOINT

Sl.No.	Noise	Symptom	Causes	Remedies
1	Noise occurring in transmission drive line (Propeller shaft & universal joints)	Noise heard only in the initial movement of the vehicle.	(1) Loose flanged yoke of universal joints (bolts are loose). (2) Worn out propeller shaft/slip joint splines due to lack of lubrication. (3) Worn or damaged universal joints. (4) Needles in the bearing short in numbers.	Tighten bolts. Replace & lubricate. Replace. Replace.
		Noise heard when vehicle is running.	(1) Loose or missing bolt at the centre bearing support. (2) Bent propeller shaft. (3) Centre joint bearing and support rubber pad damaged. (4) Shaft rubbing on parking brake cable. (5) Unbalanced propeller shaft. (6) Joint or shaft hitting the frame of vehicle. (7) Lack of lubricant in U joints, also in splines of propeller shaft & slip joints.	Provide a new bolt & tighten. Replace shaft. Replace both. Position brake cable correctly. Replace. Use shims to lift up. Lubricate with grease.

REAR AXLE NOISE

Sl.No.	Noise	Symptom	Causes	Remedies
1	Noise occurring in the differential and rear axle unit	Noise occurring when the vehicle is running straight ahead.	(1) Low oil level in differential. (2) Excessive backlash on crown wheel & pinion. (3) Worn out drive pinion & crown wheel. (4) Loose crown wheel bolts. (5) Worn out or damaged differential case bearings. (6) Worn out drive pinion bearing. (7) Improper drive pinion and crown wheel adjustment.	Fill up to level. Adjust. Change in pairs. Tighten. Replace. Replace. Readjust.
		Noises on turns.	(1) Pinions or sun gears damaged. (2) Pinions or sun gears loose. (3) Backlash between pinion & star gears excessive. (4) Axle shaft end play excessive. (5) Pinions binding on shaft. (6) Damaged surfaces between sun gear & differential case. (7) Worn out sun and star gears and thrust washers. (8) Slack or rough hub bearings.	Replace. Replace. Reduce by adjustment. (Refer to the Manual) Adjust to correct clearance. Rectify. Replace. Replace. Replace.
2	Noise occurring in differential	Noise occurring in the rear wheels.	(1) Worn out/dry hub bearings. (2) Bent/twisted axle shaft. (3) Excessive axle end play. (4) Bent wheel. (5) Loose rear axle nut. (6) Lack of lubricant on axle bearings. (7) Loose wheel nuts.	Replace or lubricate. Set right defect. Adjust. Replace. Re-tighten. Lubricate with grease. Re-tighten.

Care and maintenance of final drive of drive shaft

Repairing before failure your tractor back to work sooner and costs two to three times less than after failure repairs options.

Good scheduling means maintenance, inspections and planned repairs are done on time to prevent drive train failures caused by overlooked maintenance.

- use clean tube oil
- use correct lube oil
- always overload and fatigue
- Replace the parts before failure
- Always do the proper alignment of making parts.
- Use proper torque to mounting the drive shafts and final drive assembly.
- Use clean and standard components.
- Maintain the proper working with moving pars
- Periodically replace the oil.
- Always maintain the oil level in transmission system.

Steering system

Objectives: At the end of this lesson you shall be able to
- **state the functions of the steering system**
- **state the purpose of steering mechanism**
- **describe steering linkages**
- **state the 4 wheel steering system**
- **state the collapsible steering column.**

Function

The main function of the steering system is to convert the rotary motion of the steering wheel into angular motion of the front wheels to negotiate a turn.

The other functions of steering system are as follows.

- To turn the vehicle whenever required.
- To provide stability to the vehicle on road.
- To provide true rolling motion of the wheels at all times.
- To provide self-centering action after negotiating a turn.
- To minimize tyre wear.
- To multiply the driver's effort to turn the vehicle for easy operation.
- To prevent road shocks reaching the driver.

Principles of steering

The steering system along with the suspension system, allow the driver to safely and easily control the vehicle's direction while driving.

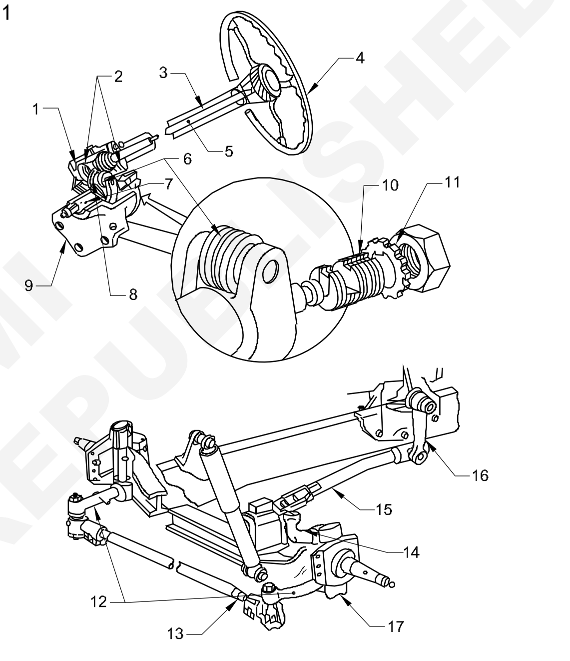
Steering Mechanism: The steering mechanism of a four wheeled tractor includes steering wheel (4) steering gear and shaft drag link, radius rod, tie rod and spindle arms. (Fig 1)

The Front Axle (F) is properly aligned by the radius rod which is pivoted on the clutch housing of the tractor. The tie rod connects the front wheel spindle arms (12) and is actuated by the steering shaft (5) through drag ball link (15).

When the steering wheel (4) is turned its motion is carried to the steering box (9) through steering shaft (5). In the steering box, this motion is converted into angular motion of the drop arm (16) (Fig 1) which is connected to the drag link rod (15). The drag link rod (15) (which is called steering rod also) at the other end is connected to the steering lever arm (14). The steering arm is connected to the stub axle spindle (17). At the lower end of the stub axle the spindle arm (12) which is called the steering lower arm is fitted. Both the steering arms (12) are connected by a track rod (13) when the steering wheel is rotated the drop arm (16) moves towards or away from the front wheel depending upon the direction of turn (right to left).

Drop arm (16) moves drag link (15). Drag link (15) moves steering lever arm (14) which in turn rotates stub axle (17) accordingly.

Fig 1



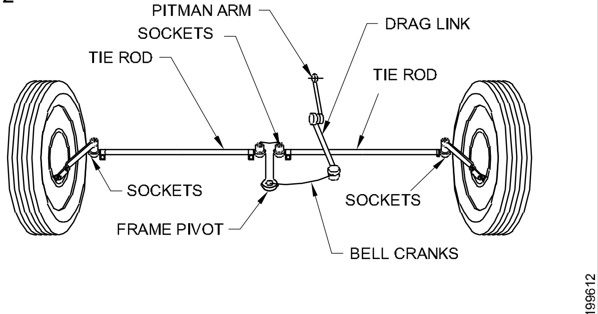
Front Wheel Drive: Front wheel leads the tractor and they are the ideal wheel.

Steering mechanism is directly related with the front wheel.

Different types of steering linkages (Figs 2-7)

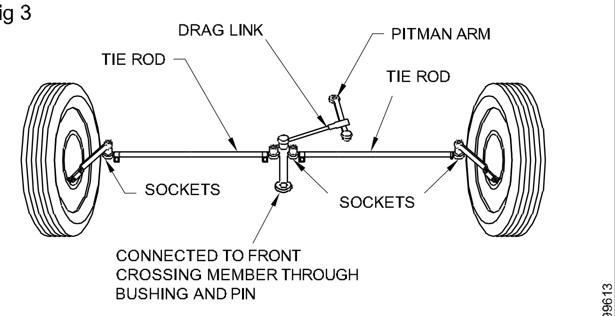
Following types of steering linkages are used.

Fig 2



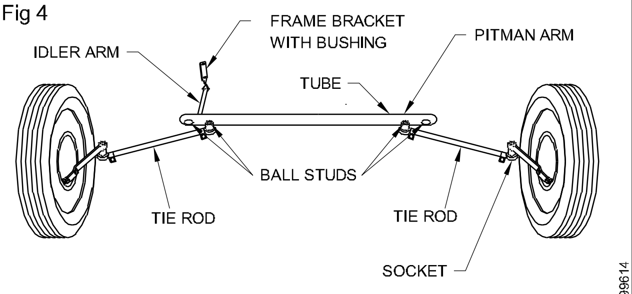
(a) CENTER-ARM STEERING WITH BELL CRANK INTERMEDIATE ARM

Fig 3



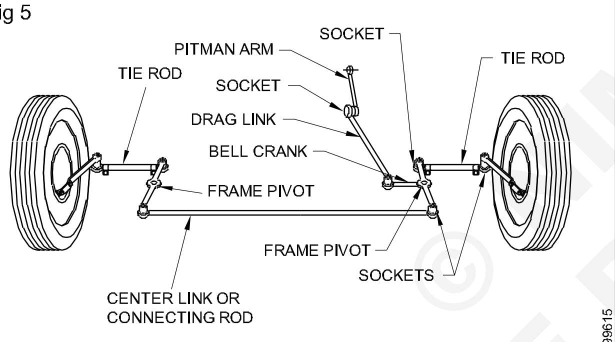
(b) CENTER-ARM STEERING WITH TRANSVERSE DRAG LINK

Fig 4



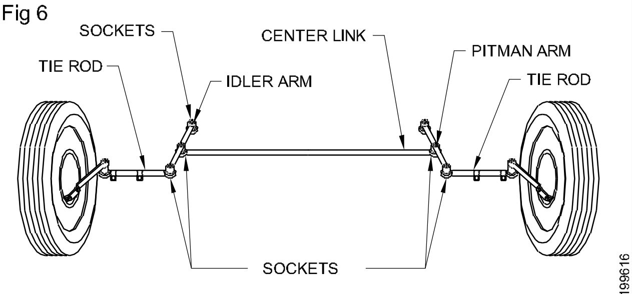
(c) PARALLELOGRAM LINKAGE WITH TUBULAR CENTRE LINK

Fig 5



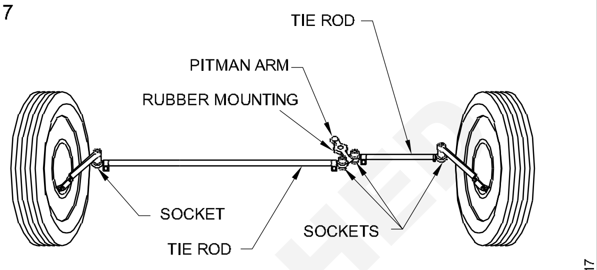
(d) PARALLELOGRAM LINKAGE WITH CENTER LINK AHEAD OF AXLE

Fig 6



(e) PARALLELOGRAM LINKAGE WITH CENTRE LINK BEHIND OF AXLE

Fig 7



(f) LONG-ARM, SHORT-ARM LINKAGE

Steering gear box (Types & Working)

Objectives: At the end of this lesson you shall be able to
- **know the types of steering systems used in tractors**
- **state the function of a steering gear box in a vehicle**
- **state the various types of steering gear boxes in**
- **discuss the function of various components**
- **study the provision of adjustments and lubrication**
- **discuss the necessity of ball joints in steering linkages.**

Introduction: The Modern Tractors have many other components for tractor operated. For ease of operation, versatility and high efficiency, some other components like steering systems and brake systems are provided.

The Steering system enables the driver to guide the automobile or wheeled tractor down the road and turn right or left as desired by turning the front wheels or a half frame (in Tractors with articulated frame steering)

Let us study the steering gear box - function and working.

Steering systems: The major types of steering used for today's tractors.(Fig 1)

– Manual Steering

– Power Steering (Hydraulic Assistant/Hydraulic Steering

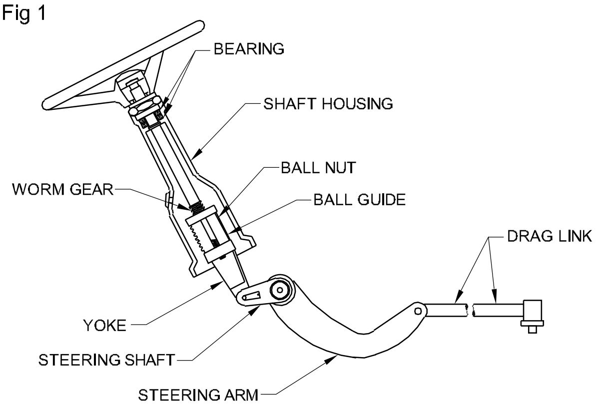
This will be studied under Apprentice Level

Manual Steering: Smaller and older tractors are often equipped with manual steering. Manual steering uses no hydraulic assistance. The operator supplies the Turning Power/Effort.

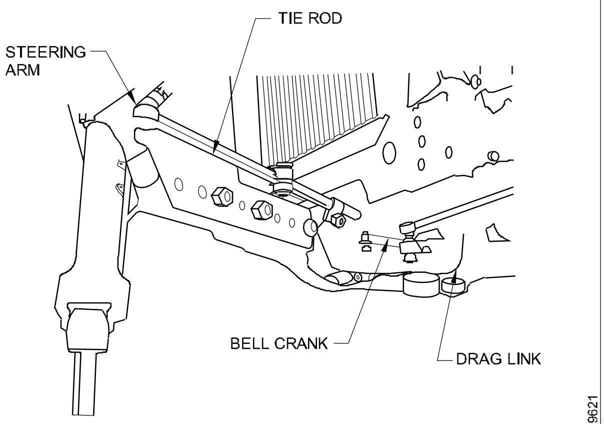
The Manual Steering system includes mainly the following items.

– Steering wheel

Fig 1



TYPE OF MANUAL STEERING MECHANISM FOR WIDE



STEERING ARM TIE ROD AND BELL CRANK

– Steering gear

– Steering Linkages

Function of Steering Gear: The Steering gear converts the rotary motion of the steering wheel into a straight line motion, which is transmitted to the steering linkage to turn the front wheels to the left or right side as required.

In Tractors Worm and Roller is largely used.

On Wide Front Axle Tractors the bell crank is attached to the Tie rods. Here ball nut and worm gear is used. As the ball nut rotates the ball crank is moved to one side or other by drag link. The tie rods transmit this side motion to the steering arms which steer the tractor.

On Narrow front end of tractors with manual steering, a worm gear turns the sector. The sector is connected to a shaft extending to the axle assembly called the "Vertical Spindle". As the spindle rotates, the wheels are steered.

Arrangement of Parts in the Steering system: A figure is given below sheering Steering gear and Steering linkage arrangements. Kindly refer to this figure during the study of this lesson.

1 **The Triple Roller is supported by turning needle bearings on a pin pressed in the holes in the boss (head) of steering arm shaft (7).**

2 **The Worm is supported by Two taper Roller bearings carried in the bore of the steering box.**

3 **The Steering shaft passes inside the steering column and is supported in its top by a radial thrust ball bearing installed in the steering column. The shaft is hollow and houses the horn button also with wires.**

4 **The outer end of steering arm shaft is supported by a bush on the side wall of steering box and inner end of the shaft by a cylindrical ball bearing.**

5 **The inner end of the steering arm shaft (Cross shaft) is provided with an adjusting screw, a tab washer and socket nut for tightening.**

6 **The adjusting screw is screw on the steering box side cover and keeps the steering arm shaft moving axially.**

7 **The outer end of steering arm shaft is with drop arm connecting the drag link.**

Adjustments: Provision has been made for Adjustment of Steering gear backlash and Bearing Pre-load.

Backlash Adjustment: Turning the adjusting screw enables one to move the steering arm shaft endwise either way. Thus change the backlash between the steering worm and the roller. Hence, the tilt or play of the steering wheel.

Pre-load on Bearings: The Pre-load on the bearings is adjusted by means of shims placed between the box and its bottom cover.

Lubrication: The Steering gear is lubricated with transmission oil poured into the Steering Gear Box through a hole closed by a plug. (Refer Tractor Service Manual for recommended Oil/Lubricants)

Manual for recommended Oil/Lubricants). The leakage of oil from the steering gear box is prevented by a lip type seal, a felt ring and sealing gaskets.

Steering Rod Ball Joints: General

The Steering linkages carries the movement of steering arm to steering knuckles. The steering linkage is so constructed that all the wheels move on turns without side slipping and with easiness and this action minimises the wear. To facilitate easy movement a number of ball joints are provided in the linkages of the steering system.

To reduce wear, the ball joints of steering linkages are lubricated with grease fitting or nipples.

Types of ball joints

1 Now-a-days rubberised polyamide inserts 6 & 7 are used instead of the springs and metal bearing inserts in the ball joints of steering linkages of Tractor/Automobiles.

2 The clearance in the ball joints of old type is adjusted by the screw plugs which are locked (after adjustments) by pins or lock rings or circlips.

Mostly in those joints a taper fit is provided for good grip and reducing slipping of joints during steering movement.

This is referred to as rear - end leg, because there is a time delay between steering input and vehicle reaction. When the front wheels are turned back to a straight - ahead position, the vehicle must again try to adjust by reversing the same forces developed by the turn. As the steering is turned, the vehicle body sways as the rear wheels again try to keep up with the cornering forces generated by the front wheels.

The idea behind four - wheel steering is that a vehicle requires less driver input for any steering maneuver if all four wheels are steering the vehicle. As with two wheel steer vehicles, tire grip holds the four wheels on the road. However, when the driver turns the wheel slightly, all four wheels react to the steering input, causing slip angles to form at all four wheels. The entire vehicle moves in one direction rather than the rear half attempting to catch up to the front. There is also less sway when the wheels are turned back to a straight - ahead position. The vehicle responds more quickly to steering input because rear wheel lag is eliminated.

Collapsible steering column

A typical car from 50 years ago not only had a massive steering wheel with a metal horn rim, but it connected to a steering column that was one piece. So in frontal collision the driver was getting injured by the steering wheel hit in the stomach.

With collapsible steering system is made of several joints and intermediate pieces. During impact the intermediate pieces, act like fuse, which collapses saving the life of driver.

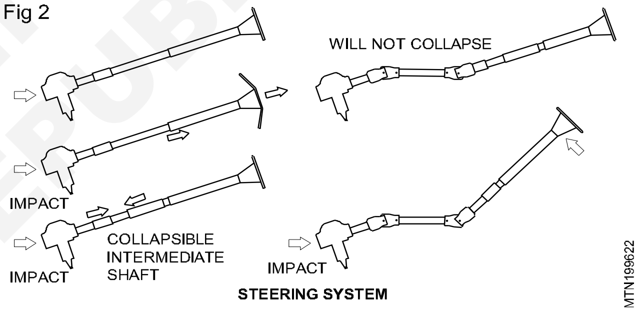
General arrangement of steering system (Fig 2)

The arrangement of steering linkage depends upon the type of from suspension and also with the location of the steering gear in relation to the front wheels.

Steering columns

The steering column is always at an inclination to vertical for comfort in driving. In fact, the driver comfort and the location of the steering gear bore on the clasis frame. Due to this two factors, the inclination of column is about 20° in commercial vehicles and 50° in motor cars and upto 70° in sports car. The steering wheel is connected to the steering linkages to turn the front wheels with great effort.

Fig 2



Steering gear box

Objectives: At the end of this lesson you shall be able to
- **state the various types of steering gear boxes**
- **state the maintenance of the various steering gear box.**

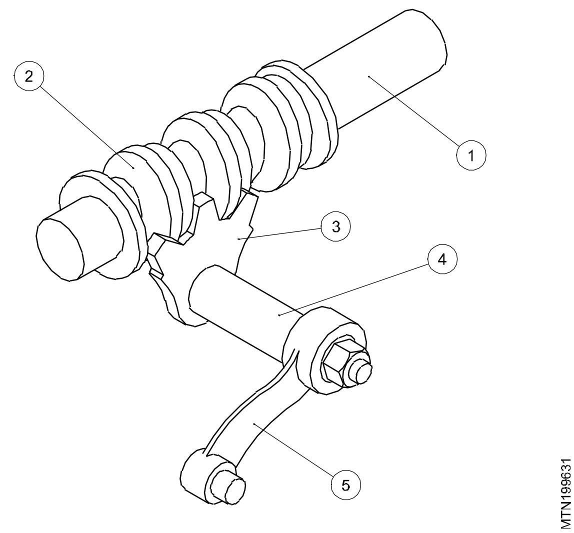
The following types of steering boxes are used.

- Worm and sector
- Worm and wheel
- Worm and nut
- Worm and roller
- Worm and recirculating ball and nut
- Rack and pinion

Worm and sector type (Fig 1)

The steering gearbox consists of the steering shaft (1) fitted with a worm (2) at one end. The worm (2) is in mesh with the sector (3). When the steering wheel is rotated, its motion is transmitted to the sector (3), through the worm (2). The sector (3) rotates at a certain angle. The sector shaft (3) in turn rotates a cross-shaft (4) which is connected to the drop arm (5). This angular movement is transmitted to the front wheels through the linkages to turn the vehicle.

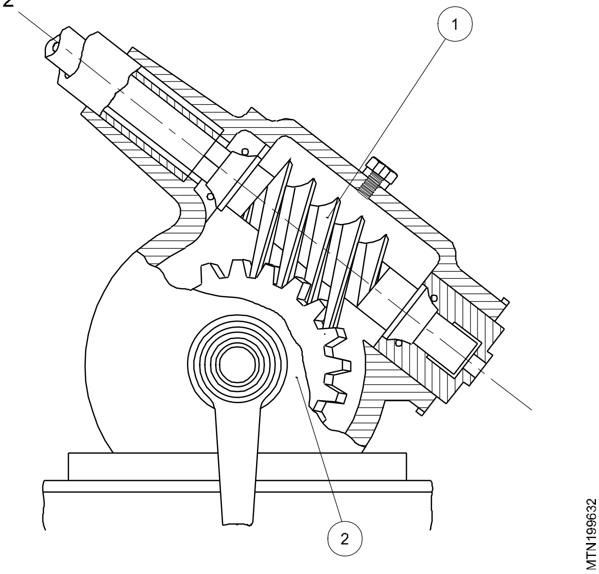
Fig 1



Worm and wheel type (Fig 2)

In this type a complete gear (2) is used instead of a sector. The worm (1) and gear (2) can be rotated to a new position as the sector portion wears out faster on use.

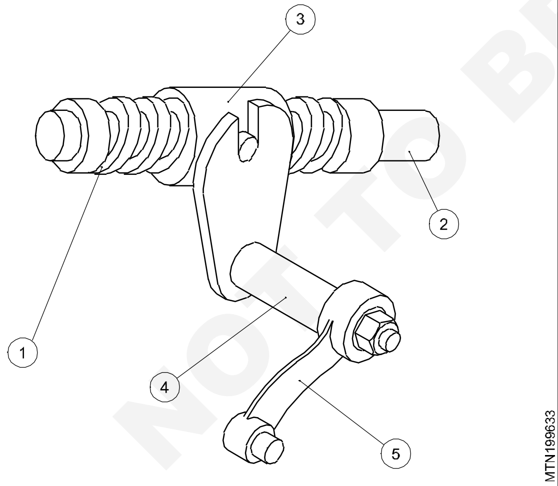
Fig 2



Worm and nut type (Fig 3)

In this type the worm (1) is an integral part of the steering column (2). When the steering column (2) rotates the worm (1) also rotates. The worm (1) is in mesh with the nut (3). When the worm rotates the nut (3) moves up and down on column (2). This enables the cross-shaft (4) to rotate in an arc. This in turn rotates the drop arm (5) in an arc. This movement is transmitted to the front wheels to turn the vehicle.

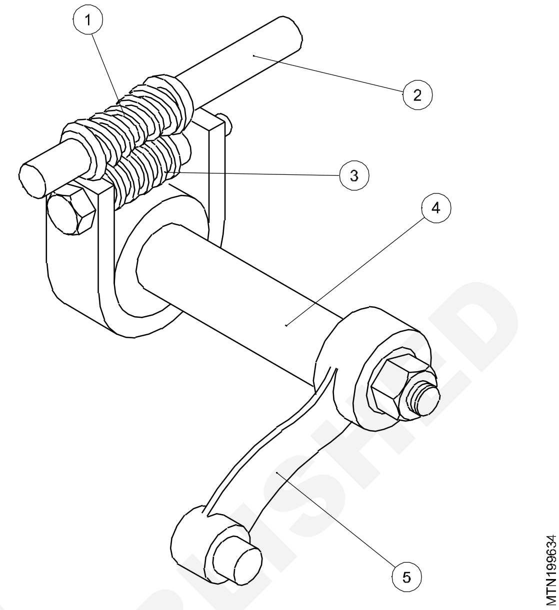
Fig 3



Worm and roller type (Fig 4)

The worm (1) is at the end of the steering column (2). The diameter of the worm (1) is more at its ends. Its diameter is gradually reduced at the centre. This enables the roller (3) to keep the contact with the worm (1) at all the positions. It also provides a variable ratio to permit faster and efficient steering. The roller (3) is mounted on the cross-shaft (4). The cross-shaft (4) is fitted to the drop arm (5). When the steering wheel is rotated, the column (2) also rotates along with the worm (1), which allows the roller (3) to rotate in an arc. This makes the cross-shaft (4) and drop arm (5) to move in an arc, which in turn moves the front wheels to the left or right through the linkages.

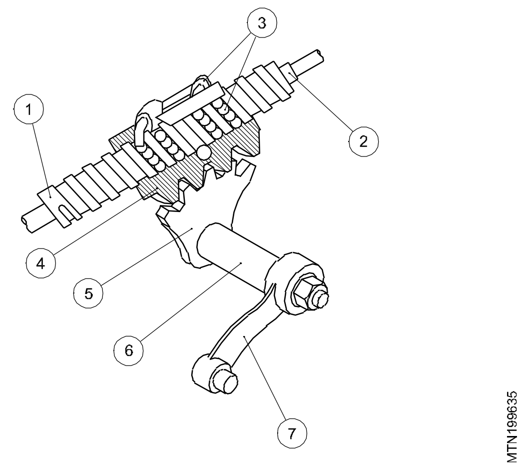
Fig 4



Worm and recirculating ball and nut type (Fig 5 & 6)

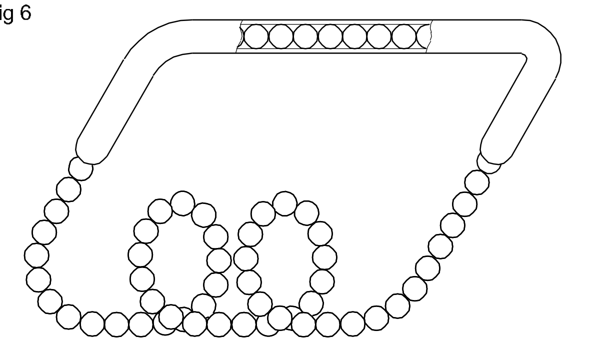
The worm (1) is at the end of the steering column (2). A ball nut (4) is fixed on the worm (1). Several balls (3) circulate in between the ball nut (4) and the worm (1). This reduces friction between the worm (1) and nut (4). A sector (5) is in mesh with the ball nut (4). When the steering wheel is rotated the steering column (2) also rotates and the ball nut (4) moves downward or upward on the worm (1). This makes the sector (5), cross-shaft (6) and drop arm (7) to move in an arc. This movement is transmitted to the front wheels to turn the vehicle.

Fig 5



Arrangement of balls is shown in Fig 6. During overall always count the number of balls and ensure that the correct quantity is inserted. Lesser quantity of ball will affect the response from steering.

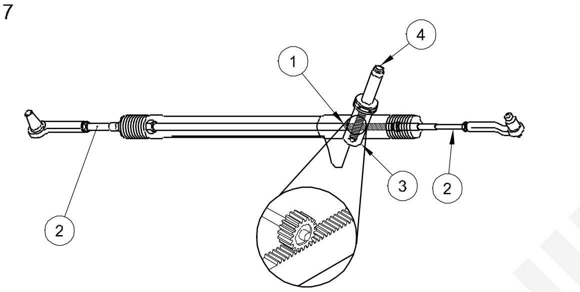
Fig 6



Rack and pinion type (Fig 7)

In this type a rack (1) is either connected or made part of a divided track-rod (2). The pinion (3) is attached to the steering column (4). The pinion (3) always remains in mesh with the rack (1). When the steering wheel is rotated the pinion (3) also rotates and the rack (1) moves left or right, causing the wheels to turn.

Fig 7



Tractor foot control steering system

In the farm tractor used the two type of steering system. They are as follows

1 Steering wheel operated system

2 Footage steering control system

Steering wheel control system: When the tractor operated on surface and field work normally used the steering wheel to directional control of tractor.

Footage steering control system: When the tractor is used with implements in the field work. Sometimes tractor need to sharp turn. So that time footage steering control is used for control the axle half shaft drive by brake band system. When apply the one brake band that side wheel drives restricted and other side wheel is freely rotate and take sharp turns.

Power Steering

Objectives: At the end of this lesson you shall be able to
- **state the need of power steering**
- **state the benefits of power steering**
- **state the types of power steering**
- **state the features of power steering**
- **state the construction of fully integral power steering**
- **state the operation of power steering**
- **state the shock absorption by power steering**
- **explain flow control valve of power steering**
- **briefly explain on pressure relief valve.**

Need for power steering

The need to achieve the greatest possible road safety under
- Increasing traffic density
- High axle loads
- Poor road conditions

Led to the development of power steering.

Benefits of power steering

- Effortless steering - reducing drivers fatigue
- Quick response - power assistance is immediate
- Positive road feel to the driver
- Absorbs road shocks
- Greater safety (in case of front tyre burst)
- Steering can be operated manually, in case of loss of power assistance
- Absolute control during driving
- Greater maneuverability

Types of power steering

There are three types of power steering system used in automobiles

1 Integral power steering
2 Linkage power steering
3 Electronic power steering

Fully integral power steering gear (Fig 1)

Salient features of power steering gear

Rotary valve

This device provides responsive steering control

Unloading valves

Furnish power steering pump protection and reduce pressure to unload steering linkage at the ends of steering gear travel.

Recirculating balls

Combines high mechanical efficiency with smooth operation.

Torsion bar

Provides positive valve centering with ultimate feel of the road.

Balanced area cylinder

Back pressures cannot affect steering stability.

Manual steering capability

Provides for steering control in the event of hydraulic failure

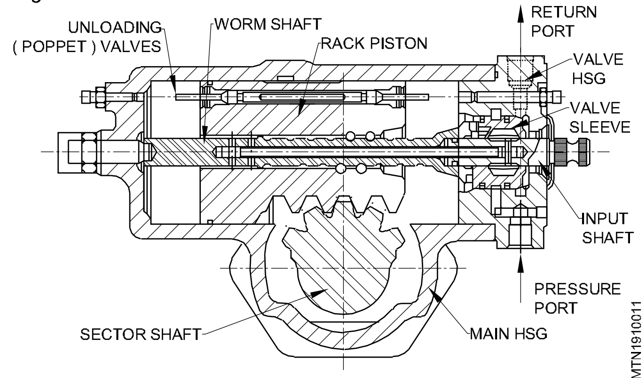
Construction

The fully integral power steering gear consists of
- A manual steering mechanism (Re circulating ball & nut type)
- Hydraulic power cylinder and piston
- A rotary control valve.

In a single compact package.

Normal operation (Fig 1)

Fig 1



When the driver turns the steering wheel, he activates the steering gear input shaft. A torsion bar pinned at its one end to the input shaft and the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to this rotational force the worm shaft acting through the re-circulation ball mechanism, tries to move the rack piston axially through the gear housing cylinder bore.

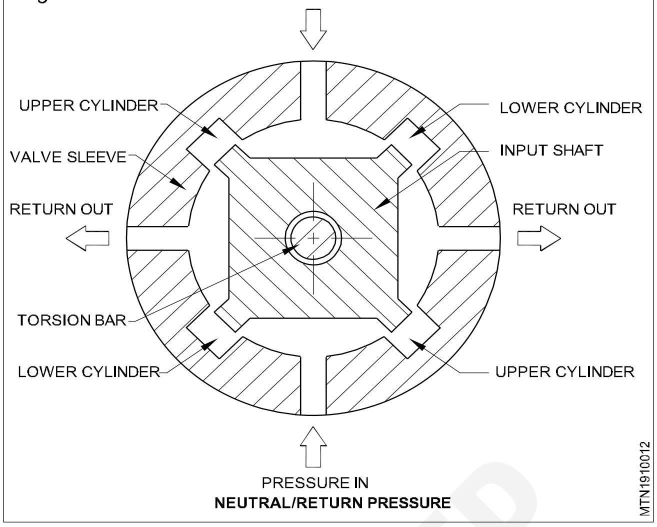
Hydraulic power assistance

The rack piston's axial movement is resisted by its engagement to the sector shaft, which is connected by linkage to the steered wheels. Because of this resistance, the torsion bar is twisted by the input shaft, thereby actuating the control valve. Pressurised fluid directed by the control valve assists in moving the rack piston axially through the cylinder bore. The rack piston then turns the sector shaft to steer the vehicle to the desired direction.

Neutral condition (Fig 2)

The rotary control valve mechanism, which is the heart of power steering system comprises of input shaft, worm shaft, torsion bar and valve sleeve. When all these components assembled together this becomes "valve assembly". The input shaft has four lands and the valve sleeve has four pockets assembled in neutral condition. The valve sleeve has keyed connection with the worm shaft. The diagonally opposite pockets connect the oil to the lower or upper cylinder. Always the valve will be in neutral condition. In this condition the oil flows to both sides of the cylinder and return back to the reservoir.

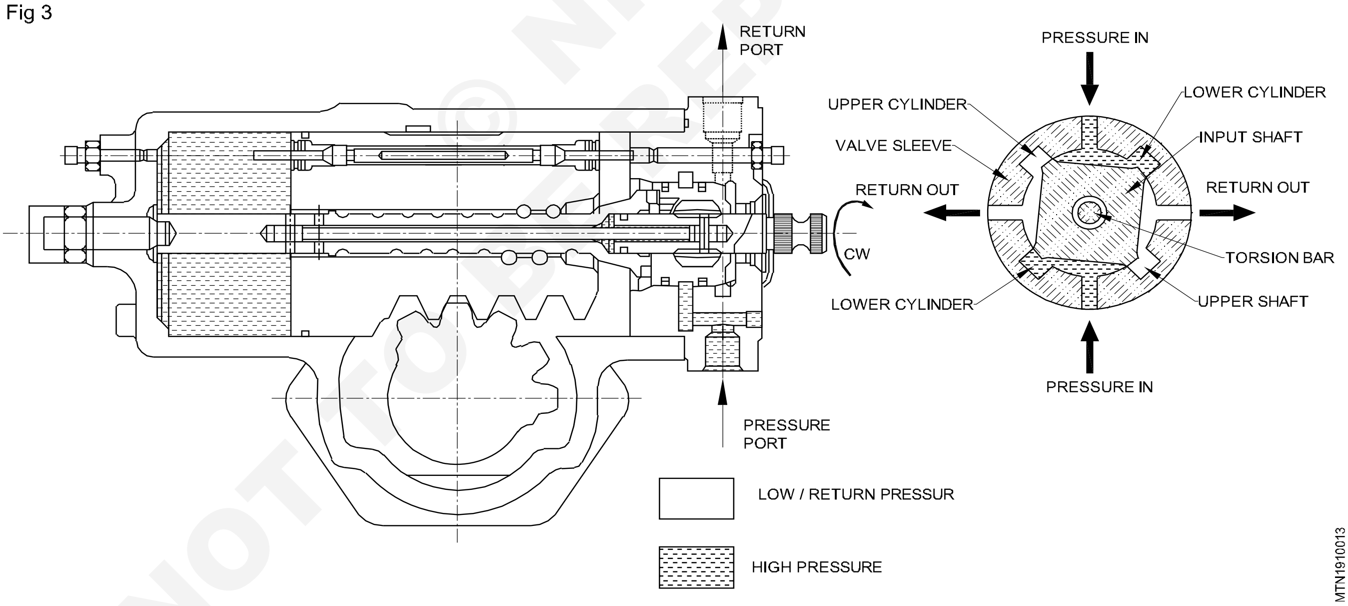
Fig 2



Right turn (Fig 3)

When the driver rotates the input shaft to the right through the steering wheel. Because of the road resistance the torsion bar gets twisted and the input shaft alone will twist to the right and disturbs the valve neutral position, thereby causing all the oil to flow to the lower cylinder and pushes the rack piston towards top. Once the driver stops rotating the steering wheel the torsion bar will gain its original position, as the worm shaft rotates and bring back the valve sleeve to the neutral position.

Fig 3



Left turn (Fig 4)

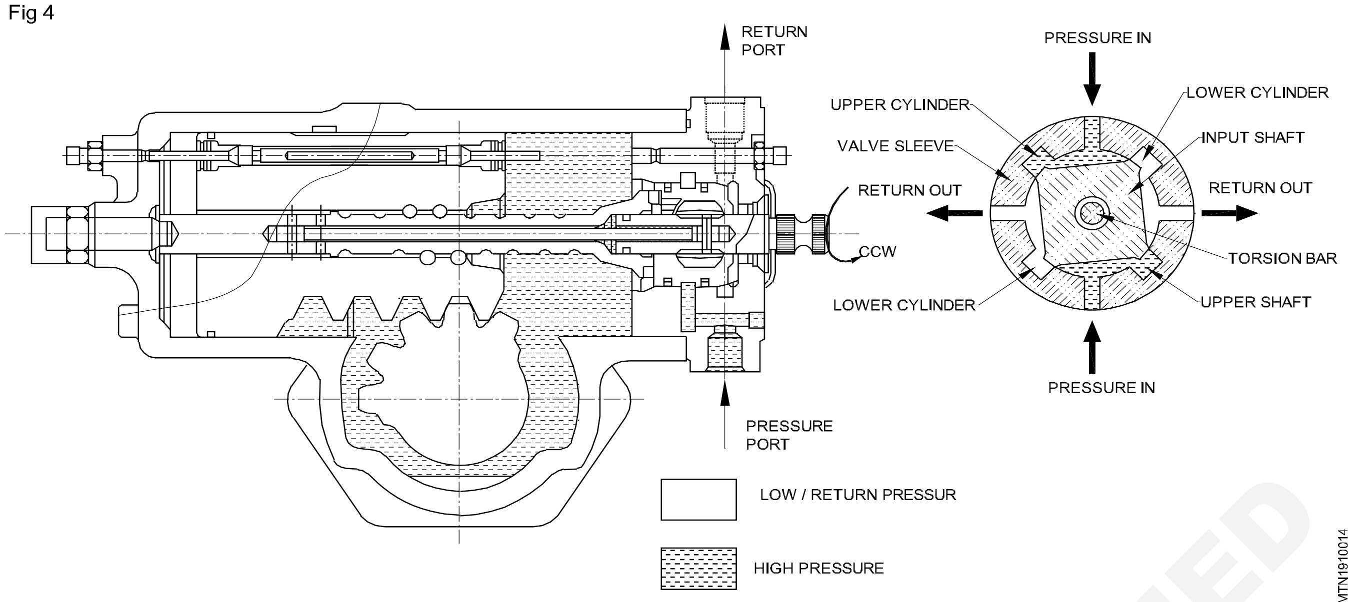
When the driver rotates the input shaft to the left through the steering wheel. Because of the road resistance the torsion bar gets twisted and the input shaft alone will rotate to the left and disturbs the valve neutral position, thereby causing all the oil to flow to the upper cylinder and pushes the rack piston towards bottom. Once the driver stops rotating the steering wheel the torsion bar gain its original position, as the worm shaft rotates and bring back the valve sleeve to the neutral position.

Shock absorption

Valve in shock absorption (Fig 4)

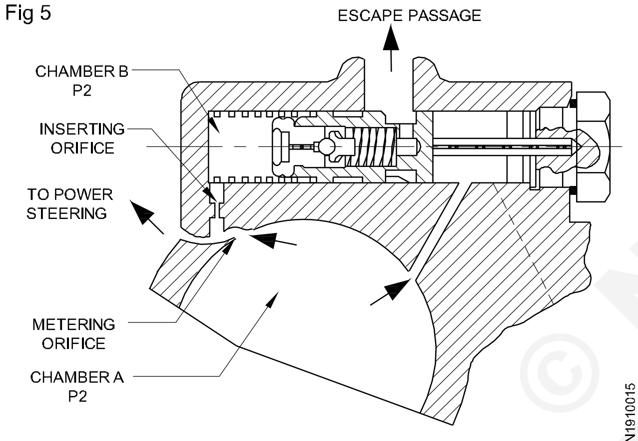
In general during the turns the driver disturbs the valve neutral position, causing the oil to flow to the respective cylinder. During shock absorption the road shocks force the worm shaft to rotate causing the valve sleeve to move from neutral condition, thereby causing the neutral condition disturbed and the oil flow on the opposite side resisting the Rack piston's movement, thus the oil absorbs all the road shocks and prevent shocks getting transmitted to the driver.

Fig 4



Flow control valve (Fig 5)

Fig 5



FLOW CONTROL VALVE

Function

The flow control valve controls the rate of flow within the power steering circuit. This is because, since the discharge rate per oil pump revolution (characteristic discharge rate) is constant, the discharge rate per unit time increases and decreases in proportion to the engine speed. To maintain uniform performance, the power steering requires a flow rate that remains within certain fixed range. The flow rate required by power steering is determined by the speed at which steering wheel is tuned, but must be such that power steering can respond at higher speeds. Consequently when the oil pump discharge rate exceeds a certain value in respective to the engine speed increase, the excess flow escapes to the interior of the pump or the reservoir so that the hydraulic fluid is always supplied to the system at the required rate.

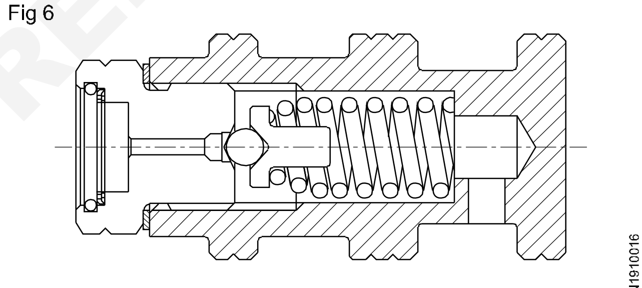
Operation

The hydraulic fluid discharged by the oil pump enters the pressure chamber, from it passes through the metering orifice to power steering chamber. When the pump discharge rate is lower than the adjustment flow rate, the fluid pressure differential between the chambers, movement of the flow control valve is prevented by the pressure of the spring and all of the fluid from the oil pump supplied to the power steering gear box.

The oil pump speed increases together with the engine speed, which increases the hydraulic fluid rate. When the discharge rate exceeds the adjustment flow rate (spring force) the spring is deformed from its original position and the flow control valve will move in and the excess oil will bypass to the suction line.

Pressure relief valve (Fig 6)

Fig 6



PRESSURE RELIEF VALVE

Function

The pressure relief valve controls the maximum pressure in the power steering circuit. That is the load on the oil pump is directly proportional to the steering wheel resistance. When steering wheel resistance is high, the hydraulic pressure required for power steering is also high and vice versa. Whenever the road wheels contact an obstacle or wheel stopper, which requires additional force to steer the wheel, the pressure will increase infinitely. Therefore a mechanism is required to prevent excessive force being applied and to protect the steering mechanism.

Operation

The pressure relief valve is built into the flow control valve. When the steering wheel is not being operated and during normal steering wheel operation the operating pressure will never raise above the adjustment pressure. Therefore the relief valve and the steel ball are seated by the force of the spring to close the passage.

The steering wheel is turned fully, therefore the power steering valve remains closed. In this state the hydraulic fluid from the oil pump is under pressure and the pressure exceeds the force of the spring, the relief valve and steel ball are lifted from its seat causing the oil to bypass to the suction side of the pump.

Trouble shooting

Noise in steering - Presence of air in the fluid will make it noisy and spongy (not responding) low fluid level also lead to noisy operation and unresponsive steering.

The remedy is to fill fluid upto the level and bleed the system to remove air.

Development of mechanical framing of tractor:

It is defined as the engineering structure of different shape like curved or straight. It contains one multi force member. The chassis frame structure is the combination of beams. The use of chassis frame to resist the moments which developed during the applied loading on tractor or power tiller. There are two types of mechanical frame as rigid structural frame and braced structural frame.

Use of power tiller: Power tiller is a small machine. It is having two wheels and it is used to hitching almost all agricultural implements for their field world. Trolley also attached with power tiller for transportation purpose. Power tiller is more useful machine for small fields. To take sharp turn hand operated steering clutches are provided for both sides.

Use of tractor: A tractor is designed to deliver the high tractive effort at slow speed. It is used for the purpose of hauling a trailer or implements or machinery of agriculture. The tractor also used in engineering industry and construction field for transportation of their materials from one place to another place.

Use of bulldozers: The tractor dozer is used for levelling the up and down field. The loader part is fitted front of the tractor. The dazer tractor is used for multipurpose for pull and push the muds and hitching the agricultural implements. It is very cheap and easy to operate.

Chassis frame of tractor: The chassis frame of tractor is a simple on which all the components and assemblies like engine, transmission, tires , axles steering system and electrical systems are attached so that overall structure which binds all these components together is attractor is called tractor chassis.

The tractor frames are divided into two types of categories.

1. Chassis tractor
2. Chassis less tractor

The front part of the engine block is fastened or attached to the front cross member. While the engine block at rear side is attached to transmission box. The front side axle is fixed.

At the name simplies these tractors do not need any type of chassis frame. The normal of a tractor chassis frame is done by the engine block itself. These machines are tough in nature to fulfil the requirements.

Wheels

Objectives: At the end of this lesson you shall be able to
- **state the function of wheels**
- **list out the varies types of wheels**
- **state wheels construction**
- **explain static and dynamic wheel balance and effect of unbalance.**

Wheels

Wheels are connected to the front and rear axles. As power is supplied to either front or rear axle, axle shafts turn the wheels and the vehicle moves.

The wheel assembly consists of a hub, rim, tyre and tube. To perform its function the wheel should be:

- able to withstand the driving and braking torque, and support the weight of the vehicle
- able to absorb road shocks
- statically and dynamically balanced
- able to grip the road surface.

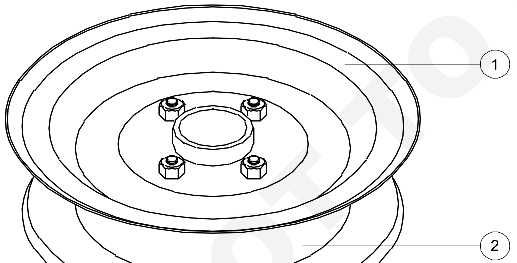
Types of wheels

- Disc wheel
- Wire wheel
- Split wheel
- Heavy vehicle wheel

Disc wheel (Fig 1)

In this type, a steel rim (1) is welded on to a steel disc (2). The tube and tyre are fitted on to the rim (2). The disk is provided with holes to mount it on the hub.

Fig 1



Wire wheel (Fig 2)

In this type the hub and rim are connected by a number of wire spokes. Alternate spokes are screwed to slope forward and backward towards the rim to absorb the braking and driving torque respectively. (Eg. Bicycle/Motor cycle wheels)

Split wheel (Figs 3 & 4)

In this type two separate discs are clamped together and a flange of discs provide seating surface for the tyre and tube. This types of wheels are used in car and scooter.

Fig 2

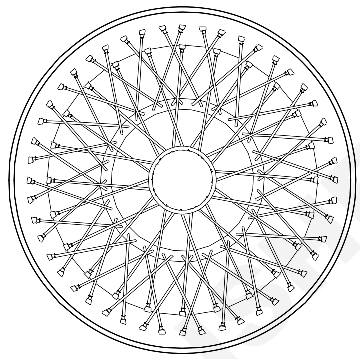


Fig 3

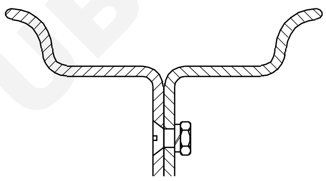
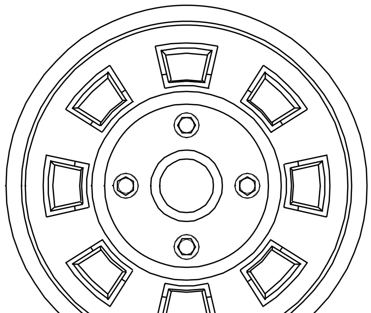


Fig 4



Heavy vehicles wheels

These wheels are similar to disc wheels except that a thicker plate is used for the disc.

Rims

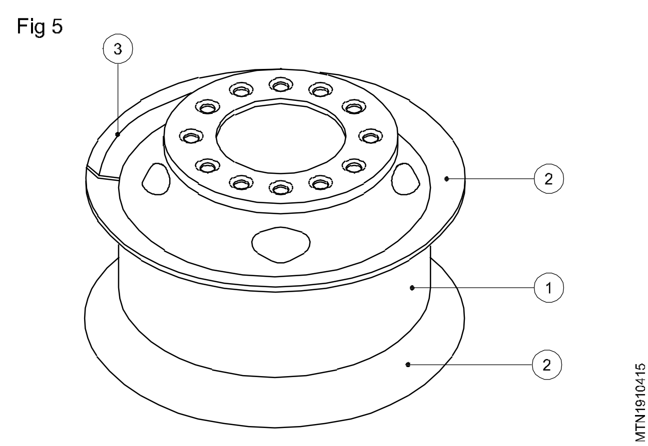
The rim provides seating surface for the tyre and tube.

Two types of rims are used.

- Flat base rim
- Drop centre rim.

Flat type rim (Fig 5)

Fig 5



In this type the rim's centre position (1) is kept flat. One edge of the rim has a projection (2), and the other end is removable to install into or remove the tyre and tube from the rim. One plain ring and one split lock ring (3) are provided on the removable end of the rim to lock the tube and tyre in position. This arrangement enables the removal of the tyre without stretching the bead.

Wheel construction

Function of each part

Wheels must have the strength to endure shocks and repulsion forces from the road surface as well as braking and driving forces. At the same time they must have the rigidity to maintain stability and maneuverability. Lastly, they must be light in order to reduce unsprung weight.

Wheel can be divided into three parts with the following functions.

Hub

This is the part linked with the frame. It has bearings in the centre. The bearings link the rotating wheel to the non - rotating frame. High linkage rigidity and dimensional precision are required for the non-rotating part, while smooth rotation and no play are required for the rotating part. This part supports the spokes and is required to have the appropriate supporting function. It is also designed to facilitate the rotating parts of the brake, the drive system and speedometer.

Spokes

The spokes support the rim while fulfilling the following conditions:

Assure accurate roundness of the rim and ensure its centre aligns with the centre of the axle shaft (Vertical vibration).

Ensure high degree of flatness with no distortion, and the surface is perpendicular to the axle shaft (horizontal vibration)

RIM

The rim holds the tyre in the correct position. In the case of tubeless tyres, internal pressure is maintained by close adhesion between the bead surface of the tyre and the flange surface of the rim. The rim width indicates the internal width of the flange and is given in inches. The rim diameter is the diameter at the bottom of the rim and is also given in inches. A rim on which tubeless tyre can be fitted is stamped, "Tubeless Tyre Applicable".

Tyres

Objectives: At the end of this lesson you shall be able to
- **state the functions of tyre**
- **state the types of tyres**
- **state the construction of tyres**
- **state the tyre specification**
- **state the tyre inflation**
- **state the need of tyre valves**
- **state the tyre ratings**
- **tyre pressure monitoring system**
- **state tyre traction rating.**
- **state the tyre temperature rating.**

Function of tyres

Tyres should be able to

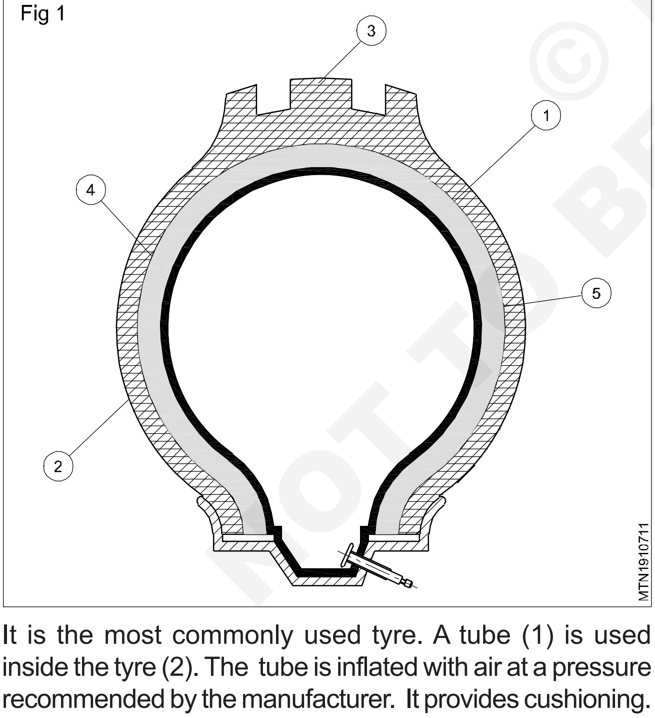
- absorb shock
- grip the road surface in both wet and dry condition
- withstand vehicle load.

Types of tyres

- Tube tyre
- Tubeless tyre

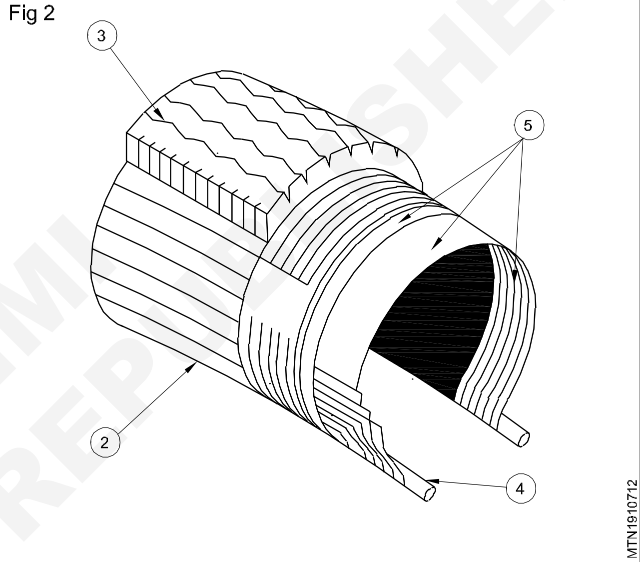
Tube tyre (Figs 1 & 2)

Fig 1



It is the most commonly used tyre. A tube (1) is used inside the tyre (2). The tube is inflated with air at a pressure recommended by the manufacturer. It provides cushioning. The outer portion of the tyre which keeps contact on the road is made of synthetic rubber. This portion is called tread (3). Steel beads (4) are provided at the inner edge. A number of plys (5) of rayon cord are provided to give strength to the tyre. The beads (4) and plys (5) provide strength to the tyre.

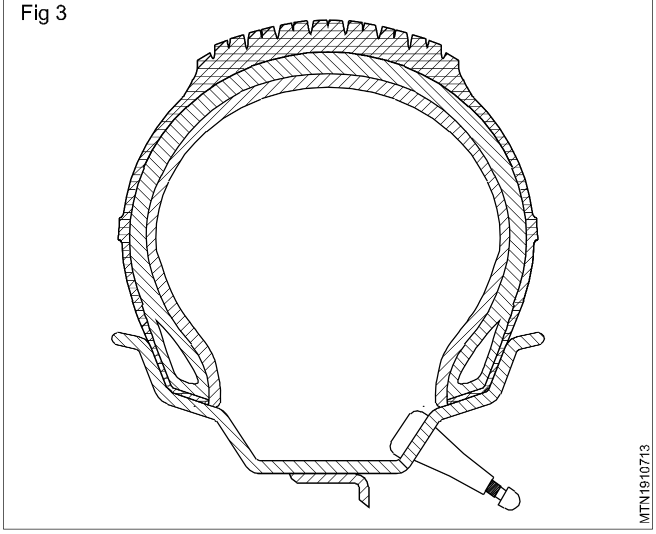
Fig 2



Tubeless tyre (Fig 3)

Its construction is similar to that of the tube tyre except that it does not have a tube and air is directly inflated in the tyre. The tubeless tyre can retain air for a longer period than the tube type tyre after puncture. This tyre need not be removed from the wheel to set right a puncture.

Fig 3

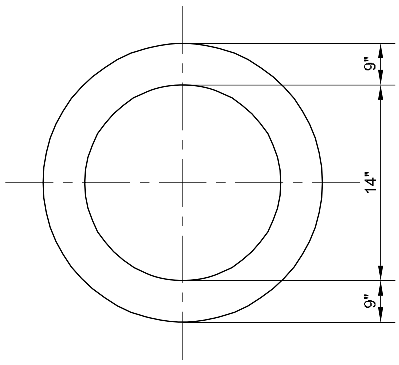


Material of tyre

- Rubber - for tread
- Nylon/rayon - for cord
- High tensile steel wire - for bead.

Tyre specification (Fig 4)

Fig 4



Tyre is specified in terms of the shoulder width, bead circle diameter and ply rating (PR).

Eg. 9"x14" - 14 PR

Here the shoulder width is 9". The bead circle diameter is 14" and the No. of plies (Ply rating PR) is 14.

Structure of tyre

Tyre outer diameter

It is the outer most diameter of the tyre (1)

Tyre width

The width of the tyre corresponds to the distance between the most protruding portions on both sides.

Overall tyre width

Rectilinear distance between both side, including all patterns and characters on tyre sidewalls.

Tyre height

Half of height obtained by subtracting the rim diameter from the tyre outer diameter.

Thread width

The width of the tyre tread surface. This corresponds as a rule to the distance between the most protruding portions on both sides.

Thread radius

This also referred to as the crown R. The radius of curvature is expressed in millimetres.

RIM width

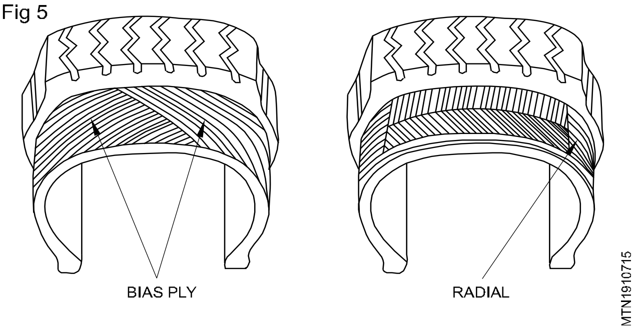
Rim width suitable for effective tyre performance

Bead circle diameter

The inside diameter of the tyre rim diameter is called as bead circle diameter of tyre.

Construction of a tyre (Fig 5)

Fig 5



It is divided into two types.

- Radial ply
- Cross-ply

Radial ply

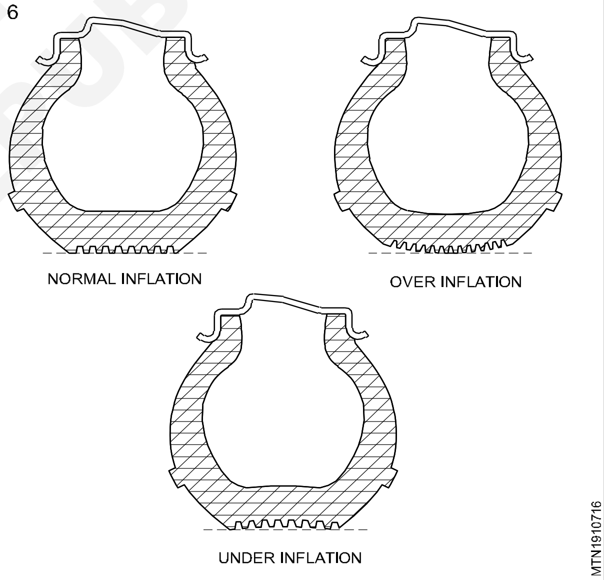
In this type plys are provided radially from bead to bead.

Cross-ply

In this type alternate plys are provided in opposite diagonal directions.

Tyre inflation (Fig 6)

Fig 6



All vehicle manufacturers specify pressure at which air should be inflated in the tyre. It depends upon the tyre size and load of vehicle etc. A tyre should be normal inflated at the specified pressure to have complete contact on road(1). If the tyre is over-inflated, it will have contact with the road only at the centre and the tyre will wear out faster at the centre (2). If it is under-inflated it will have contact with the road only at the edges which will wear out faster (3).

Tyre storage

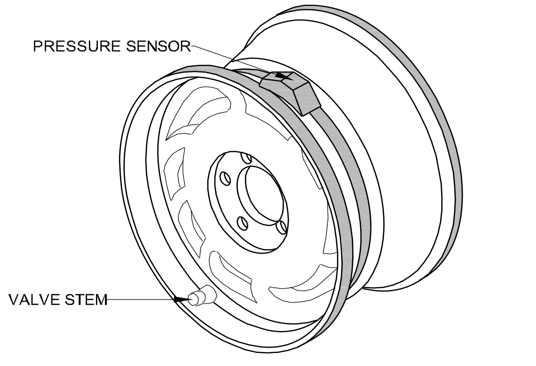
- Tyres should be stored on a clean surface free from oil, grease, diesel or other liquid.
- Tyres should be kept vertically on the surface. So that they rest on their treads.

- Tyres should be stored away from electric appliances, gas heaters etc.
- Tyres should be protected from strong sunlight.

Tyre pressure monitoring systems

Tire pressure monitoring systems are mandatory on all new vehicles produced in the United States starting in the 2004 model year. Some tire pressure monitoring systems have a pressure sensor strapped to the drop center in each rim (Fig.7). Other systems have a pressure sensor threaded onto the end of the valve stem. The pressure Sensors end radio frequency (RF) signals to the module in the tire pressure monitoring system. These RF signals change if the tire is deflated a specific amount. When the module senses a tire with low air pressure the module illuminates a warning light in the instrument panel.

Fig 7



TYRE RATING (SIDE WALL INFORMATION)

Other tire pressure monitoring systems use the wheel speed sensor signals in the ABS to monitor tire inflation pressure. When a tire is deflated to some extent, the tire diameter is smaller and wheel speed increases. Therefore, the wheel speed sensor signals may be used to indicate low tire pressure.

Location	Color code
Right front	Blue
Left front	Green
Right rear	Orange
Left rear	Yellow

Warning: Pressure sensor inside tyre avoid contacting sensor with tire changing equipment tools or tire bead.

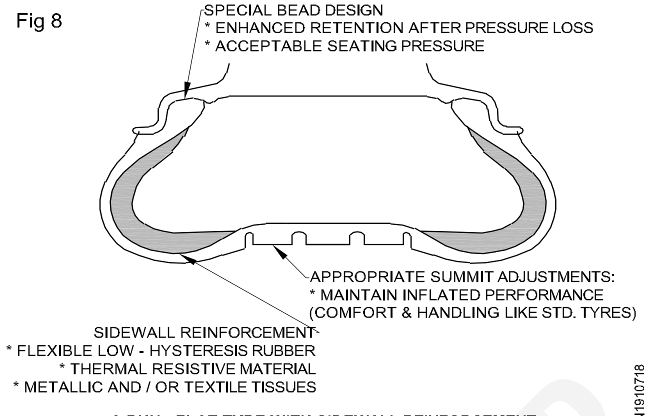
Service note: Pressure sensor must be mounted directly across from valve stem.

Run flat tyres (Fig 8 & 9)

Some luxury and sport type vehicles are equipped with run-flat tires. Run-flat tires eliminate the need for a spare tire and a jack on these cars. This provides a weight and space savings. Run-flat tires must minimize the difference between run-flat tires and conventional tires and provide sufficient zero-pressure durability so the vehicle can be driven a reasonable distance to a repair facility.

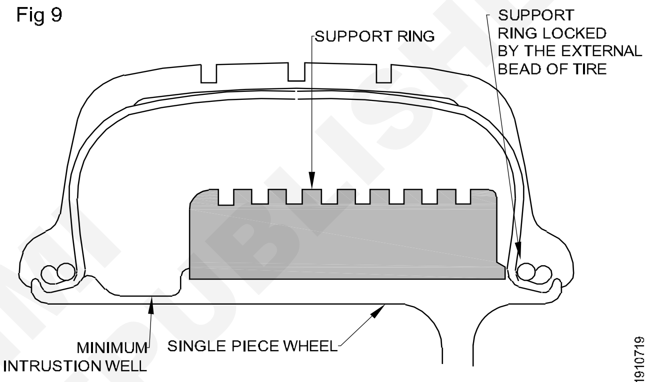
Some run-flat tires have stiffer sidewalls that partially support the vehicle weight without air pressure in the tire. Other run-flat tires have flexible rubber support ring mounted on a special rim to support the vehicle weight if deflation occurs.

Fig 8



A RUN - FLAT TYRE WITH SIDEWALL REINFORCEMENT

Fig 9

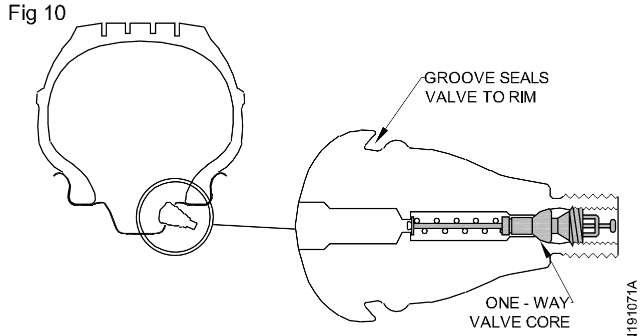


A RUN - FLAT TYRE WITH SUPPORT RING

Tyre valves (Fig 10)

The tire valve allows air to flow into the tire and it is also used to release air from the tire. The core in the centre of the valve is spring loaded and allows air to flow inward while the tire is inflated. Once the tire is inflated, the valve core seats and prevents airflow out of the tire. The small pin on the outer end of the valve core may be pushed to unseat the valve core and release air from the tire. An air tight cap on the outer end of the valve keeps dirt out of the valve and provides an extra seal against air leakage. A deep groove is cut around the inner end of the tire valve. When the valve assembly is pulled into the wheel opening, this groove seals the valve in the opening.

Fig 10

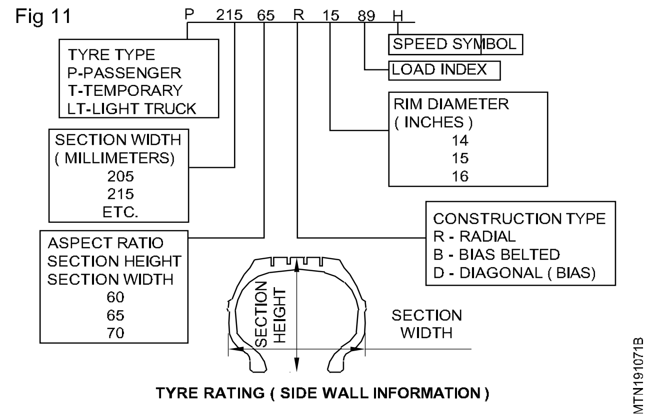


TYRE VALVES

Tyre ratings

A great deal of important information is moulded into the sidewall of the average passenger car or light truck tire. The tire rating is part of the information located on the sidewall. The tire rating is a group of letters and numbers that identify the tire type, section width, aspect ratio, construction type, rim diameter, load capacity, and speed symbol. When a tire has a P215/65R15 89H rating on the side wall, the P indicates a passenger car tire (Fig 11).

Fig 11



TYRE RATING (SIDE WALL INFORMATION)

The number 215 is the size of the tire in millimetres measured from sidewall to sidewall with the tire mounted on the recommended rim width.

The number 65 indicates the aspect ratio, which is the ratio of the height to the width. With a 65 aspect ratio, the tire's height is 65 percent of its width. The letter R indicates a radial-ply tire design. A belted bias-ply tire design is indicated by the letters A B. The letter D indicates a diagonal bias ply - tire.

The number 15 is the rim diameter in inches. The load index is represented by the number 89. This load rating indicates the tire has a load capacity of 1,279 pounds. Various numbers represent different maximum loads. Some tire manufacturers use the letters B,C, or D to indicate the load rating. The letter B indicates the lowest load rating and the letter C represents a higher load rating. A tire with a D load rating is designed for light - duty trucks. This tire will safely carry a load of 2,623 pounds when inflated to the specified pressure.

Traction rating

Traction ratings indicate the braking capabilities of the tire to the consumer. To determine the traction rating, ten skid tests are completed on wetted asphalt and concrete surfaces. Test conditions are carefully controlled to maintain uniformity. The results of the ten skid tests are averaged and the traction rating is designated A, B or C with an A rating having the best traction.

Temperature rating

Temperature resistance ratings indicate the tire's ability to withstand heat generated during tire operation. The National Highway Traffic Safety Administration (NHTSA) has established controlled procedures on a laboratory test wheel for temperature resistance testing of tires. The tire's temperature rating indicates how long the tire can last on the test wheel. Temperature ratings are A,B, or C. An A rating has the best temperature resistance. Tires must have a minimum letter C temperature rating to meet NHTSA standards in the United states.

Repair and maintenance of tyre

- maintain the proper air pressure in tyre
- maintain the even tyre pressure on all wheels
- don't apply overload
- rotate the tyre as per manufactures instructions
- check the tyre pressure before move the tractor
- the tyre is dismounted for repair and inspected internally as well as externally. It is then patched and the puncture hole is filled.
- Do not have your tyre plugged. A plug is simply inserted into the punctures area, making it unreliable. Tyres should be repaired by a tyre professional.
- The tyre has not been driven on when flat.
- The damage is only on the tread section of tyre. (side wall damage runs a tyre immediately)
- the puncture is not greater than 6mm.

Tube

Objectives: At the end of this lesson you shall be able to
- state tuff up tube
- state the structure of tuff up tube
- state hole plugging mechanism
- state nitrogen filling in tyre
- state tyre thread patterns.

Tuff up tube

The two chamber tube has two separate chambers that are independent from each other. One is the air and other is the liquid chamber. The newly developed anti-puncture sealant gel is sealed in the chamber located on the tyre tread side during the manufacturing process. As the sealant chamber is always pressed against the tyre by the pressure from the air chamber, when there occurs a hole the sealant gel enters in the hole and closes it.

Structure of tuff up tube

This show how the two chamber tube closes the hole. Usually in an event of a puncture, a hole is pierced through the sealant gel chamber to the air chamber. When a hole occurs, the gel is forced into the hole, and the fibrous material contained in the gel is squeezed out. At that time, the fine ceramic particles fill the openings of the fiber, and the vacant spaces are filled with the gel. As there is a pressure inside of the inner tube, minimal quantity seeps into the air chamber but without causing any harm as it is a water based gel.

Hole plugging mechanism

This shows a picture of the cross - section of the hole closed by the newly developed anti-puncture sealant gel, taken after the sealant gel oozes out, dries and seals the puncture.

Tuff up tube can be repaired like an ordinary tube

Though it is an innovative technology, tuff up tube is easy to repair and with some simple precautions, it can be repaired at any repair shop or by road side mechanic.

Nitrogen filling in tyres

1 Car tyres are normally inflated with compressed air

2 Air is approximately 80% nitrogen, 20% oxygen

3 Nitrogen is comparatively inert, oxygen is a reactive gas.

4 The nitrogen used for inflation in tyre depots is normally generated by a separation process from compressed air. It still contains about 5% oxygen.

5 Nitrogen used at race tracks and in industry may be 99%+ pure and contained in high pressure cylinders at 2000+psi

6 Both sources of nitrogen will be treated to reduce the amount of water vapour.

Now a day's nitrogen is used in all tyres in place of air. It is used because it doesn't expand and compress like normal air in altitude and temperature changes. That is why it is used in aviation applications.

Nitrogen is chemically a non-flammable, non - toxic inert gas. An inert gas does not react with any other gas at any temperature. This basic nature of nitrogen helps in keeping minimum moisture in the tyres.

Tyre tread patterns

- Function
- Improve grip
- Arrest skidding
- Keeps tyre cool
- Provide longer life
- Can be retreaded

Indicators are provided to show the limits upto which it can be used before renewing or ready for retreading different commercial names are given by manufactures.

Types of tyre tread (samples)

- Knobby tread
- Lug tread
- Diamond tread
- Highway tread
- Saw tooth trade

Sketches given below (Fig1)

Monitoring systems

Tyre pressure monitoring systems are designed both to recognise the air loss in the tyre and also to warn the driver.

Fig 1

KNOBBY TREAD LUG TREAD DIAMOND TREAD HIGHWAY TREAD SAW TOOTH

The following types of tyre pressure monitoring systems are used in motor vehicles:

- Indirect measuring systems
- Direct measuring system

Indirect measuring systems

When pressure is lost, the tyre's rolling circumference, which increases the engine speed in relation to the other tyres, is reduced. The engine speeds are determined via the ABS or ESP sensors. However, the driver is not warned until there is a difference in air pressure of more than 30% between the tyres.

Direct measuring system

The pressure is measured directly by sensors in the tyre. The following functions are fulfilled:

- Continued monitoring of tyre pressure whilst driving and when the vehicle is stationary.
- The driver is given early warning in the event of a pressure loss, reduced pressure and flat tyre.
- Automatic individual wheel recognition and wheel positioning.

Tyre properties

A tyre must have the following desired properties

1 **Non-skidding:** The tyre should not skid or slip on the road surface. It show grip.

2 **Uniform wear:** The tyre must get wear uniformly over its outer circumference.

3 **Load carrying:** The tyre should be able to carry the vehicle load, and stresses during each revolution.

4 **Cushioning:** The tyre should be able to absorb vibrations set-up by the thus providing cushioning effect.

5 **Power consumption:** While rolling on the road, the tyre should consume power developed by the engine.

6 **Noise:** The tyre should create minimum noise while running on the road.

7 **Balancing:** The tyre should be balanced dynamically as well statically.

Tube

A tube - tyre enclose a tube inside it. The tube is held between the rim and the tyre. Air is forced under pressure inside the tube, through a non - return valve, which projects outside through a hole in the rim. Tubes are made of rubber by moulding to conform the shape tyre. Special tyres of tubes are available which minimize the danger of punctures or blowouts. These tubes are self sealing constructions.

Tubes are manufactured with the same care and attention as tyres. Raw material are analysed and tested before use. In the manufacture of tubes but rubber is used of because of its superior qualities. Front warm - up mills the tube stock goes to machine from which it comes out on to a conveyor as an endless sleeve. This is then marked with the proper size, cut to length and stored in specially designed skids.

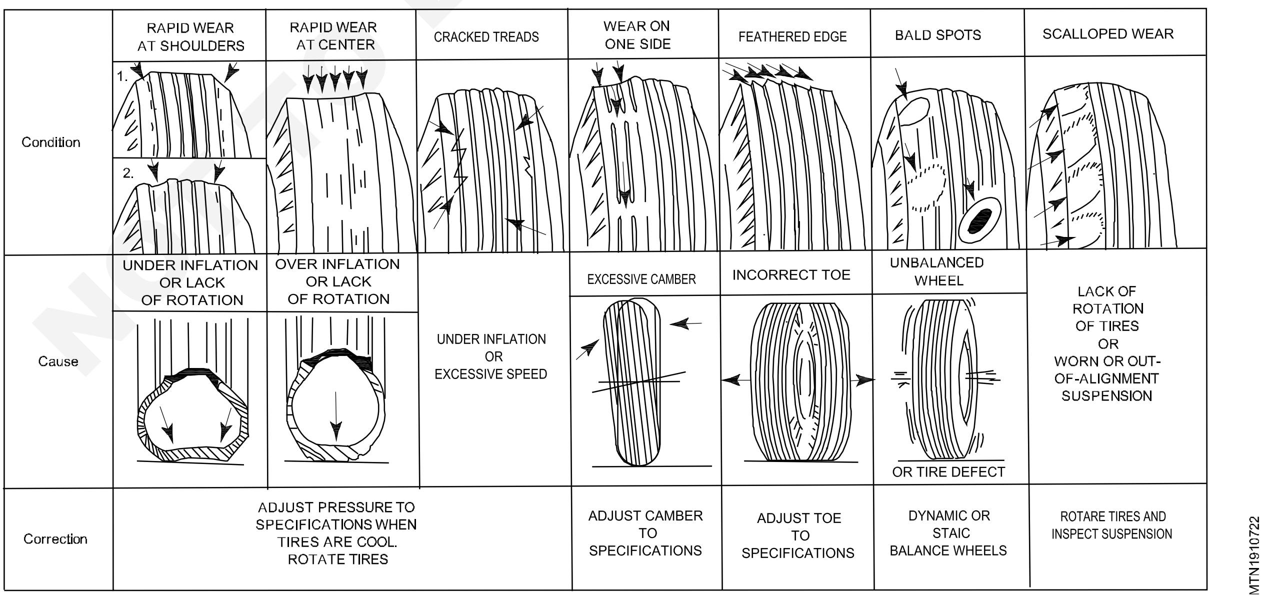
The ends of the tubes are then joined together on automatic splicing machines and are then fitted with the valves specified for each size. Each tube is then put around a forming ring and inflated to mould shape and is then cured in a steam heated mould. The mould opens automatically at the end of curing period and the cure tube is taken out. Each tube is thoroughly inspected for defects, then polished, packed and made ready for shipping out.

Tyre pressure

Conversion table for PSI and kg/cm^2

PSI	Kg/cm^2
23	1.6
26	**1.8**
29	**2.00**
32	**2.2**
35	**2.4**
38	**2.6**
41	**2.8**
44	**3.00**
46	**3.2**
50.3	**3.5**
54.62	**3.8**
57.5	**4.00**
60.00	**4.15**
71.87	**5.00**
86.25	**6.00**
100.625	**7.00**
115.00	**8.00**
129.375	**9.00**
143.75	**10.00**

Fig 2



Brake system

Objectives: At the end of this lesson you shall be able to
- **state the principle of brake**
- **state the various types of brake systems**
- **draw a layout of the mechanical brake system**
- **state the function and operation of mechanical brakes.**

Principle

- To stop the vehicle.
- To slow down the vehicle.
- To park the vehicle.

Types

According to application

- Foot brakes
- Hand brakes

According to operation

- Drum type
- Disc type
- Mechanical brake
- Hydraulic brake
- Air brake
- Air-assisted brake
- Vacuum-assisted brake

Foot brake

The brake which is applied by foot is called the foot brake.

Hand brake

The brake which is applied by hand is called the hand brake, e.g. a scooter's front brake and a commercial vehicle's and car's parking brake.

Drum brake (Figs 1 & 2)

In this type of brakes, the brake shoes (1) & (2) are placed inside the brake drum (3). When the brake is applied, the brake shoes expand through linkages, come in contact with the brake drum and stop the wheels.

Disc brakes (Fig 3)

In this type the brake pads (4 & 5) are arranged at both the sides of the disc (6) which is connected with the wheel hub. When the brake is applied the pads (4 & 5) move towards the disc (6) and stop the wheels. The following types of disc brakes are used.

Mechanical brakes (Fig 4)

When the brake pedal (1) is pressed, the linkage (2) operates the cam (3) and expands the brake shoes (4). The brake shoe comes in contact with the brake drum (5)

Fig 1

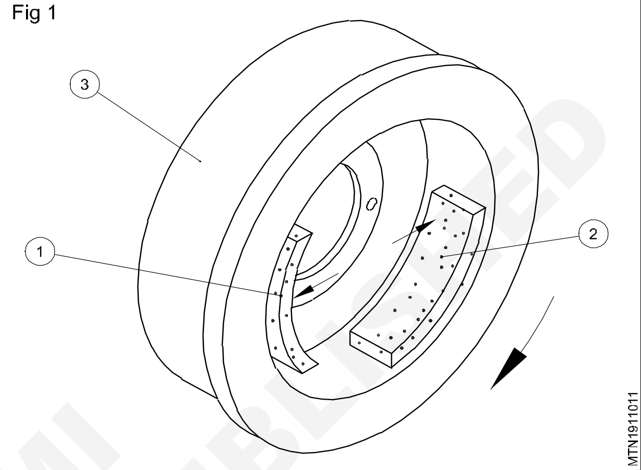


Fig 2

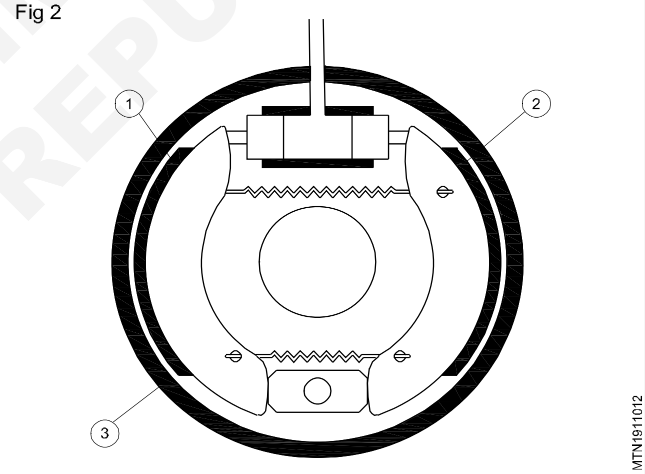
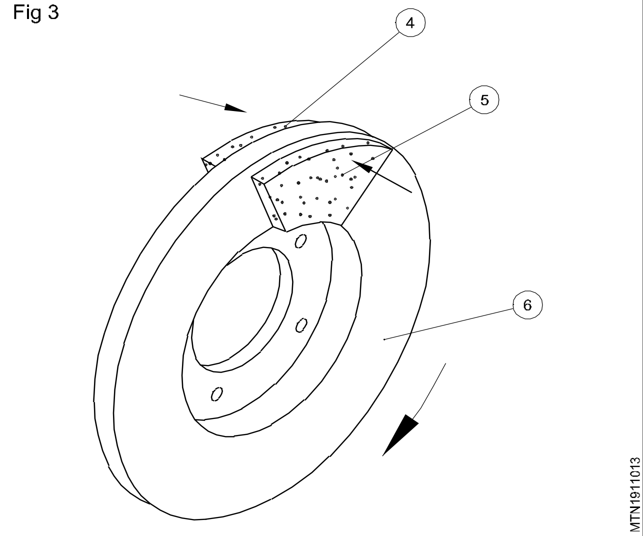
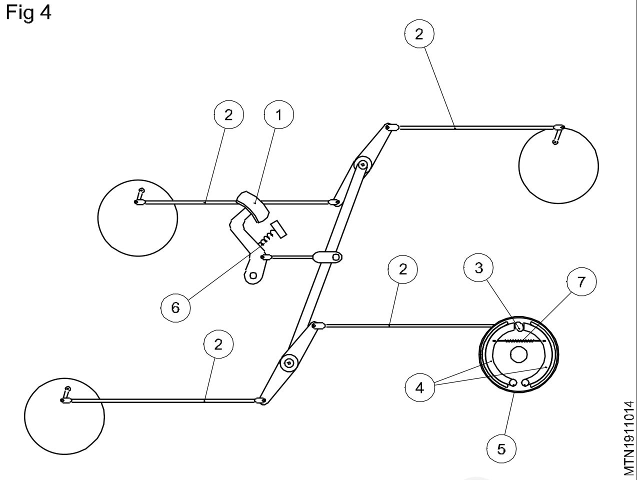


Fig 3



and stops the brake drum. When the brake is released the brake pedal goes back to its original position with the help of the pedal- return spring (6). The brake shoe comes to its original position with the help of the brake shoe retracting spring (7), and allows the brake drum to rotate. The mechanical brakes are used in two wheelers, three wheelers and the parking brakes of the commercial vehicles.

Fig 4



Mechanical advantage

Mechanical advantage is the ratio of force produced by a machine to the form applied to it. A simple machine that exhibits mechanical advantage is called as lever.

In brake system, the multiplied and applied on the wheel by means of mechanical linkage, hydraulic power, pneumatic power or vacuum power.

Hydraulic brakes

Objectives: At the end of this lesson you shall be able to
- **state the principle of a hydraulic brake**
- **state the function of the master cylinder.**

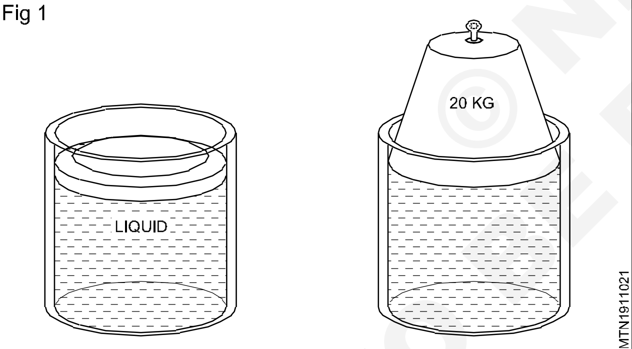
Principle

Hydraulic brakes work under the principle of Pascal's law.

Pascal's law

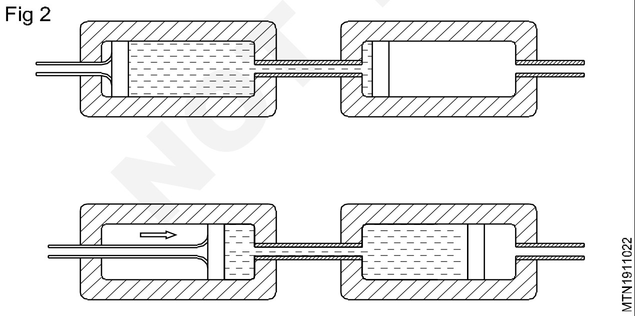
- Liquid cannot be compressed. (Fig 1)

Fig 1



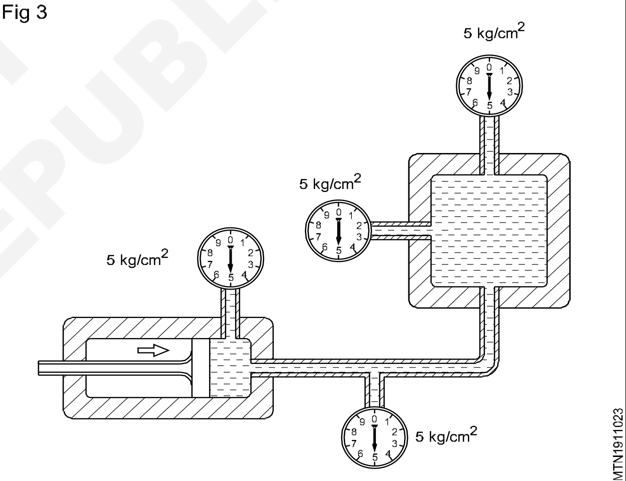
- Motion can be transmitted through a liquid. (Fig 2)

Fig 2



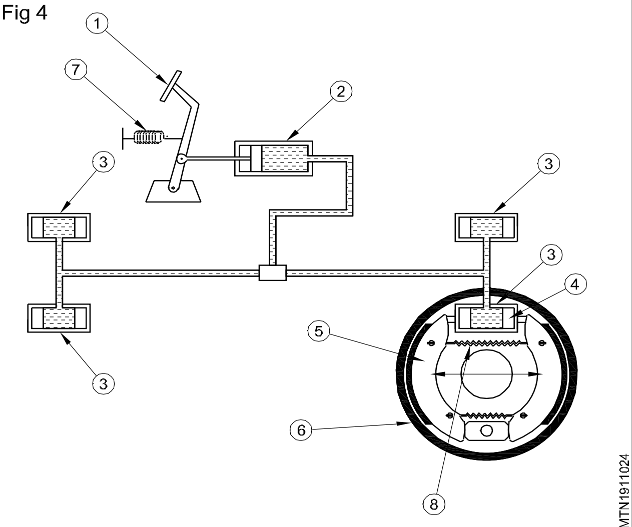
- Liquid pressure is transmitted equally in all directions. (Fig 3)

Fig 3



Operation (Fig 4)

Fig 4



When the brake pedal (1) is pressed the fluid inside the master cylinder (2) is pressurized and supplied to the wheel cylinders (3). The wheel cylinder pistons (4) push the brake shoes (5) towards the brake drum (6). The friction between the brake shoe lining and the brake drum stops the rotation of the brake drum (6).

When the brake is released the brake pedal comes to its original position with the help of the pedal return spring (7). The brake shoes come to their original position with the help of the brake shoe retracting spring (8). When the brake shoe returns to its position, it pushes the wheel cylinder pistons inside, and the pressurized fluid is sent back to the master cylinder.

Components of hydraulic brakes they are

Master cylinder

Wheel cylinder

Connecting pipes

Brake fluid

Brake fluid reservoir

Master cylinder

It serves as a pump to build up hydraulic pressure to operate the brakes. It maintains the level of the fluid in the system.

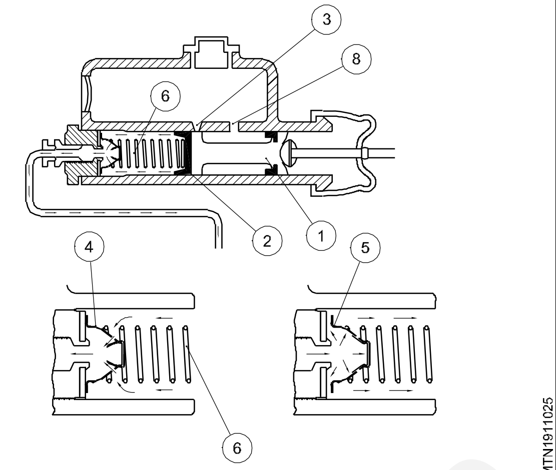
Types

- Single barrel master cylinder
- Tandem master cylinder
- Centre feed master cylinder
- Tank type master cylinder

Single barrel master cylinder (Fig 5)

When the master cylinder reservoir is filled, the fluid reaches only on the back side of the primary cup.(2) When the pedal is pumped (pumping action) the master cylinder piston returns quickly, and a partial vacuum is created in front of the piston (1). Due to the partial vacuum in the front side of the primary cup, the fluid from the back side of the primary cup reaches the front side of the primary cup via the transfer port (8) by the folding edges of the primary cup. When the brake pedal is pressed the master cylinder piston (1) moves forward and the primary cup (2) covers the compensating port (3). The fluid inside the master cylinder is pressurized and supplied to the wheel cylinders through the non-return check- valve (4).

Fig 5



When the brake is released the pressurized fluid is sent back to the master cylinder by lifting the check-valve (4) from its seat (5) against the master cylinder spring (6) tension.

When the brakes are in a fully released position the master cylinder piston spring keeps the check-valve assembly to its seat trapping some pressure in the wheel cylinders and lines, normally about 15 to 17 lbs. This pressure is to keep the wheel cylinder cups and lines from leaking and avoid the possibility of air entering the system.

Brake light switch: Brake light switch is operated by brake fluid pressure and electrical power when the brake pedal applied, the fluid pressure build up in master cylinder and same pressure act on brake light switch which is fitted end of master cylinder with electrical wire connection. When the fluid pressure act on brake light switch, inside the plate of switch connect the electrical terminals of switch. So electrical circuit has completed and brake light is glowing. When the brake pedal is disengaged the fluid pressure is released from the switch, terminal contact point also disconnected. Brake light switch is used for given a warning signal to behind the tractor.

Master cylinder (Types)

Objectives: At the end of this lesson you shall be able to
- **state the different types of master cylinders**
- **state the advantage of a tandem master cylinder**
- **state the function of a tandem master cylinder**
- **state the function of the centre feed master cylinder**
- **state the function of the tank type master cylinder.**

The other three types of master cylinders are

– tandem master cylinder

– centre feed master system

– tank type master cylinder.

Tandem master cylinder (Fig 1)

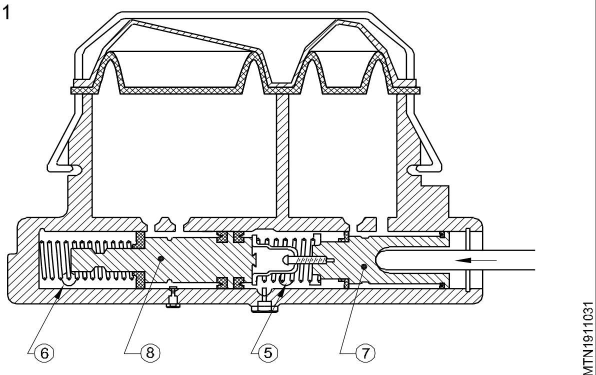
In a tandem master cylinder two separate cylinders and reservoirs are provided in the same body. There are two check-valves, one each for the front and rear brakes. In this type,in the event of failure of one brake line (front or rear), the other continues to work and stops the vehicle.

This is also called dual line brake. This is compulsory as per current motor vehicle act in India in all heavy vehicles.

Operation

When the brake pedal is pressed, the primary piston (7) is forced in the cylinder. Fluid is forced to go to the pipelines passing through the check-valve (5) to the front brakes. Further pressing of the brake pedal forces the primary piston (7). The fluid pressure forces the secondary piston (8) into the cylinder. The fluid is forced through the check-valve (6) to the rear brakes. Further pressure on the brake pedal exerts equal pressure on the shoes of all the four wheels.

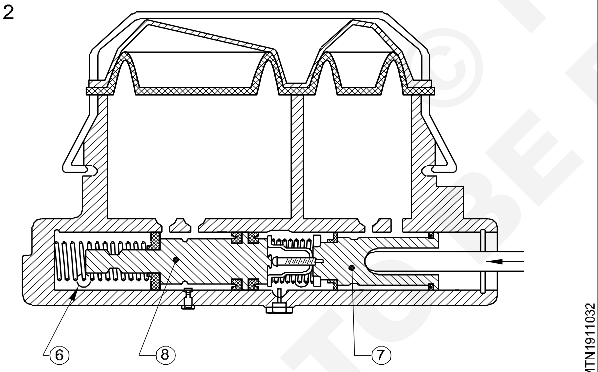
Fig 1



Failure of brakes (Fig 2)

When the front brake fails the primary piston (7) is forced forward till it contacts the secondary piston (8). Now, both the pistons move together.

Fig 2



Pressure is created on the secondary side and this forces the fluid through the check-valve (6) to the rear brakes and the vehicle is stopped.

When the rear brake fails (Fig 3) there is no pressure on the secondary side. The pedal effort pushes the primary piston (7) which forces the secondary piston (8) to stop (9). Further movement of the piston (7) builds up the fluid pressure which is transmitted to the front wheel cylinders through the check-valve (5) and the vehicle is stopped.

Brake proportioning valves (Fig 4)

The proportioning valve is installed on vehicle's with front disc, rear drum brake systems. They provide balanced braking during sudden, hard braking by restricting fluid pressure to the rear brakes. This helps prevent rear wheel lock up as the vehicle's weight is shifted toward the front wheels.

Fig 3

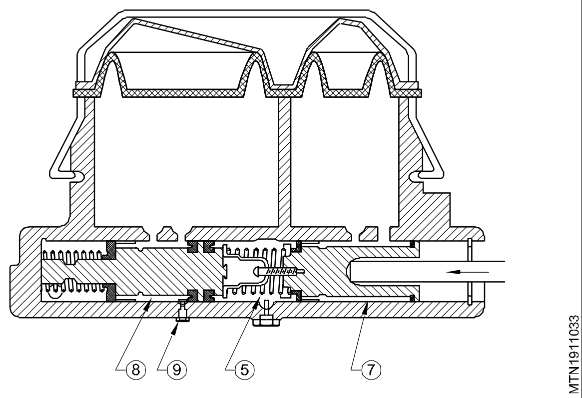
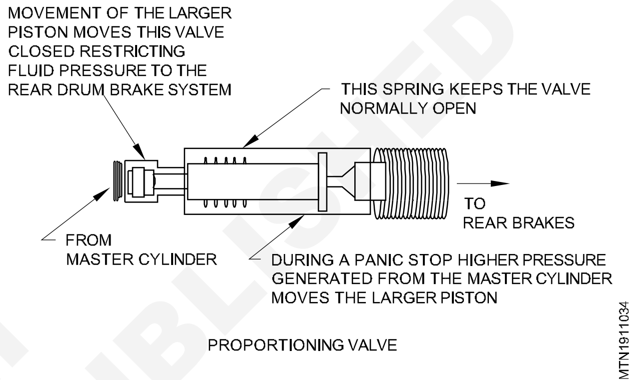


Fig 4



The typical inline proportioning valve remains open until a panic situation occurs. During a sudden braking situation, high pressure from the master cylinder moves the larger piston, closing the valve restricting fluid pressure. In late model vehicles these valves have been incorporated into the combination valve along with the metering valve and failure warning light switch. Many proportioning valves are mounted directly in the master cylinder outlet to the rear brakes. It is providing highly effective and well balanced braking of all the wheels.

A height sensing proportioning valve is installed in the hydraulic line leading to the rear drums. They are found on many light trucks, located between the vehicle's chassis and the rear axle. When a driver brakes hard, the rear lifts up and forward. This lightens the load on the rear tires increasing the chance of lock up. It incorporates a lever attached to a spring that moves a valve to restrict fluid pressure as the vehicle's chassis raises up and away from the axle.

An electronic brake proportioning EBP has replaced the conventional proportioning valve in many late model vehicles. This system monitors the speed difference between the front and rear wheels and utilizes the ABS system to prevent rear wheel lock-up. (Fig 5)

When the brake pedal is depressed, it pushes on the first (primary piston) through a linkage. The pressure builds in the cylinder and lines as the brake pedal is depressed further. The pressure between the primary and secondary piston forces the secondary piston to compress the fluid in its circuit. When the brakes are operating correctly, the pressure will be the same in both circuits.

A proportioning valve is required on vehicles that have disc brakes on the front wheels and drum brakes on the rear wheels. Disc brake pads are normally contact with the disc, while the drum brake shoes are normally not in contact with the drum. If the pressure was not proportioned the disc brakes would engage before the drum brakes when you depress the brake pedal.

Fig 5

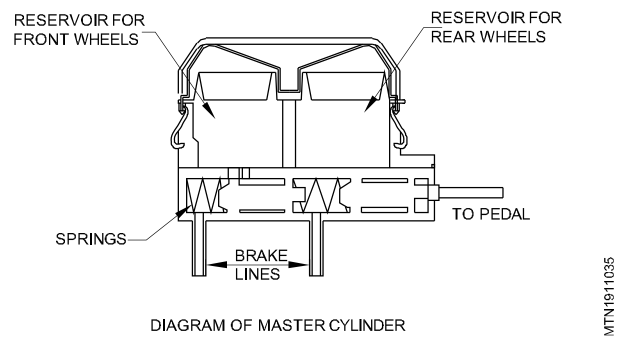


DIAGRAM OF MASTER CYLINDER

The proportioning valve compensates for this, allowing the drum brakes to engage first before the disc brakes. The proportioning valve does not allow any pressure determined pressure is low when compared to the maximum pressure in the braking system, this allows the drum brakes to engage before the disc brakes. Having the rear brakes engage first provides the control and stability needed to stop our vehicle safety.

When the driver press on the pedal. sensors monitor the pressure applied and the travel of the pedal itself. The ECU interprets these signals., along with other key inputs such as vehicle speed and steering angle and generates command signals for the hydraulic control unit.

Pressurised brake fluid is then discharged from the accumulator, travelling through solenoid-operated valves in the hydraulic control unit to the individual brakes, slowing the car. This approach has many advantages, such as the system being able to continue to increase braking pressure if an emergency situations detected -whereas a driver might otherwise let off slightly. In the EPB systems the master cylinder will feature a pressure simulator which generates increased pressure as the pedal in depressed in order to ensure suitable brake pedal feel. The master cylinder is also hydraulically linked to the braking system. In some cases just the prompt wheels, in order to provide emergency stopping. (Power element of the EPB fail).

Drum brake

Objectives: At the end of this lesson you shall be able to
- **state the various components of drum brake**
- **state the functions and operation of drum brake.**

Types of brakes

There are two types of brakes

1 Drum brake

2 Disc brake

a fixed - caliper disc brakes

b floating - caliper disc brake

1 Drum brake

A drum brake is a brake that uses friction caused by a set of shoes or pads that press against a rotating drum.

Components of drum brake (Fig 1)

Back plate

The back plate provides a base for the other components. It attaches to the axle and forms a solid surface for the wheel cylinder, brake shoes, and assorted hardware. Since all braking operations exert pressure on the back plate, it must be strong and wear resistant.

Brake drum

It is positioned close to the brake shoe without touching it, and rotates with the wheel and axle. When a driver applies the brakes, the lining pushes against the inner surface of the drum which generates friction heat of high amount. So, the brake drum is generally made of a special type of cast iron that is heat conductive and wear resistant.

Wheel cylinder: The wheel cylinder consists of a cylinder that has two pistons, one on each side. Each piston has a rubber seal and a shaft that connects the piston with a brake shoe. When brake pressure is applied, the piston are forced out pushing the shoes into contact with the drum. One wheel cylinder operates the brake on each wheel. Hydraulic pressure from the master cylinder acts on the piston cup, pushing the pistons toward the shoes, forcing them against the drum. When the driver releases the brakes, the force of the brake shoe retract spring returns the piston to its original position.

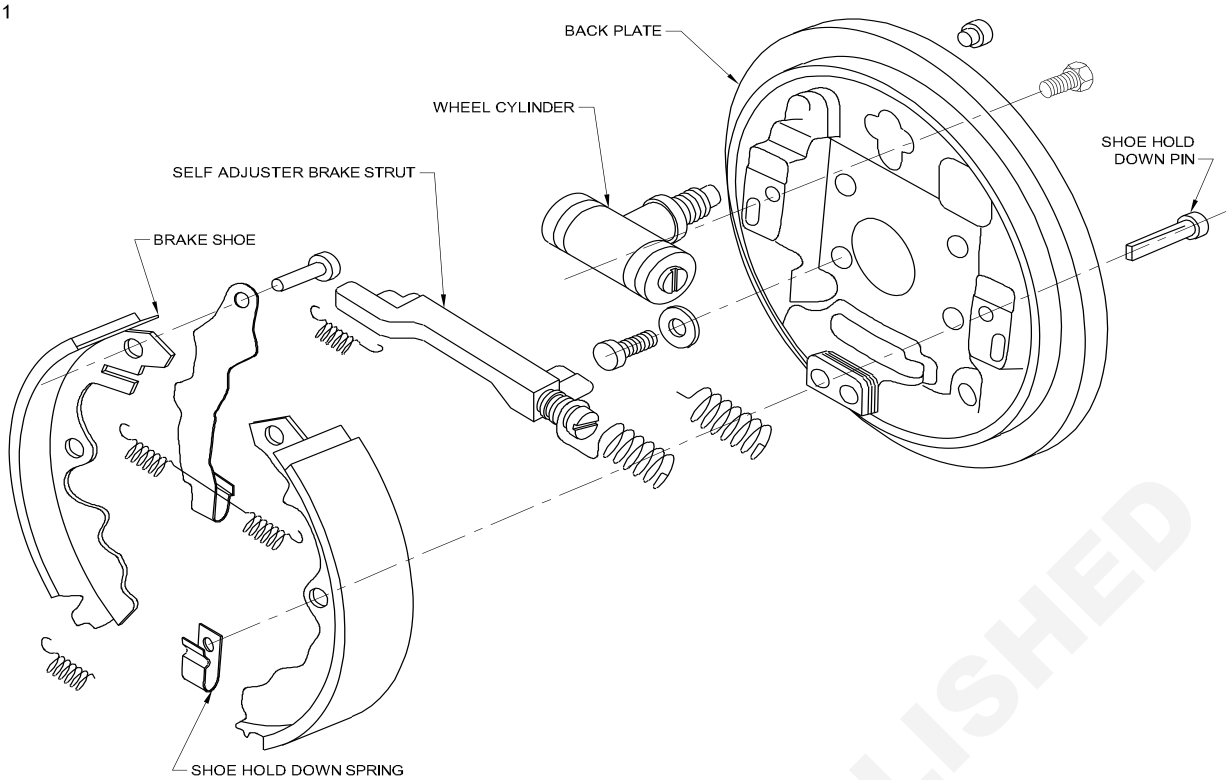
Brake shoe

Brake shoes are typically made of two pieces of sheet steel welded together. The friction material is either riveted to the lining table or attached with adhesive. The crescent - shaped piece is called the web and contains holes and slots in different shapes for return springs, hold down hardware, parking brake linkage and self adjusting components. All the application force of the wheel cylinder is applied through the web to the lining table and brake lining. Each brake assembly has two shoes a primary and secondary. The edge of the lining table generally has three "V" shaped notches or tabs on each side called nibs. The nibs rest against the support pads of the backing plate to which the shoes are installed.

Self adjuster brake strut

The self - adjuster is used to adjust the distance between the brake shoe and the drum automatically as brake shoes wear.

Fig 1



COMPONENTS OF A DRUM BRAKE

Operation

When brake pedal is pressed, either through Mechanical / hydraulic / pneumatic means, brake shoes expands against the drum. Many drum brakes are self-actuating. The brake shoes contact the drum, there is a kind of blocking action, which has the effect of pressing the shoes into the drum with more force. Because of this action, the shoes must be pulled away from the drum when the brakes are released. For which springs are provided to hold the brake shoes in place and return the adjuster arm after it actuates.

Brake lining

Objectives: At the end of this lesson you shall be able to
- **state the material required for the brake lining.**

Two types of brake linings are used.

- Organic brake lining
- Semi-metallic brake lining

Organic brake lining

These linings are moulded from a mixture of asbestos, fibre glass, asbestos fibres etc. Resin is used as a binding material.

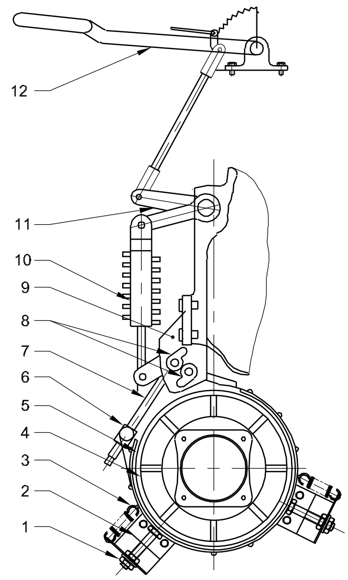
Semi-metallic brake linings

These linings are mostly used for front disc brakes in front wheel drive vehicles. It is made of fine polished steel wool. It also includes iron powder and graphite. Plastic resin is used as a binder. The mixture is heated and pressed to form the lining. Semi-metallic linings are more wear and heat resistant than organic linings. Semi- metallic linings can retain their coefficient of friction when operating at very high temperatures. (Fig.1)

Brake shoe arrangement: The brake shoe carrier plate consists of a wheel cylinder, with two pistons and two brake shoes with friction lining riveted or bonded.

During operation, the two pistons press the brake lining against the revolving drum. Through the mechanism frictional force acts on the circumference of the brake drum.

Fig 1



BAND - TYPE PARKING BRAKE

The frictional force depends on

1 Operating force at the brake pedal.

2 Mating of friction between lining and drum.

Introduction

Parking Brakes: The Parking Brakes or Hand Brakes (sometimes called) are a must for any vehicle including tractor as per MV Act. When tractor is standing on an incline, this brake is to be applied and this will make the vehicle immovable. This is a safety device for all vehicle.

Types

Normally there are two types

- Drum type parking brakes
- Bend type parking brakes

(Both types are fitted on the Transmission shaft rear end)

Working

> **The working of both the types are identical. Hence Band Operation is discussed below.**

On general purpose wheeled tractors the Band type Parking Brakes are widely used.

The Braking action is obtained by applying friction material on the band with the brake pulley which is revolving or stationary. The brake pulley is fitted at the rear end of the transmission on shaft. The brake friction Band encircles the pulley.

The lever is arranged in Driver's cabin and by pulling it by hand and latching it in the applied position by a Pawl and Toothed Quadrant.

The Band release springs provide uniform clearance between linings and pulley outer surface.

> **Backward pulling of lever makes the Band linings tight against the pulley around its circumference and thus the brake is said to be applied.**

By forwarded movement of brake lever, the springs help to return the Band to original position. (Released)

Layout of the system of Booster Brakes

Vacuum and Hydraulic Booster Brakes.

Disk brake

Objectives: At the end of this lesson you shall be able to
- **state the various components of disk brake**
- **state the functions and operation of different types of disc brake.**

Disk brake

Disc brake also works on the principles of the drum brake, disc which rotates along with the vehicle wheel and is partially held by a brake caliper assembly mounted on the suspension. When the brake pedal is depressed, the brake pads mounted on the inside and outside of the housing are pressed hydraulically against the rotating disc.

Major components of disc brake are

Disc, Piston, Brake pads and piston housing bracket.

Types of disc brakes

Disc brakes categorized into

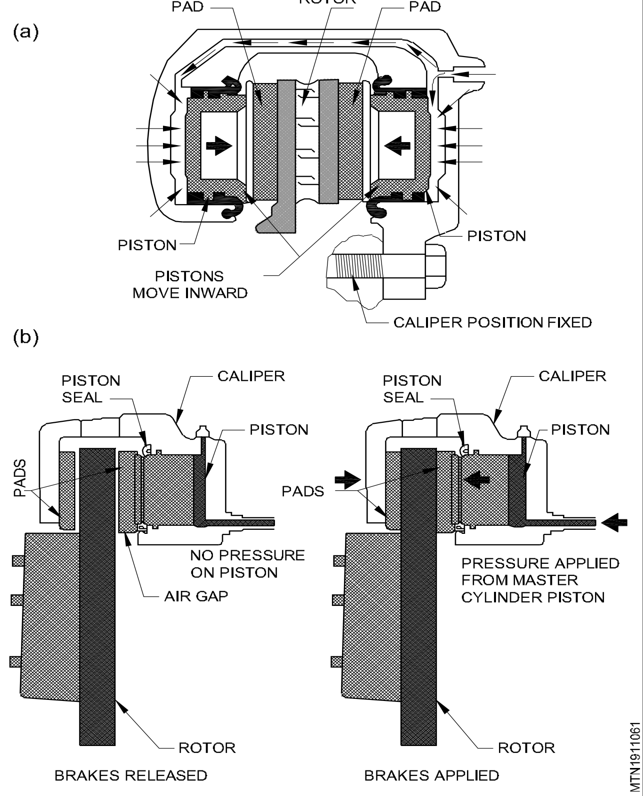
a Fixed caliper disc brakes (Fig 1a)

It contains two pistons in housing and brake pads on the piston. On applying force over brake pedal, the hydraulic fluid passes through piston housing bracket and makes the two pistons move against the brake pads located in the housing and after closing the air cap these are pressed against the rotating brake disc. Nowadays, this type is rarely used.

b Floating caliper disc brakes (Fig 1b)

When the brakes are applied, the piston moves in the housing and recesses the inner pad against the rotating brake disc. The hydraulic pressure in the cylinder of the piston housing acts both on the surface of the piston and on the bottom of the piston housing. As result, the piston housing slides on the locating studs in the opposite direction and the outer brake pad is drawn against the brake disc with same force from the wheel side. when the brake release, the air gap between the pads and the brake disc is restored force of the piston sealing ring.

Fig 1



Power assisted servo brakes

Objectives: At the end of this lesson you shall be able to
- **state the need of power-assisted hydraulic brakes**
- **draw the layout of a vacuum-assisted hydraulic brake**
- **list out the various types and their functions in the vacuum-assisted hydraulic brake.**

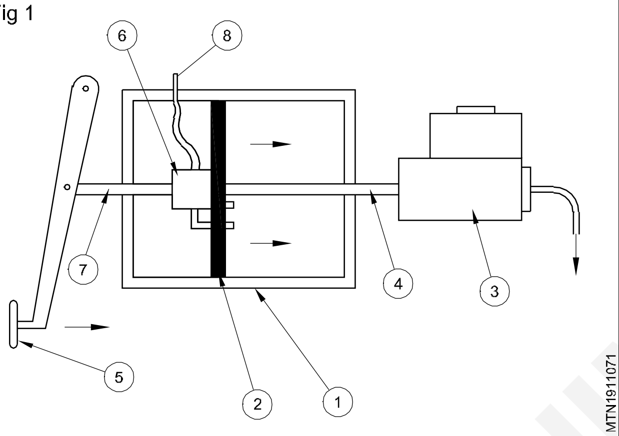
Power assisted servo brakes

It reduces the brake pedal effort without affecting the braking efficiency. Two types of power-assisted servo brakes are used.

- Vacuum-assisted power brakes
- Air-assisted power brakes

Vacuum-assisted power brakes (Fig 1)

Fig 1



The power brake unit uses the vacuum produced in an engine.

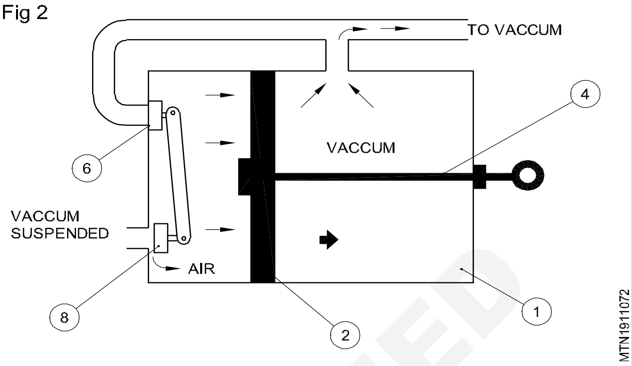
A booster cylinder (1) is a closed cylinder with a piston or diaphragm (2) inside. One side of the piston is connected to the master cylinder (3) through a push-rod (4). The other side is connected to the brake pedal (5) through a linkage (7). A vacuum control valve (6) is placed between the brake pedal linkage (7) and the piston (2).

The vacuum control valve (6) admits vacuum or atmospheric pressure to reach both sides of the piston (2). When a driver presses down the brake pedal (5), the vacuum control valve (6) cuts off the atmospheric pressure and opens the vacuum inlet passage (8) to the brake cylinder side. The atmospheric pressure acts on the piston to push the push-rod. This reduces pedal effort.

Vacuum-assisted power brakes are divided into two types.

Vacuum suspended power brakes (Fig 2)

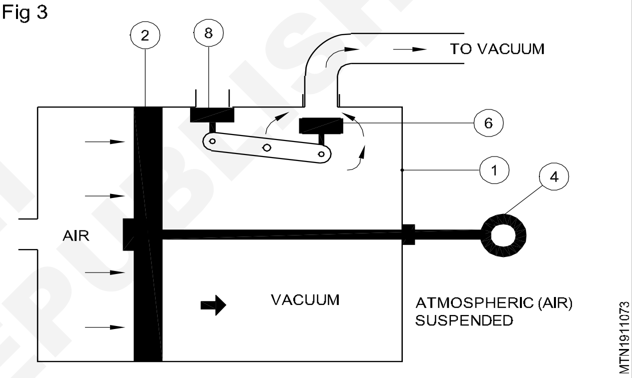
Fig 2



A booster (1) has a vacuum existing on both sides of the diaphragm or piston (2) when the booster is in a released position. When the brake is applied, the atmospheric pressure is admitted to one side of the piston by closing the vacuum valve (6) and opening the air valve (8). The difference in pressure on both sides of the piston causes the necessary movement of the piston along with the push-rod (4).

Atmospheric air-suspended power brakes (Fig 3)

Fig 3



The booster (1) has atmospheric pressure on both sides of the piston (2) when it is in the released position. When the brake is applied a vacuum is created on one side by closing the air valve (8) and opening the vacuum valve (6) to cause the piston to move along with the push-rod.(4)

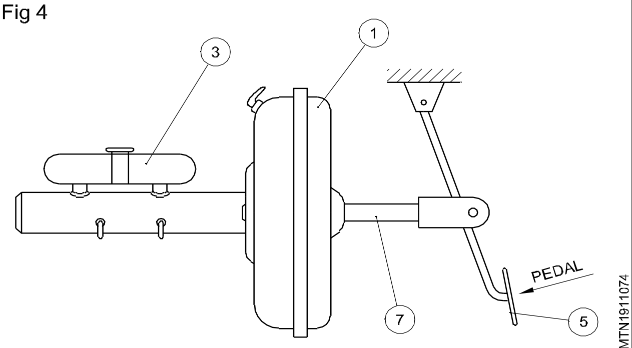
This type of power-assisted brakes will not operate if the engine is not running. A small vacuum tank is included to provide enough vacuum for several brake applications after the engine has stopped.

Types of brakes

- Integral type brake
- Multiplier type brake
- Pedal-assisted type brake

Integral type (Fig 4)

Fig 4

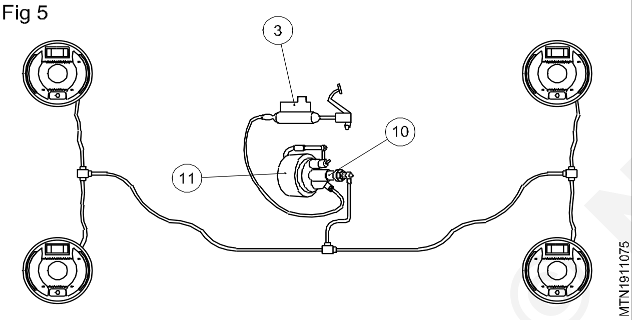


In this type the brake master cylinder (3) is an integral part of the power brake assembly (1). The booster assembly (1) is fitted between the brake pedal (5) and the master cylinder (3). When the brake pedal is operated the linkage (7) actuates a brake valve in the power brake assembly. An atmospheric pressure is applied to one side of the piston or diaphragm and the vacuum to the other side. The difference in pressure causes the piston/ diaphragm to move. This movement forces the master cylinder piston inside for effective braking. Most cars and light vehicles use this type of system.

Multiplier type (Fig 5)

This type multiplies the pressure produced by the hydraulic cylinder (10) . When the brake is applied, the hydraulic pressure from the master cylinder (3) actuates a control valve in the multiplier unit (11). This causes to admit atmospheric pressure to enter at one side of the diaphragm. The other side of the diaphragm has a vacuum. Due to the difference in pressure the diaphragm is forced to move. This produces high hydraulic pressure which is transmitted to the wheel cylinders. A very light pedal pressure multiples several times and produces heavy braking action.

Fig 5



Pedal-assisted type (Fig 6)

This system has a power cylinder assembly (1). It assists in applying the brakes through a mechanical linkage (7). When the brake pedal (5) is pressed the linkage to the power cylinder is actuated. It causes the valve (4) to open and moves the diaphragm (2) within the power cylinder (1). This movement is carried through the linkages (6) to the master cylinder (3) and increases the total force applied for the braking action. This set up applies the booster pressure to the brake pedal instead of directly to the master cylinder.

Vacuum booster (Fig 7)

A vacuum booster helps in reducing pedal effort. Inside the booster, vacuum is created when the engine is running and the brake is not applied. In this position the vacuum port (3) of the rear chamber (4) remains open and the atmospheric port (5) remains closed. Thereby vacuum exists in both the front (6) and rear chambers (4). When the brake pedal is pressed its push-rod (1) pushes the diaphragm assembly (2). This causes the vacuum port (3) to close and the atmospheric port (5) to open. Now, vacuum exists only in the front chamber (6) and air at the atmospheric pressure exerts in the rear chamber (4). This forces the diaphragm assembly (2) to move towards the front chamber and pushes the master cylinder push-rod (8) to apply the brakes. When the brake is released the diaphragm assembly (2) comes back to its original position by the return spring (7), closing the atmospheric port (5) and opening the vacuum port (3).

Fig 6

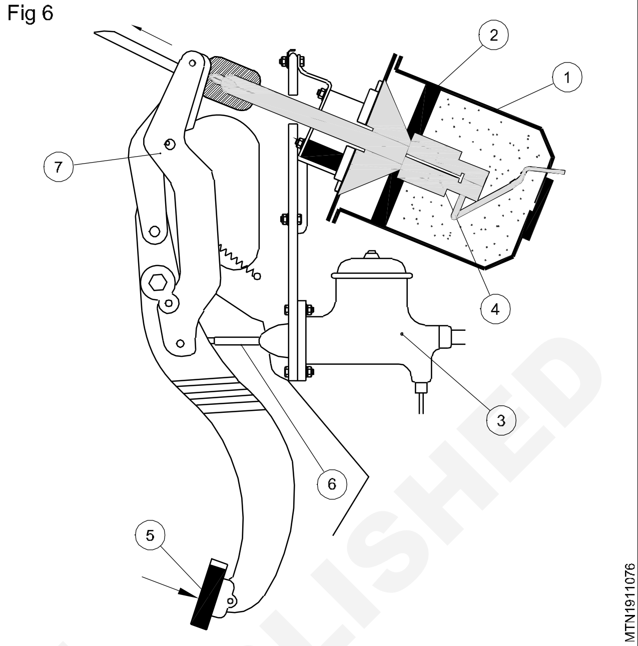
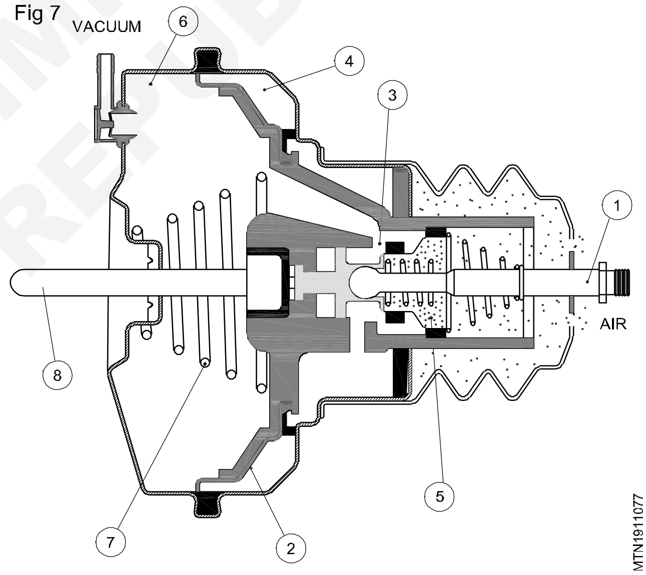
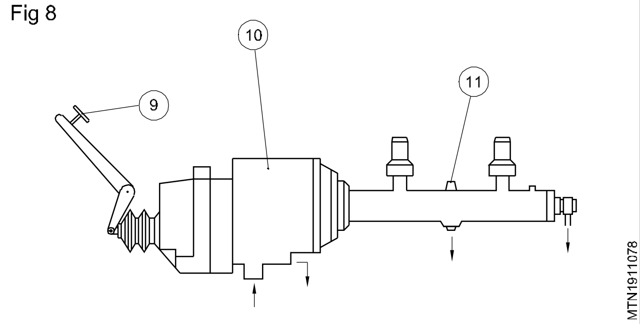


Fig 7



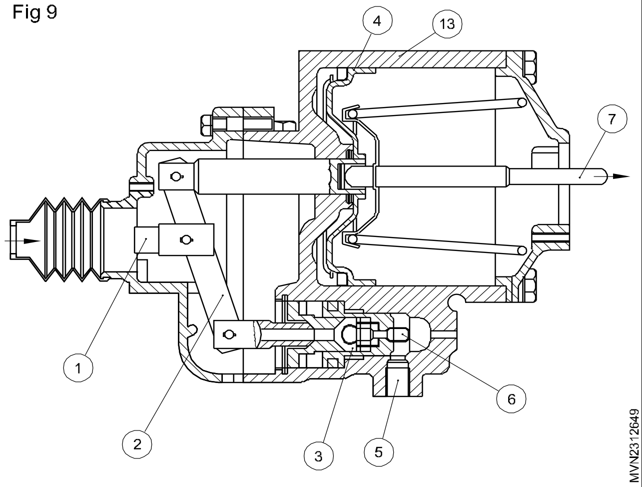
Air-assisted power brakes (Fig 8)

Fig 8



In this system instead of a vacuum, air pressure is used to assist in the application of brakes. It is a lever type servo-fitted (10) on the chassis. The front end is linked to the brake pedal (9) and the rear to the master cylinder (11). This will boost the force applied on the master cylinder at the time of application of the brakes. Details of servo unit 10 shown in Fig 9.

Fig 9



Operation

When the brake pedal is pressed, the fork rod (1) which is linked to the brake pedal presses the lever (2). The lever (2) is linked with the air control valve (3). The air control inlet valve (6) opens and allows high pressure air from the air compressor to reach into the cylinder (13) behind the piston (4) through the air inlet port (5). The piston (4) moves forward pushing the master cylinder piston rod (7). The brake fluid under high pressure goes to the wheel cylinders to actuate the brakes.

The functions of the other units in this system like the air compressor, unloader valve, flick valve etc, are the same as in the air brake system.

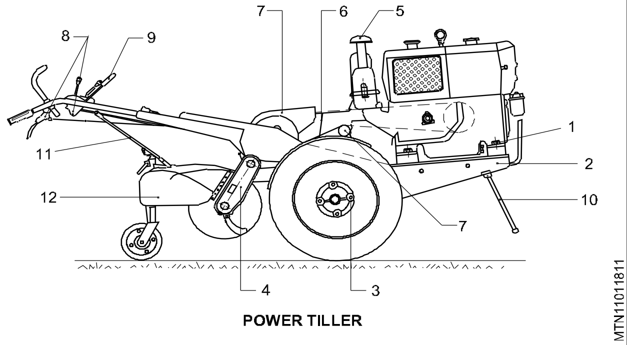
The piston rod (7) is linked to the brake pedal rod (9) in such a way that in the event of air pressure failure, the pedal rod (9) can press the master cylinder rod (7) and the vehicle can be stopped.

Power tiller

Objectives: At the end of this lesson you shall be able to
- **define a power tiller**
- **explain the purpose and scope of a power tiller.**

Definition of a power tiller (Fig 1)

Fig 1



POWER TILLER

Power tiller (1) is a small machine (tractor) having two wheels and upto 15 HP, used to draw almost all agriculture implements in the field. Trolley (2) can also be attached with power tiller for transportation purpose. During the field operation with implement, the operator is to walk along with the power tiller to control the tiller as well as implements. At the time of transportation a separate wheel is provided for operator to drive the tiller in different speeds. The parts are named below.

Parts

1 Foundation bolt
2 Chassis
3 Wheel bolts
4 Rotary chain case
5 Air cleaner
6 'V' belt
7 Tensioner
8 Steering Clutch Lever
9 Main Clutch Lever
10 Front stand
11 Handle stay
12 Rota Tiller Assembly

A wide variety of types and sizes of power tillers are available. Recent improvement include

1 Well enclosed working mechanism.
2 Three or more speed transmission with reverse gear.
3 Power take off shaft.
4 Adjustable tread wheels.

Available attachments & implements include plough, planters, cultivators, various kinds of harrows, hay and lawn mowers, grader blades and rotavator.

Purpose and scope of power tiller

Power tiller is more useful machine for small fields and orchard where the implements is to take turn with in a small space to avoid the damage of the bunds as well as trees. To take sharp turn side clutch or steering clutches are provided for both sides.

All most all agriculture implements (primary tillage implements as well secondary tillage implements) such as ploughs, harrows, cultivators, mowers, grader blades, pump sets, rotavator etc. can be used with power tiller effectively for field operation. For puddling the paddy field specially designed rotavator and cage wheel (steel wheel) can be used for effective operation.

Different systems of power tiller

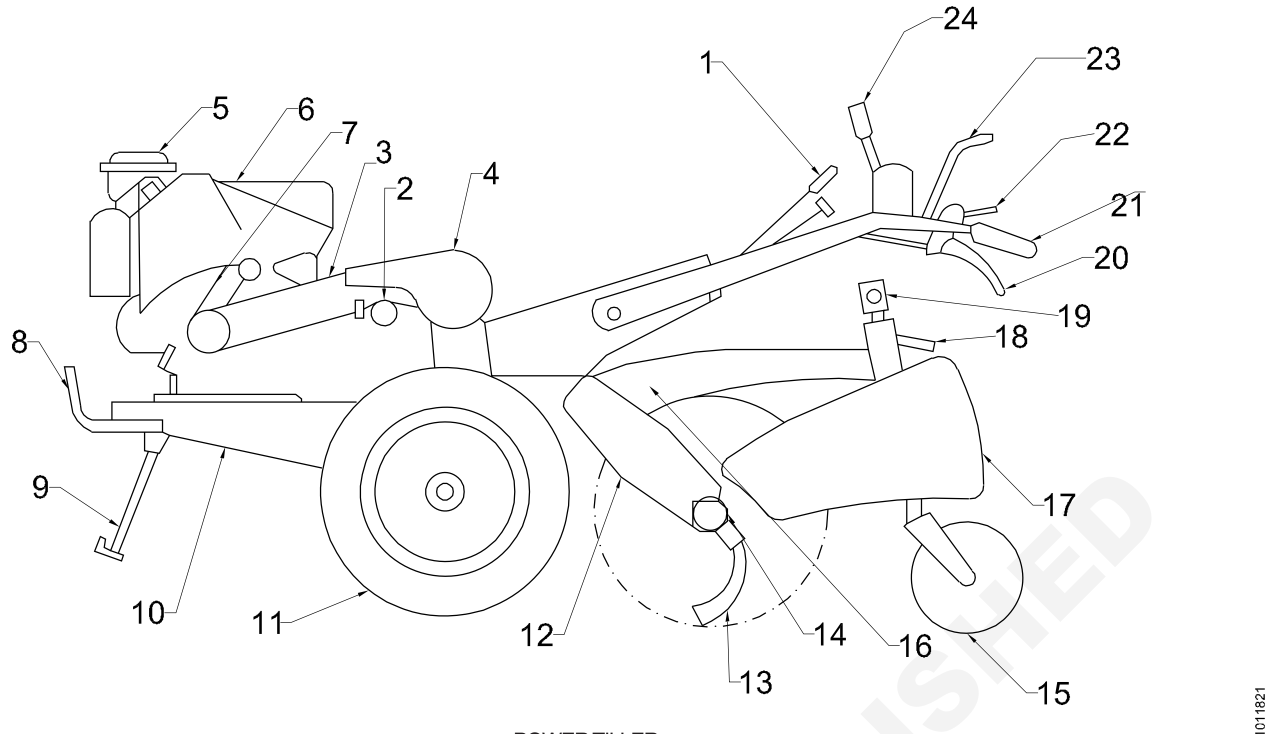
Objectives: At the end of this lesson you shall be able to
- **explain the constructional details of a power tiller**
- **study the attachment to the power tiller**
- **describe the different systems of power tiller**
- **state the components of different systems.**

General construction of power tiller

Power tiller consists of several installations as below (Fig 1)

i Engine and its auxiliary apparatus
ii Power transmitting system
iii Chassis construction
iv Running installation
v Driving instruments, switches and controls
vi Hitching device and power take - off
vii Rotary tiller (or other equipments)

Fig 1



POWER TILLER

Power tiller consists of main transmission lever (1) tension pulley (2) V - belt (3) V - belt cover (4) Air cleaner (5) Engine (6) Fan belt (7) Bumper (8) stand (9) Frame (10) Wheel (11) Rotary side case (12) Tine (13) Rotary shaft (14) Tail wheel (15) Rotary frame (16) Rotary side cover (17) Handle stay (18) Tail wheel adjusting handle (19) Side clutch lever (20) Handle (21) Throttle lever (22) Auxiliary handle (23) and main clutch lever (24).

Engine of power tiller

Engine mounted on the power tiller can be classified from the several standpoints; kind of fuel, operating cycle of engine, cooling system and etc.

Generally, power tillers employ 4 - cycle diesel engine. As to the cooling system of engine, more number of water - cooled engines is used than air - cooled engine.

Regarding engine horsepower is ranging from 4.5 HP to 12 HP. We can see the tendency that the light power tillers, which are mounted with 4.5 - 6 HP engine, are used as general - purpose walking - type tractor. Many of these capacities power tiller are equipped with air - cooled petrol engines, and weight of machines are not so heavy. They are used not only for the rotary tilling jobs, but furrowing, seeding, inter - cultivation, weeding, and transportation job.

Power tiller, which is designed mainly for the heavy rotary tilling jobs of the paddy field, is equipped with 6 - 12 HP diesel engine, and tilling width is 55 - 70 cm.

If capacity and revolution speed of the engine is suited to the requested performance of the machine, normal agricultural engine will be possible to be mounted on the engine frame and can be used.

Wheels

One or two kinds and sizes of rubber tyre wheel are arranged as the announced standard wheels. However, if another size and shape tyres are wanted for the special condition of field, optional wheels such as wide - rim rubber tyre wheels, iron wheels with rags, strake wheels will be available.

At present, tyre size of 5.00 - 12 and 6.00 - 12 are very popular.

Wheel tread is changed according to the kind of jobs and method of job. Tread adjustment is made by means of changing the fixed position of wheel on the wheel shaft and turning the wheels.

Hitching device

Most of power tillers are provided with so - called box hitch to connect the rotary tiller to the machine body, and two fixing bolts are applied to limit the movement of rotary tiller.

When other kind of equipment, such as plough and trailer, is hitched, a hitch pin, which is inserted in the centre hole on the box hitch, allowing the equipment to swing, right and left.

Power transmitting system

Strictly speaking, power transmitting system and construction of each part varies according to the type and capacity of power tiller. Here explanation on the most popular type of power tiller is given.

Revolution power of engine is transferred to the main clutch pulley by the v - belt. When main clutch is engaged, the power from the engine is transmitted to the transmission gear box, where gear speed is changed and suitable speed is selected. Then the revolution speed is reduced and torque is increased.

A portion of revolution power is transferred to the driving shaft of the wheels through the steering clutches (side clutches). Another power is transferred to the rotary shaft through P.T.O. clutch and final driving gears or chain.

Clutch

An installation to cut and connect the power transferring is called a clutch.

The clutch which is applied for stopping tractor run without stopping engine, and for stopping revolution of transmission gears in order to change gear speed easily, is named as engine clutch. Often, engine clutch is called main clutch to distinguish this clutch from other clutches, such as P.T.O. clutch and steering clutch.

At present, two kinds of clutches are used as the main clutch; tension pulley type clutch and friction type disc clutch.

In the case of tension pulley clutch, revolution power from the engine fly - wheel is transferred to the driven pulley (main clutch side) only when the tension pulley pushes up the V - belt to give enough tension to the belt. When the tension pulley is down and free from the V - belt, the belt is just slipping around the pulleys, so that the revolution power is not be transferred.

Such tension pulley clutch is very popular as the main clutch of small power tiller or walking type tractor. The clutch is not only functioning power transferring, but it operates as a safety device against overload and sudden shock.

Most of big capacity power tillers are equipped with friction type disc clutch as the main clutch, and dry type multi - plate clutch is very popular.

When the clutch lever is controlled to the cut - off position, the pressure plates in the clutch are lifted off from the friction plate by the action of release arms against the pressure of clutch springs, and transferring of revolution power is cut off.

While engine is operating and V - belt rotates the driven pulley, the friction plate which is connected with the driven pulley shaft is revolving. Normally, such friction type disc clutch is installed inside the driven pulley and constructed as one body.

Usually, dog clutch is applied for the steering clutch of power tiller. To turn the power tiller to right - hand side, the right - hand side clutch is cut off to slow down the revolution of the wheel. When turning to left - hand side, the left - hand side steering clutch has to be cut off to make turn easy. When the machine turns, out - side wheel revolves faster than inside wheel and steering becomes easy.

Steering clutches are employed for walking - type tractor and power tiller. Steering clutches are not applied to 4 - wheeled tractor, because tractor is provided with a differential gears device, which helps to make sharp turn, together with use of the divided foot brake.

Transmission gears

In the case of popular power tiller, revolution speed of the engine ranges from 2,000 r.p.m. This revolution speed is high to drive the operating parts.

Therefore, it is necessary to reduce the revolution speed by means of transmission gears and reduction gears. Every power tiller is designed with having proper gear reduction ratio, to increase the torque of operating parts.

On the other hand, according to the kind job and conditions of the field, power tiller must change the running speed in order to perform good job and to get moderate traction force.

To meet wide range of speed requirement, most of power tillers have 4 - 6 forward speeds and 1 - 2 backward speeds.

The table below shows us the proper speed for several kinds of field jobs as the result of many experiments. As to the speed of transportation on the road, it is recommended that for safety the traveling speed is not over 15 km/hr.

Proper traveling speed for each job	Kind of job traveling speed (m/sec)
Rotary tilling	0.3 - 0.7
Puddling with rotary	0.4 - 1.0
Ploughing	0.7 - 1.2
Transportation with trailer	3.0 - 4.0

Revolving speed of the rotor (rotary) ranges widely from 150 r.p.m to 350 r.p.m., so operator must select suitable traveling speed of the machine and tilling pitch of the rotary, considering the soil conditions.

Power outlets

The main power outlets of a power tillers are at wheel axle for forward travel and at rotary shaft for rotary motion of soil working tines. Some power tillers have are separate power take off shaft for use on low speed stationary farm equipment. For irrigation pumps, sprayers, dusters etc., the power is taken directly from the shaft of the power tiller engine.

Rotary tiller

Rotary tiller is detachable from the body of power tiller. It consists of rotary shaft, tilling tines or blades, driving gear trains, steel cover and side covers, side mud-guards and rear rubber guard, gauge wheel and its height adjusting crank.

Tines and blades are fixed to the brackets on the rotary shaft by bolts and nuts. So the direction of the tines and blades are changeable.

Power tiller - maintenance

Objective: At the end of this lesson you shall be able to
- **describe the maintenance of power tiller.**

Good maintenance is essential for safe, economical, and trouble - free operation. It will also help reduce air pollution.

Care at the running - in period

First of all, just after receiving a new power tiller, confirm the model number and manufacturing number of the chassis and engine, so that you can order spare parts for maintenance and repair in the future.

Then, check all the parts of power tiller, whether nuts and joints are missing or nor, and tighten them properly.

The pressure of the tyres also must be checked. Check and confirm the amount of lubricating oil at every moving part.

During the running - in period, heavy driving of the power tiller should be avoided to get long life of the power tiller. "Running - in" means to use the machine with special caution for a short period at the beginning of use, so that the various parts of the machine would make smooth revolution and operation.

For a successful running - in, the engine should not be driven at very high speed for the period of 30 - 50 hours, nor force the power tiller to do very strenuous works during the period. Don't start power tiller and stop suddenly. Traveling speed on the road also must be limited in the low speed gear.

When the running - in period was over, refill with new lubricating oil to the transmission gears case, rotary gear case, driving chain case and others.

Check and care of engine

Regarding maintenance of the engine, time interval of the check duffers according to the kind and capacity of the engine.

As to the engine oil, the designated viscosity of oil has to be used. As the cooling water, a clean soft water is used, and alkaline water and other harmful water should be avoided.

Lubrication in the operating parts

Always, fill the lubricating oil in the transmission gear case and the rotary driving gear case up to correct level. If oil level gauge shows shortage of the oil, immediately remove the oil plug and fill SAE 80 - 90 gear oil.

Sometimes the main clutch lever, steering clutch lever and wire must be supplied with SAE 20 - 30 engine oil, so that engagement and disengagement of the clutches would be very smooth.

Rotary shaft, wheel shaft, gauge wheel of rotary tiller and other moving parts have to be lubricated with SAE 20 - 30 engine oil or grease.

As to drainage of the lubricating oil, it would be best that the oil is drained just after the operation of machine, when the oil is still warm and in a flowing state. The dirts in the oil also would flow out easily with the drained oil.

Clean the air cleaner using compressed air periodically. Clean the fuel filter if it is clogged with water or dirt, using pure fuel.

Air cleaner maintenance

The air cleaner filler dust particles. This has to be cleaned regularly to get clean air. Loosen the fastener of air cleaner (Fig 1) and remove the top cover of the air cleaner (Fig 2).

Fig 1

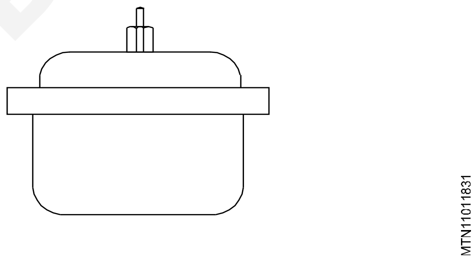
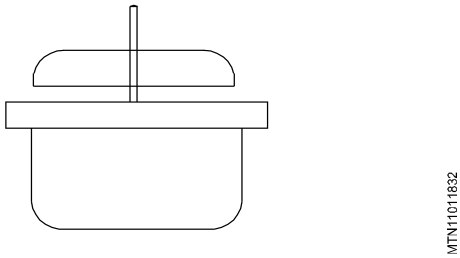


Fig 2



Take out the air cleaner element and clean it with compressed air (Fig 3). Clean the bottom bowl of air cleaner from dust (Fig 4).

Fig 3

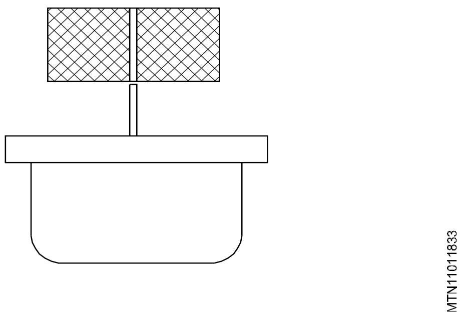
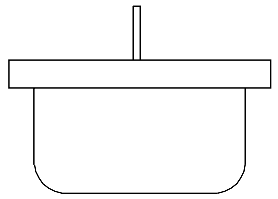


Fig 4



Tyre change

Loosen the axle bolts in a cross fashion and remove wheel. While putting back care should be taken to give sufficient torque in crossed fashion to prevent loosening.

Gear box lubrication oil change

Use gear box oil SAE 90 grade. Change every 500 hours of operation. To change gear oil, completely un screw the drain plug provided under the gear box housing drain old oil. Put the plug back with the washer. The fill oil upto mark.

Safety and proper use

- Do not tamper with parts which may increase the governed speed.
- Do not run engine at excessive speed. Operating an engine at excessive speed increased the hazard of personal injury.
- Manufactures select the governed top speed based on design and requirements of the equipment.
- Do not spill diesel fuel on hot surfaces such as the muffler which may ignite the fuel.
- Store fuel only in approved containers.
- Do not run the engine in a closed area. Exhaust gases contain carbon monoxide, which is odourless and prisonous.
- To prevent accidental starting always loosen the high pressure fuel line at the fuel injection pump, before working on the engine or equipment driven by the engine.
- Do not operate engine if air cleaner is removed.
- Do not operate without a muffler or tampered exhaust system.
- Damaged mufflers could create a fire hazard. Inspect periodically and replace if necessary.
- Do not operate engine with the guard or housing removed.
- Removal of these protective devices exposes rotating parts.
- Always keep hands feet & body clear of rotating parts.
- Do not touch the cranking device before the engine has come to a complete standstill.

Storage

Cleaning and oiling

Wash the soil and dust attached on the machine with water and dry.

Apply the grease and oil to the rotating parts and working parts.

Recommended oil SAE 20/40

After completing the works and in case the lubrication oil is dirty, replace the oil with new oil.

Put the main clutch lever on OFF position. Close inlet and exhaust points with corks.

Long storage

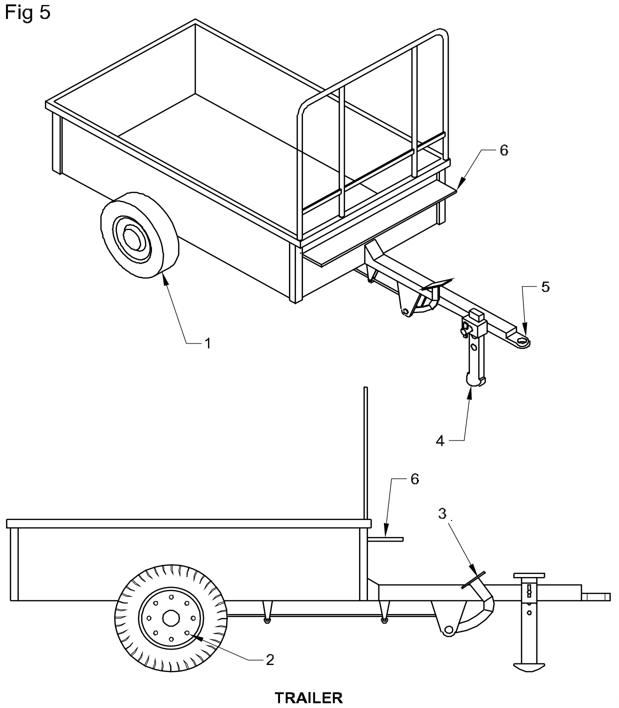
If the engine is taken out of operation for a long period, a conservation treatment must be carried out to prevent corrosion damage.

Drain the fuel tank. Apply anti corrosion oil in the tank. Put speed control lever to full load. Pull starter rope slowly approximately 5 times. Close the inlet and exhaust ports with corks or adhesive tape. Store the engine in a dry place, protect against all influence of weather.

Special Attachment to Power Tiller: A specially designed trailer is used alongwith Power Tiller. A figure is shown here with parts duly marked. The figure is self explanatory. (Fig 5) This can be attached to the Power Tiller when required. The parts are named below:

1 Tyre
2 Wheel Nuts
3 Brake Pedal
4 Stand
5 Hitch point
6 Seal for operator

Fig 5



Hitching

Objectives: At the end of this lesson you shall be able to
- **explain the meaning of hitching**
- **state the purposes of hitching**
- **state the types of hitching.**

Meaning of Hitching

It is a device or a system of coupling/attaching the implements with the tractor for field operation. The tractor is a power source to which implements is connected by a suitable and safe hitching system ensuring effective operation of the implement attached to it.

Purpose of Hitching: The conventional implements used for the farm work are devoid of mechanical power source. The conventional power sources such as human or animal power have their limitation, when extensive cultivation is proposed. The only solution to this problem is to use mechanical power source. Therefore it become essential to attach an implement to the power source by means of a suitable linkage system called hitch system. The considerations are

- To provide for safety of power source (tractor), Implement and Operator.
- To provide for maximum utilization of power source. This means to get more work done with less power used.
- To provide for ease of control and adjustments (mechanically, hydraulically or electronically) in varied field conditions and operations required.
- To provide facility for quick attachment or de-linking.

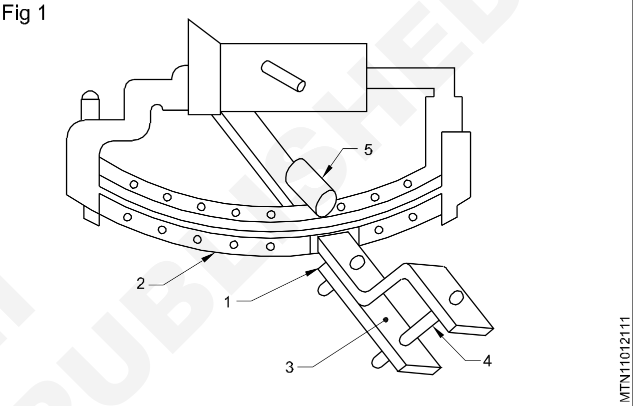
Type of Hitching: The type of hitch is adapted according to the implements mounting facility. There are three types of main hitching.

- Single point hitch
- Two points hitch
- Three points hitch

Single point hitch

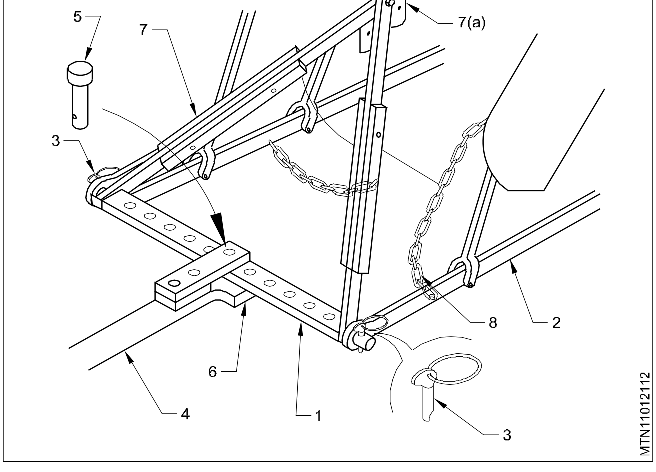
There are two main types of single point hitch point. The Fig 1 illustrates the swinging drawbar (1) hitch point. The swinging drawbar can be moved on either sides of the quadrant (2) having holes on the quadrant plates. After the implement is hitched to the 'U' hitch bar (3) provided with the hitch pin (4), the implement is ready for use. Keep the lock pin (5) unlocked during trial run. It is seen that the swinging draw bar will swing on right or left adjusting with the pull exerted on the implement. Lock the pin (5) when most suitable point of hitch is determined with the least side draft effect. The swinging draw bar takes care of wide range of variation in the field conditions. Side draft on the left of the equipment will pull the front wheels on right and vice versa. With the result the additional effort is exercised on the steering wheel to keep the work moving. In such cases swinging draw bar provides an ease of steering the tractor.

Fig 1



Now this type of single point hitch with a swinging drawbar is eliminated and a modified system is developed using lower links (2) of the tractor accommodating multi-hole flat bar called drawbar (1) as shown in Fig 2. Other incorporated parts which provide semi-rigid drawbar assembly are stay links (7) which are bolted at the near of the tractor as shown (7a). The lower ends of the stay links (7) are assembled with lower links (2) to the pins of the drawbar (1) on either sides. All these three ends are secured by linchpins (3). The chains (8) attached to the lower links (2) restrict the lateral movement of the lower links. The holes provided on the drawbar are to facilitate hitching of the hitch bar (4) of the implement forming 'U' clamp (5) at the end. To insert hitch pin, keep the drawbar in and align the hole of drawbar

Fig 2

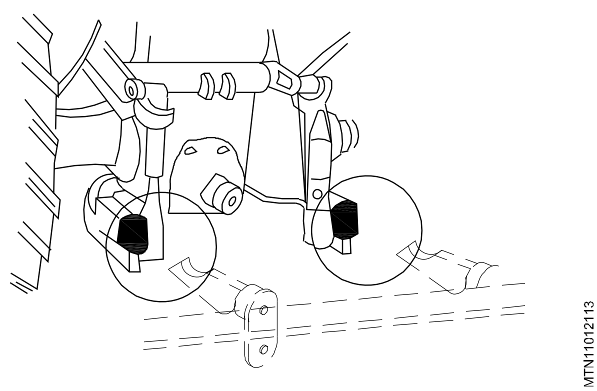


with that of ‘U’ clamp holes and insert the lock pin. The inline holes on the drawbar is to align with the force of tractor to the implement, preventing the side pull. Accordingly the inline holes and the drawbar are selected. This is done while working in the field. The hitching point (hole) can be relocated for operation. This should be done during operation.

For hitching the trolley, there is a fixed hitching bracket, fixed to the tractor (end) just below the driver’s seat. This point should never be used to hitch the implement, thus preventing over turning of the tractor in the field.

Two point hitch system (Fig 3)

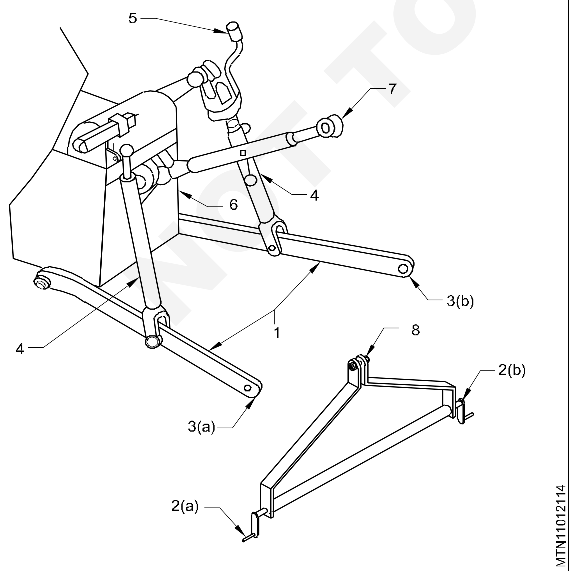
Fig 3



It is a modified system of the single point hitch, providing two side by side points at the rear of the tractor. These points serve as two gripping points to attach the two points of the implements. This system eliminates the deficiencies encountered in the single point. This system is relevant to the semi-mounted type equipment also. The front weight of the implement is transferred to the rear wheels of the tractor. It is operated hydro-mechanically. Housing the same power source, heavier implements can be used as compared to the mounted type equipment.

Three points hitching (Fig 4)

Fig 4



The Fig 4 illustrates the three point hitching assembly comprising of lower links (1) which take the hitch pins 2 of the implement in their sockets (3a & 3b). The left pin (2a) of the implement will get into the socket of left link (3a) and the right pin (2a) get into the socket of right link (3b).

These lower links are pinned to the support ends which can be lifted up and lower down hydraulically with the help of arms (4). Adjustable screw type top link (5) have socket ends. One end fits to the rear side bracket and pinned and similarly other end, 7 pins to the top (Third point) hitching point of the implement (8). There are three important function of top link (5).

1 It levels up the implement longitudinally. (lengthwise)

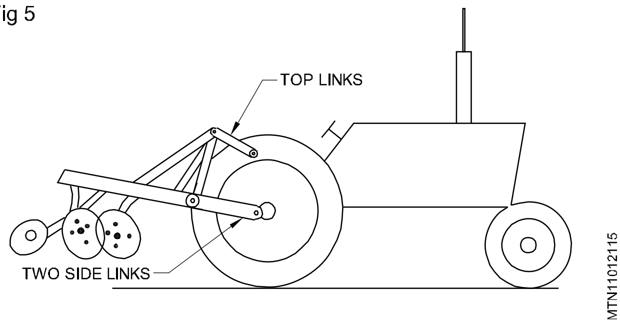
2 It helps to transfer the weight of the working implement on wheels for ensuring stability. Any in balance in weights of front and rear wheels can cause overturning of tractor.

3 During the use of wedging type implement such as mould board plough, ridger, cultivator and sub-soiler etc., the penetration angle can be adjusted by adjusting the length of top link. By decreasing the length of top link, the penetration angle will increase and by increasing the length the angle will reduce.

The link chains (9) serve the purpose of restricting the sideways movement of the implement in use. The restricted sideways movement, prevents interference of implement with other attachment causing damage. In several cases it is observed that the tyre threads are severely damaged beyond repairs.

Fig 5 illustrates how an implement hitched to the three point linkage system can be lifted up hydraulically. The implement becomes one unit with the tractor.

Fig 5



Field practice of disc plough

Objectives: At the end of this lesson you shall be able to
- **explain the purpose and scope of disc plough**
- **state the constructional details of disc plough**
- **explain the adjustment of disc plough**
- **state the pre-check of the disc plough.**

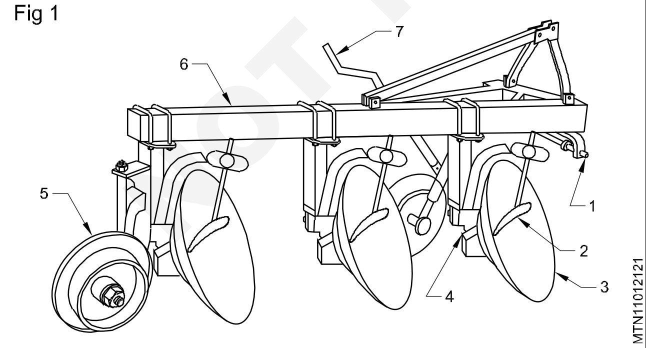
Purpose and importance of disc plough

Disc plough is developed as soil turning equipment when the cultivators encountered severe difficulties in using the wedge type ploughs. The initial soil inverting plough was designated as mould board plough in which a share and a mould board and a land side Fig. are the main components of the wedge type plough. While working underneath of the soil surface innumerable obstacle such as plaint rools, stubble, stone, hard subsoil and rocks are very common. Due to these obstacle the mould board plough operation became limited i.e. the lank which is already been cultivated became a working soil for the plough. To overcome the difficulties of the hidden obstacles disc plough was innovated. Instead of having a sliding type share, a complete disc became rolling share, which eliminate stucking of the share into the obstacles and over ride. The disc have a tendency to slice the roots and hard soil.

With its heaviness in construction, this plough not only handles uncultivated land, but also is used as a primary equipment for reclaiming the land. It has a tendency to cut the soil, lift the soil on the surface on the concave and partially invert the soil, but mixing the soil effectively in order to obtain preferable inversion, scraper is attached. The another advantage of disc plough is to cover the area with faster speed as compared to the mould board. The disc are fitted on taper roller bearing there is atleast frictional resistance employing the maximum initialisation of power for ploughing. However, high speed reduces cutting action. On the other hand slow speed will reduce the inversion and moving action. Therefore while ploughing with the disc plough section of the speed depends on soil condition and depth of the soil.

Constructional details of disc plough (Figs 1,3)

Fig 1



The constructional details of disc plough can be divided into four assemblies

1 the hitching unit (1)

2 beam or frame (6)

3 disc assembly (3)

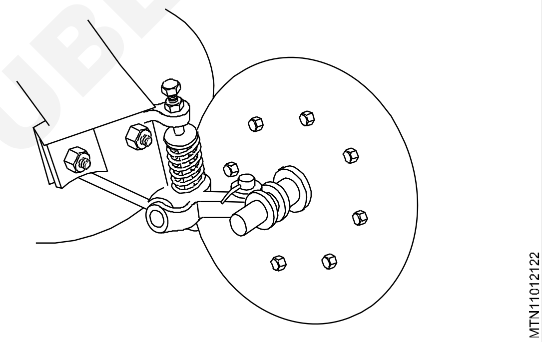
4 rear farrow wheel and ground wheel adjusting lever (7)

The hitching unit (1) comprises of cross shaft having being shaped as hitch pin on either end making as single piece. However there are separate pin screwed into the end of the cross shaft. The single piece cross shaft are more dependable with regards to the stability and rigidity.

This is a tripod like construction made by the heavy plates to frame for top link attachment. The front to braces of the tripod is bolted to the bracket, provided on the frame. The longer brace joints the two braces on the top with the help of plates, and the other end grips the bracket provided on the frame. In some disc plough heavy duty plate is welded to the frame to provide top link fitting.

Beam or Frame (6) (Fig 2)

Fig 2

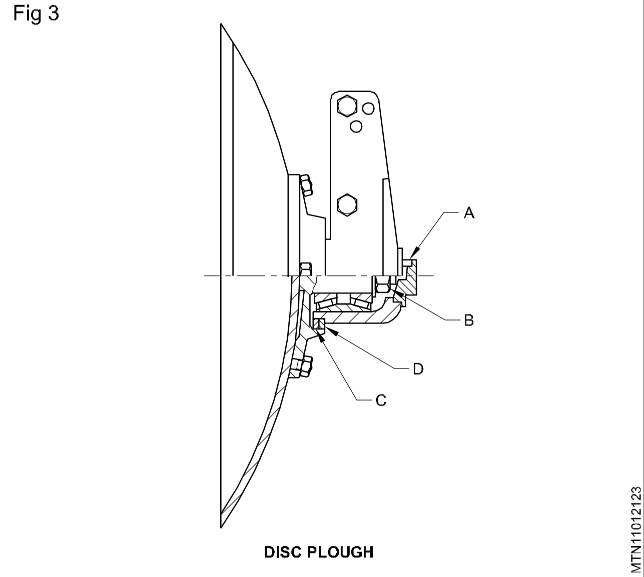


The frames are made either of a heavy duty steel pipe or a hollow square box. As the frame has to hold different components it is to be very strong. It is deliberately made heavy in penetration into the soil. However, the total weight of the equipment should not exceed the hydraulic lifting capacity of the tractor. According to the Nos. of disc to be fitted the standards are securely fastened by the bracket which are adjustable on the frame. In some cases the standards constitute part of the frame or welded to the frame. Standards are meant to provide fastening to the disc bottom.

Disc Assembly (3) (Fig 3)

We have earlier discussed about disc in the Ex.1, of disc harrow. The disc of the plough is much heavier than the disc of the disc harrow. Each disc of the plough is fitted to the individual standards; but the disc of the harrow constitutes the gang having more than one mounted on a shaft equally spaced. A set of common bearing are used in the disc gang give anti-friction rolling. In case if disc plough on each disc has its own bearing set, it gives free movement and bear the shock.

Fig 3



Note

A indicates grease nipple

B indicates Nut

C indicates Seal

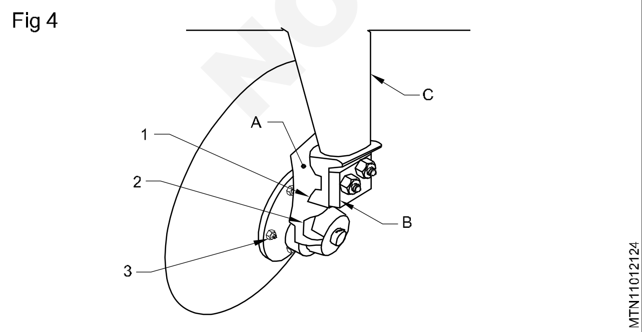
Rear furrow wheel and ground wheel (5) (7)

In the mould board plough there is a part called land side which is designed to absorb the thrust of the load on the mould board while drawing. The land side outer surface is in contact with furrow wall constantly.

In the disc plough the furrow wheel travels against the side thrust of the plough minimising the side draft. The land side slides while furrow wheel rolls, reducing the frictional losses. The furrow wheel (5) is attached at the terminal end of the frame. The heavy duty disc plough having bottom more than two are provided with the ground wheel, which travels on the unploughed land. It helps in for the having the depth of the first bottom of the plough. They are useful when the surface of the field is level. In unlevel land this wheel is to be lifted up completely to have uniform depth of ploughing. The ground wheel can be lifted up by cranking its handle (7). It also helps to keep the plough level for dehitching and hitching.

Adjustment of Disc plough (Fig 4)

Fig 4



The different adjustment of the disc plough are illustrated in the Ex.No. But for the sake of understanding the principle of the following informations are necessary.

In Fig (4) 1,2,3 indicate hub mounting with rearings and seal. Letter 'C' indicates vertical line.

The cutting angle is important to help the penetration of the rolling edge of the disc. There are two angles which are important to define cutting angle. One is viz., disc angle and the tilt angle. These angles are illustrated in Fig 4. The disc angle is also called horizontal direction with respect to line of travels. The tilt angle is also nominated as vertical angle. In this, the disc is inclined with respect to the vertical line as shown in the Fig. The former angle helps the resistance to the movement in the straight line, and tilt angle helps suction of the edge into the soil when pulled. The combination of these two angles are responsible for desired penetration into the soil. The recommended disc and tilt angle are 46° and 22° respectively.

The cross shaft is provided with crank like shape. If the right pin is rotated to the front, the first bottom will reduce its width of because of changing of disc angle and vice versa. The main question is why this adjustment is essential. The first reason of this adjustment is that it will not leave the unploughed land in between the disc. Second thing is to reduce draft, while reducing resistance and penetration in order to reduce the side draft. The adjustment opposite to the above one will have more resistance and penetration and fully ploughed land.

The pre-checks are to be conducted before the farm operation. But there are some important consideration when these points are discussed during lesson presented.

1 We should be sure that all rolling components such as disc furrow wheel and ground wheel are free to move. It is presumed that the trainees going out to the practical do grease all the greasing points. any laps on this exercise will incur heavy maintenance cost and subsequently very loss of valuable time for operation. The trainees should appreciate this points whenever check points are observed.

2 It is always recommended not to alter the previous adjustment of the disc, if the disc plough has earlier being used unless some difficulty in the side draft and penetration of the disc observed. However it must change no part is lost.

3 In the earlier para the importance of tilt and disc angle is discussed. The trainee must know and should be able to locate how to make the changes. The manufacturer supply the maintenance and part catalogue which should be read by all the owners and operators.

Harrows

Objectives : At the end of this lesson you shall be able to
- **state the importance of harrow**
- **state the different type of harrows**
- **state the components and constructional details of disc harrow**
- **state the field adjustment of disc harrow**
- **state the field operation of disc harrow**
- **state the maintenance disc harrow**
- **state the working of other six different type arrows.**

Importance of harrows

Harrows is one of the tillage tools, which are used to prepare the land by breaking clods, cutting weeds. Pulversing the soil, converting seeds, and smoothing the surface.

This tool is mainly used for seed bed preparation just before planting.

Type of harrows

1 Disc harrows
2 Drag harrows
 - Single bed harrows
 - Spring bed harrows
3 Blade harrows
4 Guntaka harrows
5 Acme harrow (knife harrow)

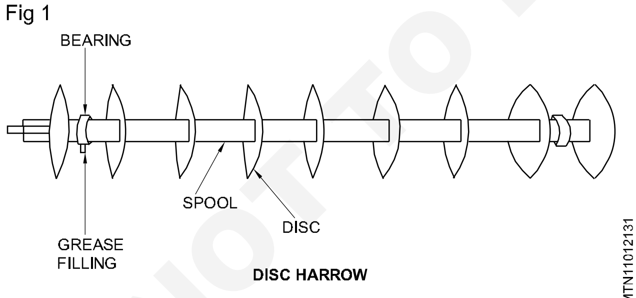
Uses

Harrows are used for primary tillage and light duty harrows are used for secondary tillage - seedbed preparation, summer fallowing, chemical incorporation, weed control, to spread seed and fertilizer to disk after ploughing, to pulverize lumps and to control weeds.

Components and constructional details of disc harrow

The components are indicated in the (Fig 1)

Fig 1



DISC HARROW

Disc blades

The blades of the harrow are concave in shape and have a sharp edge. The diameter and thickness various depending upon the harrow type, size and weight. However in general a thickness of 3 mm to 9 mm and a diameter of 40 cm to 60 cm are common. Blades with notched edge are also available for the areas where heavy crop residue or grass is to be cut and pulverized. The blade spacing varies between 18 cm w 36 cm depending upon the nature of work. For fine finish work the spacing is less. A spool made of cast iron with machined ends is used for spacing.

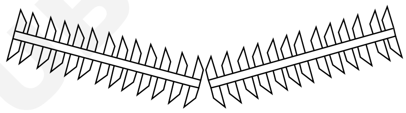
Gang

A group of more than two discs when fitted on a shaft with spacers in between them is called a gang. The shaft can be square or round and is normally known as arbor bolt, one end of the shaft has threads and the other end a large washer. The discs mounted on the shaft are tightened with the help of washers and nuts, making the gang a composite unit in which the disc, shaft spool rotate together.

Arrangement of gangs

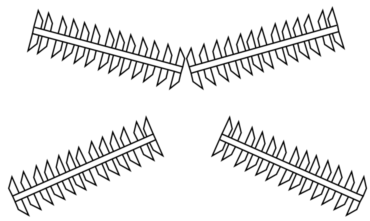
i Single action: Two gangs are placed end to end, which throw soil in opposite directions (Fig 2)

Fig 2



ii Double action (or) tandem: In this type two gang are placed one behind the other. The front gang throwing soil to the right and the rear gang pulls the soil back to the centre. Double action harrows are also known as tandem harrow (Fig 3)

Fig 3

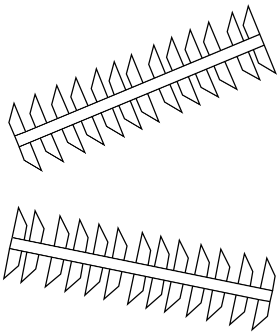


iii Offset : An offset disc harrow has two gang of discs. The concave disc on front gang moves the soil to the right hand side and the rear to the left hand. The land is tilled twice and the fields are nearly leveled after harrowing. The angle of the gang is variable and can be adjusted to suit particularly tilling requirements and soil conditions (Fig 4).

Bearings

The gang is mounted on the frame through bearings housing which carry bearings. These bearings can be either friction type, which remains filled with grease, or antifriction type. All the bearings are subjected O axial thrust caused due to tangling of the shaft. This effect is countered by the edge of the spool, which runs in the ring groove of the bearing housing.

Fig 4



Main frame/spool

The frame is the main body on which gangs are attached through bearing standard. Arrangement to angling the gang and the drawbar are also connected to the main frame.

Disc harrow - Adjustment

a. Disc gang angle O' cuffing angle adjustment

Generally the gang cutting angle varies from degrees from the line perpendicular to the line of single or double action harrow but may be used between the two gangs, in. some offset. Increasing disc gang angle improves penetration, I working in a previously worked field minimum gang must be used. The angle can be increased for penetration in dry soil while it should be reduced plugging in wet soil. Thrash cutting and coverage be increased with the increase in the gang an accordingly the draft also increases proportional the front and the rear gang angles can be change the help of an angle selector, by sliding the gang the desired position, by loosening the clamp by tightening when the desired angle has been obtained. Generally the rear gang angle is kept a little more than the front gang is. While clamping the disc gangs to the frame make sure the rear disc tracks centrally between the marks made by the front discs.

Tightening when the desired angle has been obtained. Generally the rear gang angle is kept a little more than the front gang is. While clamping the disc gangs to the frame make use the rear disc tracks centrally between the marks made by the front discs.

b. Disc harrow leveling: To eliminate uneven penetration and side draft the fore and aft leveling is to be done by means of top link. While the tractor pulls to the right, the rear gang should be lowered a little. When the tractor pulls to the left, the rear gang should be raised. The implement may be leveled side to side by turning the implement leveling lever clockwise or anticlockwise.

c. Soil leveling Disc harrow should leave the soil smooth and free of ridge and valley. If a ridge is left in the centre of a tandem harrow, increase the front gang angle and reduce the rear gang angle.

If a valley or low spot is left in the centre reduce the front gang angle and increase the mar gang angle. Re - level the harrow and increase the speed of travel.

Ridges at the outer ends can be leveled by moving rear gang to pull in more soil or by reducing operating speed. Reducing front gang angle also reduces the amount of soil thrown out.

Furrow filler blades may be added to the outer ends of rear gang to till and level the furrow left by outer blade when operating in loose soil.

d. Offsetting the harrow : The offset harrow can be used directly behind the tractor or can be offset to the right or to the left while working in the orchards etc. To offset, loosen or if necessary remove the clamp bolts and move the harrow along with the attaching channel to the right or left. When the determined amount of offset is obtained, clamp the harrow frame to the attaching channel assembly. The front gang can be offset to the right or left, to a maximum of two feet in relation to the hitch frame. The rear gang may also be moved to the hitch frame. The rear gang may also be moved to the right or left to a maximum of two feet with respect to the front gang, thus giving a maximum of four feet (1.2 m).

e. Scraper adjustment : For conical type blade the gap between scrapers should be 1/8' at the inner point and ¼" at the outer point. For spherical blade, the gap should be ½". The scrapers can be adjusted by loosening the bolts at the scraper's clamp.

f. Depth control : The depth at which the implement is required to work is controlled hydraulically by raising or lowering the control lever on the tractor.

g. Disc harrow penetration: Factors affecting disc harrow penetration are

I Angle of gang

II The weight of the harrow

III Blade diameter Small blades penetrate better, larger blades work deeper in soft soil.

IV Blade sharpness

V The angle of hitch

Disk harrow - field operation

1 Before starting the operation determine the soil and thrash conditions of the field and make the preliminary adjustments accordingly. Final adjustments will be made in the field.

2 Divide the field into land of approximately 25 m width (harrowing in the field is usually done in lands and breaks, to avoid awkward turns in the headland). If necessary, disc the boundary of the field to demarcate the area to be disced. Start the operation in the centre of the first land. Make adjustment, if necessary, in depth and level settings. After the first pass take a left hand turn and start along one side of the field leaving a strip of land equal to the headland in width. Continue the operation on the right side of the first pass. Successive passes in the same manner carry the work further across the field each time, until the uncultivated strip left in the first land disappears. At this point another strip is set off in the second land.

3 While using a trailed type disc harrow, care should be taken to turn the harrow only in the left direction.

4 After finishing operation in all lands, make three passes in the head land.

5 It has been observed than in certain soil conditions, the soil tends to stick to the discs, the proper adjustment of the scrapers and the gang angle not withstanding. This problem is minimized if the discs are having clean and finished surface to begin with. Hence under sticky soil conditions, it is good practice to operate the disc harrow in a sandy soil first to give the discs the necessary, polish after removing any mud sticking to them.

6 If second disking is necessary, working at right angles or diagonally to the first pass improves results.

Disc harrow - Maintenance

Lubricate the bearings and moving parts. Do not over grease as this may accumulate dirt. Check nuts and boils for tightness. Repair or replace damaged or missing parts.

Sharpen or replace worn, racked or broken blades. After use, thoroughly clean all thrash, soil and dirty grease from the harrow. Before storing clean dirty blades and coat with heavy grease or antirust compound.

Working of other six different type harrows

1. Drag harrow

- Drag harrow used to cut branches from the trees for use in leveling the soil in earlier days.
- Presently farmers drags long bamboo pieces with long nails to break the soil crush an stir the surface.

There are two principle of kinds of drag hammers namely

1 Spice tooth harrow

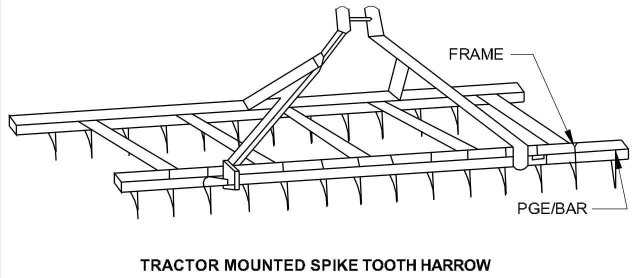
2 Spring type harrow

2. Spike tooth harrow

It is a harrow with peg shaped teeth of diamond cross - section attached to either rectangular (Fig 5) or a triangular frame (Fig.6). The triangular frame is made of wood and is pulled by a pair of animals. The rectangular type spike tooth harrow frame is made of steel and is pulled by tractor. The spike tooth harrow is also known as peg - tooth harrow, bar harrow, drag harrow, section harrow or smoothing harrow. Its main use is to smooth and level the soil directly after ploughing. It is used to break clods, stir the soil, uproot the weeds, level the ground, break the soil crust and cover the seed. It can be used to cultivate corn and cotton and other row crops in early stages of growth. It is of two type rigid and flexible type. Animal - drawn spike tooth harrows are usually of rigid type. The teeth of spike tooth harrows are made of hardened steel. The teeth may be square, triangular or circular in section. It can stir the soil up to the depth of 5 cm.

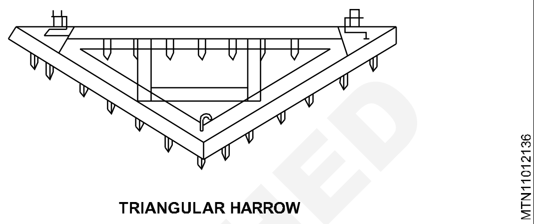
3 Spring tooth harrow: It is a harrow with tough flexible teeth, suitable to work in hard and stony soils. It is fitted with springs, having loops of elliptical shape (Fig 7). It

Fig 5



TRACTOR MOUNTED SPIKE TOOTH HARROW

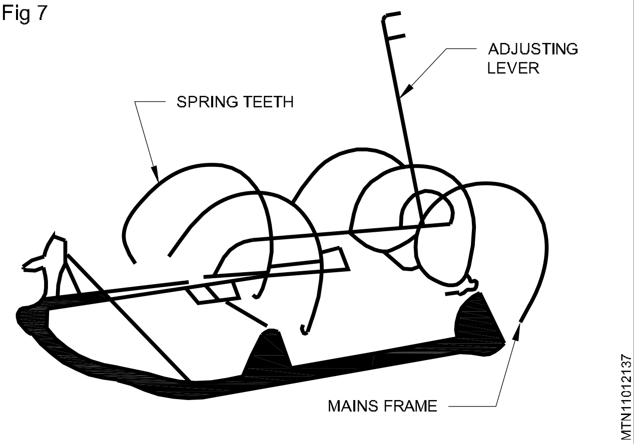
Fig 6



TRIANGULAR HARROW

gives springing action in working conditions. It pulverises soil and helps in killing weeds. It can also be used to loosen previously ploughed soil ahead of grain drill. In this machine, teeth penetrate deeper than spike - tooth harrow and tears out the roots and bring them to surface. This harrow consists of teeth, tooth bars, clamps, frame, clevis, lever and links. The teeth consists of wide, flat, curved, oil - tempered bars of spring steel, one end of which is fastened rigidly to a bar; the other end is pointed to give good penetration. Adjusting angle of teeth by means of levers controls the depth to which teeth will penetrate the soil. The teeth are available with points of various widths and shapes with detachable points for different types of work. Trailing type spring tooth harrows are available in sizes ranging from 2.4 to 11.0 m. The draught of spring - tooth harrow varies from 100 - 200 kg/m width, depending upon the type of work and soil conditions.

Fig 7

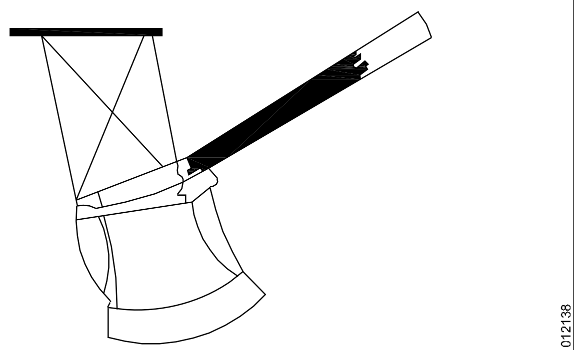


4. Blade harrow : This is also known as bakhar (Fig. 8). It consists of one or more blades attached to beam or frame and used for shallow working in the soil with minimum soil inversion. It is used to prepare seedbed mostly in clay soils. The blade is made of steel and its width varies from 40 to 100 cm. The body of the beam is made of wood.

5. Guntaka harrow: It is and improved type of blade harrow. The functions of Guntaka are same as that of Bakhar.

6. Acme harrow (knife harrow): It is a special type of harrow having curved knives. Front part of knife compacts soil and crushes the clods. It is good for mulching also. The knife is made of high carbon steel. Putting additional weight on the frame may increase depth of penetration.

Fig 8



ANIMAL-DRAWN BLADE HARROW

Description of trailing type of disc harrow

Objective: At the end of this lesson you shall be able to
- **state the purpose/function of disc harrow**
- **describe the various sub-assemblies of the disc harrow**
- **explain the recheck points of the equipments and tractor which are to be hitched.**

Purpose function

1 Primary field operation

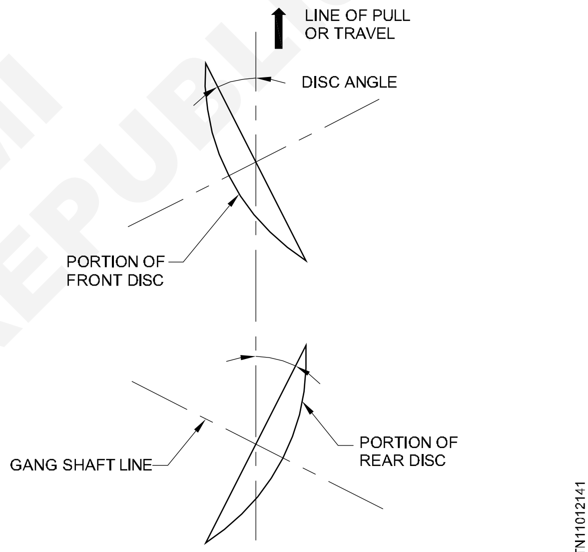
This equipment is used after the mould board plough or disc plough. The later breaks the hard crust of the top soil and hard crust of the top soil and penetrate into depth to cut the soil and dislocate it. This initial workup with the soil is called the primary field operation. The primary tillage operation is characterised by breaking up of the top soil. It is composed of lifting up of rigid soil structure, turn and invert it. These equipments leave the surface of the soil rough and undulated and therefore cannot be regarded as suitable tilth condition for plantation of seeds.

2 Secondary field operation

Therefore the soil still needs subsequent operation to further breaking up of soil to improve the tilth condition of the soil. To effect these subsequent operation a set of equipment is required. The secondary farm equipment are those which are used to break clods, reduce the residues of the previous crop and make the field moderately smooth eliminating undulation and the operation thus carried out is called secondary field operation. This particular equipment is characterised.

- To break down the clods and reduce the trash and weed grass stubble into small pieces and mix it well with the soil.
- To prepare the soft seedbed absence of long root of the previous crops.
- To create soil much for preservation of moisture from subsoil.
- Partially turning the soil upside down with curvature of the disc.
- Its operation also helps the evening of the undulation of the soil surface.
- Because of the angular rolling of disc harrow, the disc over ride the hard hidden obstacle. (Fig 1)

Fig 1



Sub-assemblies

To simplify the study of disc harrow we may divide the details of description as under.

1 The hitching assembly
2 Frame assembly
3 Disc & Disc gang with scraper (Fig 1)
4 Adjusting lever

The hitching assembly (Fig 2)

For all trailing type disc harrow, a most common hitch system adopted is single point. The Fig 2 illustrated the hitching configuration. The hitch bar (3) of the implement is pinned and locked onto the draw bar (6) at the centre when the implement is being transported. At this moment all the discs (1) travel in the straight line in the direction of tractor travel. In the present disc harrow as shown in the figure, there are two gangs (5) having a set of six disc each.

The set of discs throws the soil on the right side due to concavity of the disc facing right side. Whereas the set of discs facing left side throws soil on the left side.

The hitch point on the draw bar is changed when the disc harrow is engaged into the soil. A corresponding fig shows that while the harrow is put to work, the rear gang (5) is subject to change the angle with respect to line of travel. A slight angle will cause the disc to penetrate. In such change, the disc of the front gang will also turn to anticlock-wise direction and the rear will turn to clockwise direction resulting both gangs discs to wedge into the soil and cut the slice of soil As the gangs move with the discs touching the ground, the resistance caused by the disc angle will affect dig into the soil. The earth slice so cut will travel on the disc surface causing pulverization. All these causes and effects finally affect the position of the hitch point to bring centres of resistance of each gang and line of pull and hitch point in a straight line. This will eliminate any side pull on the front wheels of tractor or reduce required penetration of the discs. There are four points on which pull is at work. There is centre of pull of tractor, two disc gang points of resistance against centre of pull of tractor and point of hitch. The only point which could be varied is the point of hitch for effective operation of this type of disc harrow. The point of hitch in align to other points of pull and points of resistance change in the position of the hitch point is determined.

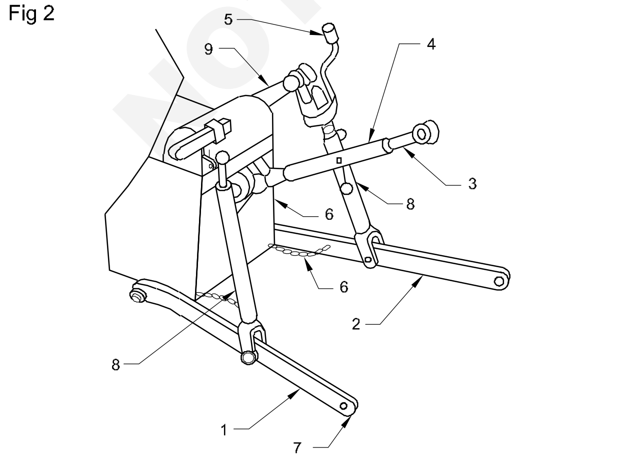
The second point of consideration is to determine the point of hitching and the coverage of harrowing width while the harrow is being operated. (ie hitch the hitch bar at a such point which will prevent overlapping or leaving a strip in harrowed at each pass).

Another point which will influence is selection of hitch point is the use of disc harrow in offset cutting. The harrow operation is also required to cultivate under the orchard trees where height of fruit bearing branches grow low. In such condition, tractor cannot move close to the tree. The harrowing operation is possible only when the harrow is hitched off setted from its normal hitching position.

In all these above conditions the hitch point is determined when the harrow is put to work and varied field conditions.

Three points hitch system (Fig 2)

Fig 2



The figure shows the system of three points. The subject is taken up in lesson - tilted “Hitching”. However for the sake of renewing the subject the following important points are to be kept in mind while this system is adapted for disc harrow.

1 Two points comprise of two lower links viz left and right (1 & 2) which hold the two hitching pins of the mounted type harrow.

2 One point is located with the adjustable screw type top link (3) which hold the third point located with the upper portion of the harrow.

3 Mounted type disc harrow when used with three point hitch system it should be ensured that the disc harrow is level laterally and horizontally so that all the discs operated at the uniform depth.

4 Ensure that all the points comprising hitch are intact and secured by linchpins.

5 Side chains are intact to their position. A lapse in this hitch system can result severely in terms of damage of disc harrow edges and tire treads.

Frame Assembly: Frame consists of the facility for hitching the implement with tractor, such as three points or single points draw bar, brackets for fitting of the gang shaft of the disc assembly also provision for fastening the disc scrapers. In certain disc harrow there is a provision to place additional weight to dig disc into the moderately hard soil. The frame is constructed with the channel or heavy duty angle iron to make it strong.

Disc gang with scraper: This is an important working assembly which is directly engaged to the soil. The disc is the main part of the harrow which is round in shape having concavity generally denoted as concave disc. The concav-ity helps in penetration of the sharp edge of the harrow while rolling on the ground. Suitable angle is given to the disc’s to resist the rolling in the direction of the tractor, resulting in penetration of the edge of the disc. Angle given to the disc with the respect to the direction of the movement is called the Disc angle. The disc are sharpened by a fixer or a grinder as shown in the Fig. to maintain the disc sharp.

There are other parts like arbor bolt which passes through the central square hole of the disc and the spool providing the spacing between two disc. The spool are made of cast iron having square hole through.

Spool are also of two types.

– Spacer spool which are used for spacing.

– Bearing spool which are splitted (two halfs) to accommodate the bush bearing.

With the latest development to overcome the difficulties in maintenance, ball bearing are introduced which are anti-friction bearing properly sealed. When more than one disc is assembled on the single shaft is called gang. If there are more than one gang, they are installed on a frame as front or rear gang. The gang are fitted in such a way that if the front gang throws the soil to right side then the rear gang throws the soil to left side resulting complete pulvarisation of soil. Separate scrapers are fastened with frame to scrape the sucking soil from the inner surface of the disc. If this soil is not recommended while rolling, the penetration of the disc into the soil will be affected.

Adjusting lever: The levers are used to provide disc gang angle with the help of suitable adjusting fastening so that the front unit of the disc angle with respect to the forward movement of the tractor. This facilitate gang to gang angle as shown in the Fig. As stated above the front gang throws the soil on the right side, the rear one will counter act to equalise the pressure on the disc. This arrangement prevents the steering pull on either side.

Pre-check of the equipment and tractor which are to be hitched

This is uncommon to put in the theoretical portion of this subject which is meant for practical exercises. The main idea to putting this in theory is to make the trainees aware of importance regarding these points. It is like training upto make us ready go to work.

– Check all the nuts and bolts, pins and brakes for their serviceability, repairability and replaceability.

– Lift up the gang with the help of crow bar and revolve the gang to see the free rotation.

– Check all the nuts and bolts, pins and brakes for their serviceability, repairability and replaceability.

– Lift up the gang with the help of crow bar and revolve the gang to see the free rotation.

– Check the tightness of the individual disc.

– Check for the scraper (fitted to the frame) are positioned with the proper spacing between the inner disc surface and the scraper.

– Check up the sharpness of the disc as well as damage.

– Refer the disc harrow manual for complete maintenance and keep the record in log book.

– Check all the three point linkage assembly as well as draw bar assembly provided with linchpin or lock pin.

– Check up the air pressure in both front and rear wheel.

– Check up the hydraulic control lever for the effective operation.

– Before transporting the harrow, check that the disc gang are in the normal position.

Hitching - Precautions

Objectives: At the end of this lesson you shall be able to
- **use of hydraulic lift in tractor**
- **explain the precaution to be observed while hitching**
- **explain the de-hitching**
- **state the danger in overloading and incorrect hitching of the implement.**

Use of hydraulic lift in tractor: In a tractor having an implement supporting the hitch at different elevations, a source of fluid under pressure, a control valve for admitting fluid to or releasing fluid from the cylinder, draft controlling operation of the control valve responsive to the implement draft, position controlling operation of the valve responsive to height of the implement supporting hitch, the position control means including a servo lever operated responsive to height of the hitch, the draft control means including a second servo lever operated responsive to height of the hitch, the draft control means including a second servo levers each being mounted adjacent the control valve, a lever mounted for rotator about a fixed centre and supporting the pivot for movement in a direction to cause the lever to engage and operate the control valve. Whereby the servo levers are supported and either servo lever may operate the valve, the implement draft control means serving to lift the hitch above the level established by the position control means as required to maintain preselected implement draft but being inoperative to lower the hitch below the level established by the position control means.

In a tractor as claimed in claim the other ends of the servo levers each being positioned by a manually adjusted quadrant lever through a linkage making sliding contact with said other ends of the servo levers.

In a tractor as claimed in claim 2, the draft control servo lever having a one way connection with the linkage associated with its quadrant lever to permit said servo lever to become disengaged from said linkage, where by the hitch height is limited by the position control mechanism.

A tractor hydraulic lift control system is provided with a manually adjusted quadrant lever for determining the draft at which the tractor is to operate and a second manually adjusted quadrant lever for determining the implement height. The draft control may raise the implement above the height determined by the position control but may not lower. It below the height determined by position control. Precaution to be observed while hitching

The procedure to be observed in connection with the hitching is aimed to avoid accidents which are generally encountered while working in the field.

1 The lock pin used to the single hitch point is generally lost or misplaced. There is a tendency to use common bolts with the nut which is not recommended. Due to the mud which became loose by frequent jerk on the hitch point and lost in the field. Rendering the bolts to slip off the hitch point. This create a considerable inconvenience for further operation. Always use the proper hitch pin proved with linchpin.

2 It is not advisable to employ the disc harrow in the field without being properly greased.

3 In three points linkage hitching up and down movement of the screw to be ensured.

4 Always keep tractor and implements in time before they are put to work. Keep all the field tools handy to meet the requirement in the field operation.

5 The height of the hitch point of the tractor should be as low as possible to avoid over turn of the tractor.

6 Never use higher speed above recommended by manufacturer.

7 Never neglect proper uniform or outfit including shoes to avoid the accident of negligence.

De-hitching: There is a general tendency to disconnect the harrow on the side of the field or in the field. In such practice the implement gets neglected. It is always advisable to bring the disc harrow to its place where it is kept to give the attention for its maintenance. Keep hitch pin and the linchpin on the proper place to avoid searching. If the disc harrow is smeared with soil, it can be washed and checked and placed.

Danger in overloading and incorrect hitching of the implements

It is pointed in the earlier para that the hitch point of the tractor should be lowered to the extent that no overturning takes place while toeing the harrow. One of the reason attributing to the overturning of the tractor is over loading. Illustrates the danger. The operation is to insure that the tractor toeing the load behind is not exceeding while operating in the field. Fatal accident are experienced if operator is not knowledgeable. It is quite often that inspite of all precaution tendency of the tractor for overturning due to one of the reason is overloading or high point hitching. Another vital reason of over loading takes place when the implement in stuck with an obstacle without the knowledge of the operation. In such cases the operator should declutch reverse and rise the implement then locate the obstacle.

Cultivators

Objectives: At the end of this lesson you shall be able to
- **state the uses of cultivators**
- **state the different types of cultivators**
- **state the constructional details of cultivator**
- **state the maintenance of cultivators cultivator.**

It is an implement consisting of a number of tynes attached to a frame which is used for tilling the soil between standing row crops.

Uses

- To control weeds so that they do not compete with crops for water and nutrients.
- To achieve rapid infiltration of rainfall and adequate aeration.
- Breaking the clods
- Creating a mulch on the surface of the field, to conserve the moisture
- Sometimes used for sowing operation when provided with sowing attachments.
- Interculturing, especially when the plants are germinated. The row to row distance may be varied according to the requirement.
- to prevent surface evaporation loss.

Types of cultivators

Cultivators are classified according to use of source of power

1 hand operated cultivators
2 power driven cultivators

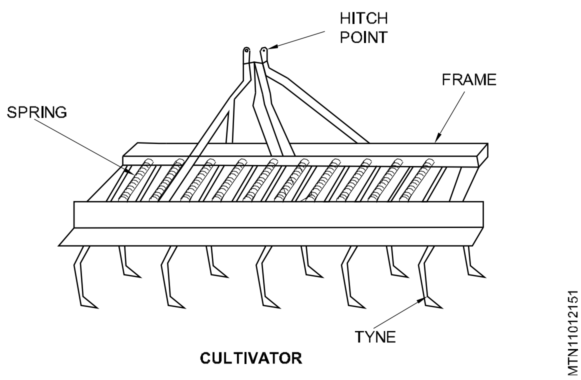
According to the type of working parts they are classified as

1 Shovel cultivators
2 Disk cultivators
3 Surface cultivators

Components and constructional details of a cultivator

The different parts of the cultivator are given in (Fig 1)

Fig 1



Frame

Frame is made of steel flat usually of size 40 x 10 mm. There is vertical hitch or clevis arrangement with the help of which animals of varying sizes can be hitched to the cultivator.

Hitch point

Connected with three point linkage of tractor.

Tyne

The tyne is made of mild steel flat having carbon content ranging from 0.15 to 0.25%. A flat of usually 40 x 6 mm size is used for tynes.

Shovel

Shovel is usually of reversible type. The width of the shovel varies between 50 and 75 mm and is made of steel having carbon content ranging from 0.5 and 0.6%. The thickness of the shovel ranges between 3.15 to 4.50 mm. The cutting angle varies in the range of 15° to 20°. The shovels are fixed to the tynes with suitable bolts.

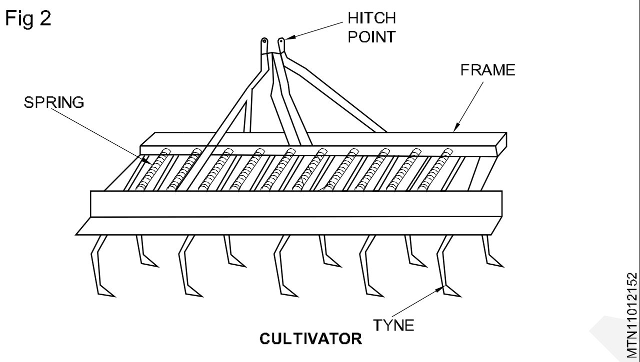
Spring

The springs operate, when the points strike roots or large stones by allowing the tynes to ride over the obstruction, thus preventing damage. On passing over the obstruction, the tynes are automatically reset and work continues interruption.

Cultivator with spring loaded tynes

A tyne hinged to the frame and loaded with a spring so that is swings back when an obstacle is encountered is called spring loaded tyne (Fig 2)

Fig 2

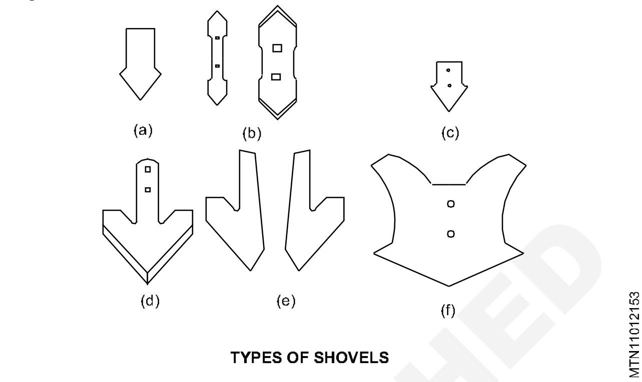


Each of the tyne of this type of cultivator is provided with two heavy coil springs, pretensioned to ensure minimum movement except when an obstacle is encountered.

The tynes are made of high carbon steel and are held in proper alignment on the main frame members. A pair of gauge wheels is provided on the cultivator for controlling the depth of operations. The cultivator may be fitted with 7, 9, 11, 13 tynes or more depending upon the requirements.

For actual cutting the soil, different types of shovels and sweeps are used. A few important shovel and sweeps are (Fig 3)

Fig 3



a Single point shovel

b Double point shovel

c Spear head shovel

d Sweep

e Half sweep

f Furrower

Cultivator

Maintenance

Check shovel point and sharpen or renew. Adjust shovels for uniform depth of penetration. Check for general condition for frame. Oil and adjust tension of spring trips. Replace badly worn wheel bearings. Remove endplay from wheels with the take - up washers provided. Adjust wheels to toe - in slightly. Lubricate wheel bearings.

Thresher

Objectives: At the end of this lesson you shall be able to
- **state the function of thresher**
- **state the types of thresher cylinders**
- **state the cleaning system of thresher**
- **state the threshing concave adjustment**
- **describe the precaution while handling threshers in field**
- **explain stop/brake light circuit**
- **state the care and maintenance of threshers.**

Function of threshing system

This consists of a stone trap, rear beater, cylinder and concave. The crop material, from the header assembly passes through the rotating cylinder and stationary concave where it is threshed and the bulk of grain is removed.

Cylinder

Three types of cylinders are available

1 Spike tooth

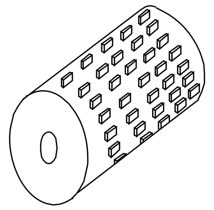
2 Rasp bar, or

3 Angle bar

1. Spike tooth cylinder (Fig 1)

The spike tooth is mostly used for rice or soya bean etc. whereas a rasp bar cylinder is suitable for most of the grains. In spike tooth cylinder many steel teeth are bolted or welded to the metal bars. The concave also has teeth

Fig 1



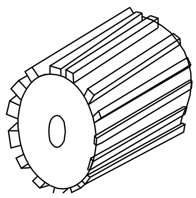
SPIKE TOOTH CYLINDER

mounted on bars. The combination of spike teeth of cylinder and concave tear and shred the material and thus threshing takes place.

2. Rasp bar cylinder (Fig 2)

The rasp bar type cylinder consists of a number of corrugated steel bars attached to the steel bars. The concave is a grate consisting of parallel steel bars held together by curved sidebars. The direction of rasp of corrugation of one bar is opposite to the other. The corrugations of the rasp of the rasp bar create rubbing action on the crop.

Fig 2

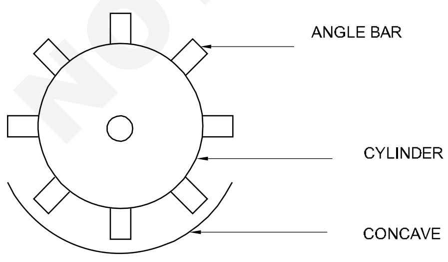


RASP/BAR CYLINDER

3. Angle bar cylinder (Fig 3)

Depending upon the crop, the cylinder can be run at a variable speed between 600 and 1400 rpm. High speeds should be preferred for the crops that are difficult to be threshed, for e.g. damp straw where as for easy to thresh and sensitive crops the low speed should be used. The variable speed is possible with the help of variable pulleys. In addition to the provision of cylinder speed, the clearance between cylinder and concave is also adjustable and depending upon the grain size & moisture content, a well combination of cylinder speed and concave clearance gives satisfactory results.

Fig 3

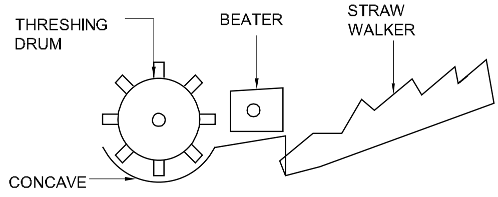


ANGLE BAR CYLINDER

Rear beater (Fig 4)

As shown in Fig 4, a beater is an assembly, which diverts the straw coming from cylinder towards straw walker.

Fig 4

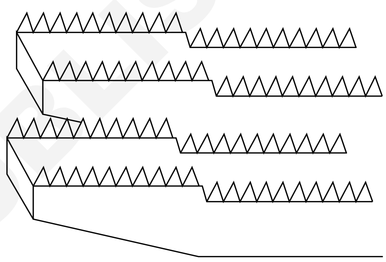


REAR BEATER

Straw walker (Fig 5)

The straw assembly consists of four individual walkers, is mounted on a crankshaft at 90o or 180oapart and thus oscillate to and fro. The box like structures are in several steps and is inclined towards the rear. Serrated strips with the teeth pointing in travel direction are attached to the walkers to improve the distributing of the threshed material over the whole walker area when combine is working on slopes. All the walkers have wide meshed sieve which allow loose grain to fall down on the return pan, which ultimately slides back to cleaning sieves.

Fig 5

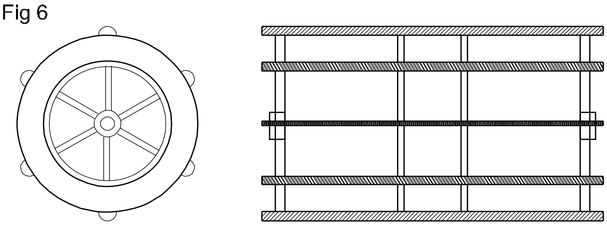


STRAW WALKER

Threshing drum

The majority of modern combine-harvesters are beater bar threshers. The drum is provided with beater bars. The drums are open and consists of three spoked wheels, mounted on a shaft and provided with flat laths extending over the whole width of the cylinder and carrying 6 to 8 beater bars which are screwed in place (Fig 6).

Fig 6

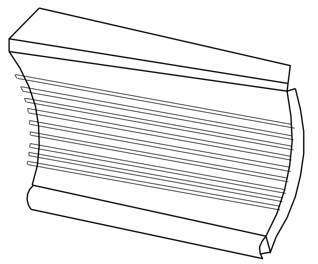


THRESHING DRUM

Concave (Fig 7)

The concave, which also consists of steel bars, is arranged below the drum (Fig 7). A great number of steel bars are placed side-by-side and fastened in such a way that a semi-circle is formed. A gap is left between any two bars, allowing the kernels to pass through. In the majority of cases, the concave consists of 12 and more steel bars, which are attached by means of wire, forming unit.

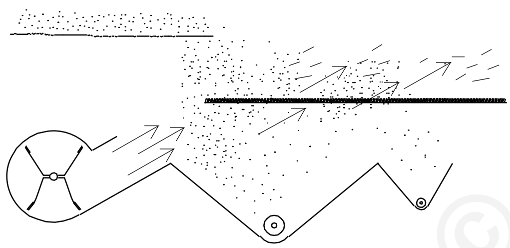
Fig 7



C. Cleaning system (Fig 8)

Two sieves, one over another are arranged below straw walkers (Fig 1&3). The upper sieve is an extension of grain pan and it gets grain along with thrash from pan. The upper sieve has an adjustable aperture, which can be increased or decreased. The lower sieve, which is known, as grain sieve has holes of the grain size and is not adjustable. Both the sieves are shaking rearward. A blower supplies air current at a high velocity, which is also adjustable. The grain and thrash falling on upper sieve gets separated. The bigger size of straw/chaff etc. is thrown away whereas grain with small pieces of thrash moves over the grain sieve. The grain falling below is taken to grain auger and elevator.

Fig 8

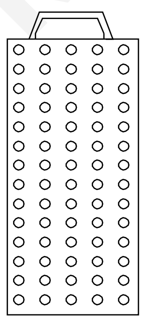


CLEANING SECTION

Sieve (Fig 9)

The cleaning unit usually consists of an upper and a lower sieve (Fig 9). A fan is arranged under each sieve. The fan blows an adjustable current of air into the space below the sieves; the air velocity should be high enough to carry the mixture to be cleaned on the sieves. At the same time, the airflow separates chaff and other light particles from grain, carrying off the light particles and chaff. The grain is allowed to drop through the sieve and, seen in travel direction, slides towards the end of the cleaning section a grain auger.

Fig 9

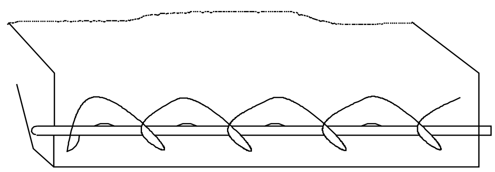


SIEVE

Cross grain auger (Fig 10)

The grain auger transfers the grain to an elevator, provided with buckets or rubber flaps, which carries the grain into the grain tank of the combine-harvester or to a sacking mechanism (Fig 10).

Fig 10



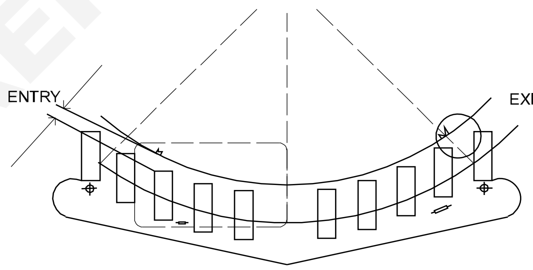
CROSS GRAIN AUGER

Threshing concave adjustment

The concave is suspended on a cradle with the help of a tubular shaft. This tubular shaft is moved with the help of a suitable leverage through basket quick adjusting handle. When the lever is pressed down, the concave is lifted up and brought close to the drum, this is known as quick adjustment. Suspension levers on both sides of basket are adjustable and the clearance between the rasp bars and basket is adjusted through these.

In the front clearance of 14 to 15 mm is provided and at the back end clearance of 7 mm is provided as shown in Fig 11. This clearance should be kept equal on both sides in the front as well as on both sides at rear.

Fig 11



THRESHING CONCAVE ADJUSTMENT

Concave fine adjustment

Apart from quick adjustment which is put to use while starting the machine, or when the drum gets choked, the concave is lowered down giving enough room to the crop to clear out. There is a fine adjustment also provided to suit moisture-maturity of crop and type of crop. This is accomplished by bringing the basket close or apart from the threshing drum by the hand wheel.

Fine adjustment and setting

For different crops having different rates of maturity and moisture content, the clearance between basket and threshing drum can also be adjusted; over and above drum speed can be varied although it can not be specified as setting depends upon the following factors:

1 Travelling speed

2 Maturity of crop

3 Condition of crop

4 Moisture content of crop

5 Type of soil

6 Density of crop

7 Type of fields, i.e., big or small

It should be noted that while increasing threshing drum speed, the gap between concave and drum has to be reduced and while reducing the speed, gap increases.

Cylinder speed need to be higher and concave clearance lower in the morning or in the night time when the moisture content is higher or when the crop is slightly wet.

Concave and cylinder clearance and drum speed are very important factors for better threshing. Although losses due to cylinder are lower when checked but the basket clearance and cylinder speed has direct influence on rack and shoe losses. Poor adjustment in machine will result into:

1 Less threshing action; un-threshed heads

2 Too much threshing action:

   a) Excessive chewing of straw

   b) Overloading of sieves

   c) Excessive trailing

   d) Overloading of ear elevator.

Never examine or adjust a cylinder and concave when the power unit is running unless there are special instructions for doing this.

The concaves assist the cylinder in producing the rubbing action. Thus when the clearance between the concave and cylinder is decreased the severity of this action is increased. The clearance of the angle bar concave can be measured by means of a scale, bolt, measuring block, or a stick of hardwood accurately shaped to form a thickness gauge. It is good practice to measure the clearance at each end and at the centre of cylinder. The range of concave clearance given in the instruction book is the operators guide.

There are three essential things to consider when adjusting the sieve in the cleaning unit, namely, the size and shape of the sieve, the air blast and the motion. The cleaning unit requires perhaps closer attention on the part of the operator than any other and so should be studied carefully.

The fundamental aim should be to keep the air blast from the fan striking all parts of the cleaning mechanism with sufficient force to cause the refuse to become alive and more or less float across the chaffer and the shoe sieve. The general recommendation is to use as much wind as possible without blowing grain out onto the ground.

Besides this care should also be taken that regular and periodical cleaning the lubrication is being maintained. Due care should be given to the parts to be replaced which may otherwise spoil other attached parts.

While handling threshers

Threshers

Thresher is one of the dangerous machines, and accidents of hand and finger cutting occur sometimes in the operation of thresher due to intoxication, fatigue or carelessness of the operator. Do not remove guards and other safety device.

Do not operate the thresher without proper information. Use trained and skilled labour for feeding of crop. Do not fed ear heads by hand, use pushing device. Do not wear loose clothes, bangles, watch, etc. While working. Do not use intoxicants like liquor, opium, etc. While working. Do not smoke or light fire near threshing yard and thresher. Do not stand on thresher while operating or transporting. Do not working while tired. Do not make adjustments when the thresher is working. There should be proper lighting arrangement. The tractor silencer should be in vertical position. Do not keep crop within 7 meters radius from the tractor; always keep ready a fire extinguisher. Take due care to keep the hands at a safe distance away from any moving parts.

Type of tillage and their uses

Objectives : At the end of this lesson you shall be able to
- **state the importance of tillage equipments**
- **state the type of tillage and their uses.**

Importance of tillage and uses

Tillage is a basic operation in farming

Tillage equipment is used,

- to create a favourable condition for seed placement and plant growth.
- to obtain a seed bed of good tilth.
- to destroy the weeds and prevent their growth
- for free air circulation
- to retain moisture from rain/atmosphere
- to prevent erosion by wind.

Types of tillage and its use

Tillage operation are grouped according to the equipment used.

1 primary tillage

2 secondary tillage

Primary tillage

Heavy implements like ploughs and harrow ploughs are used for tillage operation. Primary tillage is done for good seed bed preparation prior to lighter operation like harrowing and leveling.

Secondary tillage

Harrows, cultivators, swepers, tillers etc are wood for tillage after primary tillage. This is used for lighter operations performed on the soils, before and after seed placement.

Mould board plough

Objectives: At the end of this lesson you should be able to.
- **state the uses of mould board plough**
- **state the constructional details and components of mould board plough**
- **state the procedure for field adjustment of mould board plough**
- **state the field operation of mould board plough**
- **state the maintenance of mould board plough.**

Uses of mould board plough

Ploughs are used for primary tillage operations.

The mould board plough looses the furrow slice, inverts the furrow slice with more or less pulverisation

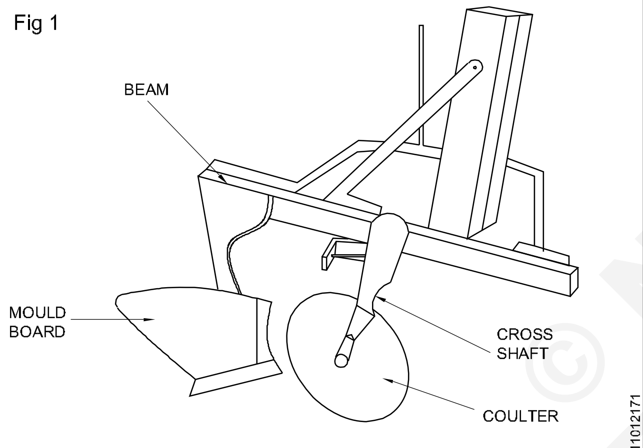
It cuts trash and buries it completely.

It is also used for turning green manure crop for decaying under the soil, which adds humus to the soil.

Constructional details and components of mould board plough

The main parts of mould board plough are given in (Fig 1)

Fig 1



MOULD BOARD PLOUGH

- Plough bottom

  (plough bottom includes land slide, mould board and share)
- Plough accessories

The plough accessories include
- Adjusting coulters, jointer
- Plough frame and beam
- Gauge wheel
- Lifting mechanism
- Plough hitch
- Levelling and depth adjusting mechanism
- Furrow opener

Plough bottom

Plough bottom is the basic unit of plough. The three main parts are landside, mould board and share which are rigidly attached to the frog.

The plough bottom is a three sided edge with the landside and horizontal plane of the share's cutting edge as flat sides and top of the share and mould board together acting as a curved side. The primary functions of the plough bottoms are to invert the furrow slice to cover thrashes. The size of plough bottom is the width if furrow it is designed to cut.

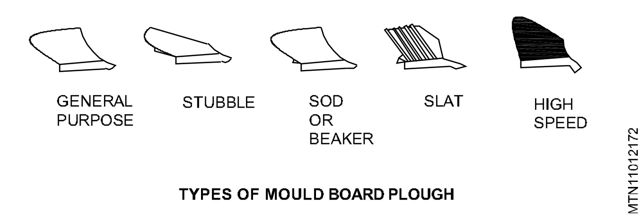
Land side: It is a long flat metal piece, which absorbs the side forces when the furrow is turned. It slides along the face of the furrow wall. It also helps to steady the plough while it is being operated. The material used in making land side is cast iron, solid steel and soft centre steel. A small metal piece is fitted at the rear of the land side, is known as heel.

Mould board: The mould board is bolted to the side of the frog just above the share. It turns the furrow slice on its edge. It may be made up of solid steel, soft centre steel or chilled cast iron. Solid steel and soft centre steel are the best under most conditions owing to the facts that this material scours better. Solid steel is better where scouring is not a problem. Chilled cast iron is better for sandy, gravely soils.

The cutting edge of mould board is known as shin. Detachable shines are used for stony and gravel soils where wear is excessive.

On some mould board an extension is provided to turn the soil over more gradually and completely. Mould boards can be classified as shown in Fig 2.

Fig 2



TYPES OF MOULD BOARD PLOUGH

General purpose (Fig 2): Works well in ordinary conditions. Suitable for clay and stiff sod soil, old ground.

Black land : Scours more easily in black lands than general purpose. It has a relatively small mould board area. Also suitable for "Gumbo soils".

Sod or breaker (Fig 2): A sod bottom has a long, low mould board with a gradual twist (spiral) that completely inverts the furrow slice with a minimum of break - up, thus covering vegetative matter thoroughly.

High speed mould board (Fig 2): They are specially designed generally purpose bottoms for ploughing efficiency at high speed.

Share: Share is the business end of the plough bottom, it cuts the underside of the furrow slice away from the land.

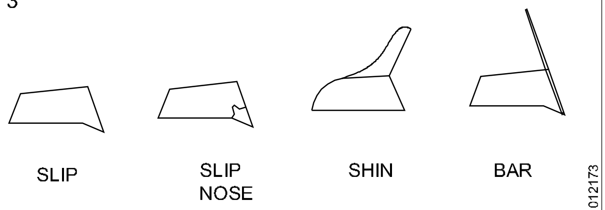
It is bolted to frog. The main parts of a share are point of share (which enters first into the soil and also supports plough bottom). Throat or cutting edge of share (which cuts the furrow slice) from soil body. Wing of share (which is the outside corner of cutting edge) and gunnels of share (which supports the plough bottom against furrow wall). (Fig 3)

Types of share (Fig 3)

Material for share

Cast iron : Cast iron shares are used in cheap ploughs as they are easily broken.

Fig 3



TYPES OF SHARE

Chilled cast iron : It does not wear rapidly. It is especially adapted to sandy and strong soils but works well in clay or loam soil.

Soft centre steel : It is used on steel ploughs that do not scour well. A plough scours well when the soil is not sticky for the surface, takes good finish and consequently will scour where other metals do not.

Solid steel : It is used where scouring is not a problem. This share is tough and resistant to shock but not resistant to abrasive material. It is also called crucible steel. It is fairly high carbon steel, which is forged into shape.

Frog : Frog is that part of plough which joints the mould board, land side and share together. The materials used in making frog are mild steel and cast iron.

Plough accessories

All the parts other than the plough bottom can be considered as accessories. Included in the list are as follows.

1 **Frame and beam:** The plough beams usually provide the main part of the frame or tractor plough. Extra frames are provided to support the wheel axles and lift mechanism. Most plough beams are curved upward and forward and then downward to the hitch point for proper alignment.

2 **Cross shaft** : The steel shaft fitted at the front at right angles to the beam is known as cross alignment.

3 **Coulter** : Coulter serves to

   a) Reduce draft of plough

   b) Avoid the share

   c) Cut the trash over the surface off the field for better coverage by the furrow slice.

   d) Clean the furrow wall and width slightly

   Mostly used coulters are.

   a) Rolling coulters (disc type)

   b) Sliding coulters (knife type)

Jointer is a miniature plough attached with coulter. It shapes like the plough bottom. It prevents weed to stick with share and also reduces draft by cutting top layer of hard soil.

4 **Lifting Mechanism**

5 **Plough hitch**

6 **Levelling and depth adjusting mechanism**

7 **Farrow opener**

8 **Wheel** : These are attached at the end of beam to control depth of ploughing. Some ploughs have and adjustment for lead of furrow wheel away from the furrow wall to adjust pressure against the land side.

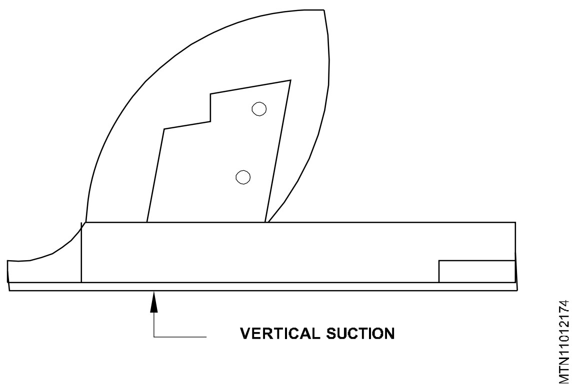
Field adjustment of mould board plough

These are two main factors which influence the ploughing in soil.

i **Vertical or down suction**

This is the bend downward of the point of share to make the plough penetrate the soil to the proper depth when the plough is pulled forward. The amount of suction shall vary from 1/8 to 3/16 inch depending on the style of plough and the soil it will make to work in. This suction can be measured by placing a straight edge on the bottom of the plough extending from the heel of the bottom of land side to the point of share, then measuring vertically and the greatest clearance from the straight edge to the plough bottom (Fig 4).

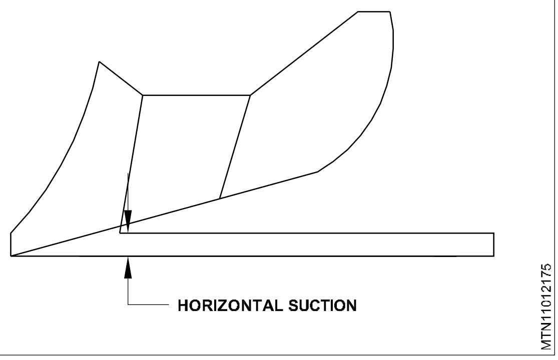
Fig 4



ii **Horizontal or land suction**

Horizontal suction is the amount the point of share is bend off line with the land side. The object of the suction is to make the plough take the proper amount of furrow width. Horizontal suction is measured by playing a straight edge on the side of the plough extending from the heel of the landside to the point of share, then measuring horizontally the greatest distance from the straight edge to the plough bottom. The amount is usually about 3/16 inch (Fig 5).

Fig 5

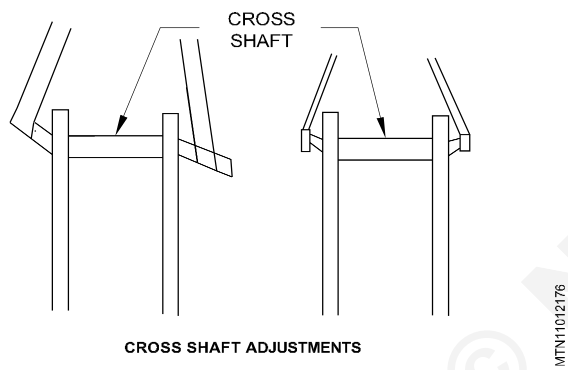


Plough setting - step by step sequence

Cross shaft

Have the centre of the cross shaft directly beneath the top link attachment point on the plough. The cranked end of the cross shaft should be vertical at this stage. Giving variations in the cranked ends the width of cut can be vertical at this stage. Giving variations in the cranked ends the width of cut can be changed slightly (Fig 6).

Fig 6

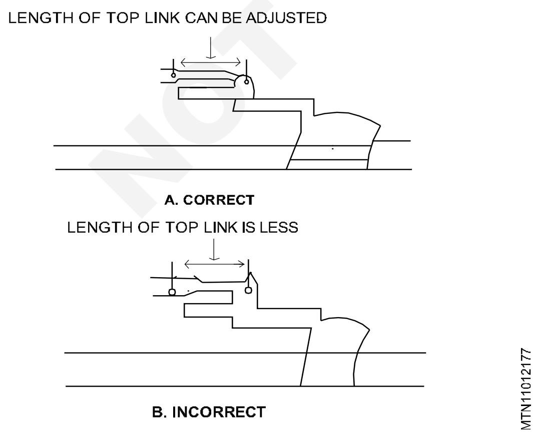


CROSS SHAFT ADJUSTMENTS

ii Top link setting

Set the top link to its standard length. By shortening or lengthening the length of the top link the pitch of the plough can be adjusted if the front plough bottom goes deeper than the rear, the top link should be lengthened. Whereas shorten the top link if the rear bottom penetrates more than the front one. Fix the length of the top link when each and every bottom reaches upto uniform depth (Fig.7).

Fig 7



iii Lower link setting

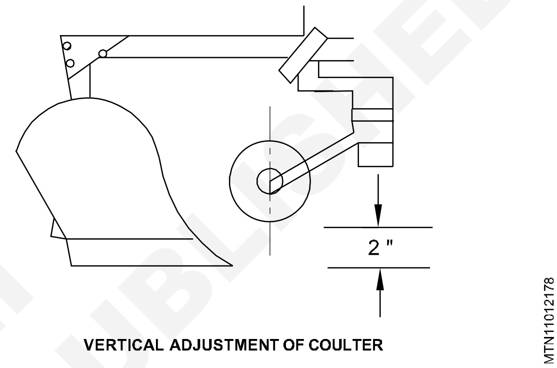
Use levelling lever to get plough frame parallel to ground. This must be judged from the tractor seat during work. While marking the headlines, the operator should make the use of this leveling lever.

iv Coulter (Fig 8, 9, 10)

Coulter settings are most important. It is almost impossible and certainly tedious to give correct coulter settings for all ploughs in all conditions because it does not have any certain procedure even though vertical and lateral adjustments are carried out on a plough.

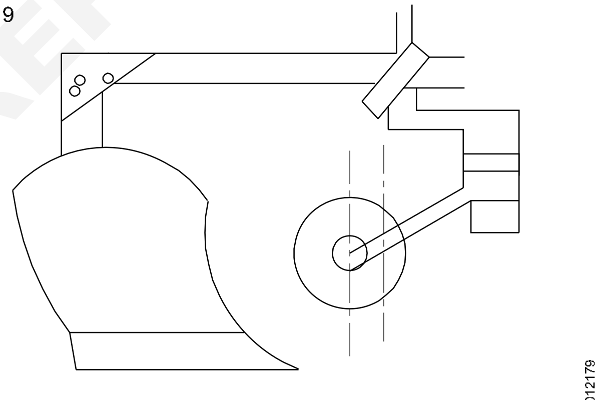
In general the coulter should be set about half the depth of ploughing. The best rule is to put the plough toe work and set the rear coulter first to give a clean cut furrow wall and match the remaining coulters to it. Have coulters really sharp and just deep enough to do the work. If set too deep, a disc coulter will act as a wheel and carry part of the plough weight. This must be avoided.

Fig 8



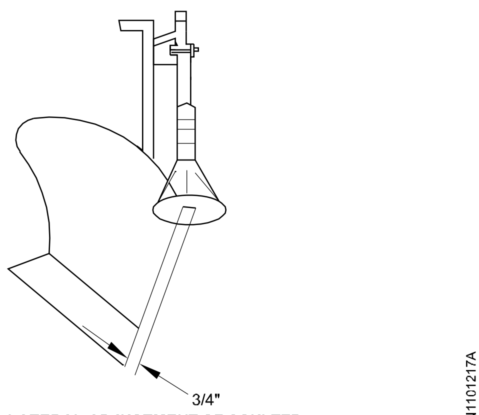
VERTICAL ADJUSTMENT OF COULTER

Fig 9



COULTER CAN BE SHIFTED BEHIND FOR HARD SOIL

Fig 10



LATERAL ADJUSTMENT OF COULTER

v Jointer

After adjusting the coulter, adjust the jointer blade to run on an average of 2" deep. Adjust the jointer point close to the coulter blade and see that the coulter turns freely and does not touch the jointer points.

Set the jointer deep enough so that the whole surface of its miniature mould board will be scoured by the turning soil. If the soil over flows this miniature moulds board, the jointer is too deep.

Set the jointer points slightly to the landside of the plough point, usually about ½".

Regulate the pitch or angle at which the jointer meets the soil so that the jointer mould board will scour well.

vi Depth of work

Set the plough to work at the depth desired. Do not go too deep for type of width of mould board.

vii Tractor and plough alignment

The aim here is to achieve the most favorable position of tractor and plough in order to reduce side draft to the minimum.

viii Final top link setting

Adjust the length of the top link to get all bases working at equal depth. Always remember to have correct tyre pressure to suit conditions. Whenever additional weight for traction is necessary, add weights to the plough before adding to the tractor.

ix Adjusting land - side clearance

Set the furrow wheel to prevent the landside from pressing against the furrow wall. When the rear furrow wheel properly angled into the corner of furrow, a little space approximately is maintained between the land side and furrow wall.

x Adjustment of furrow wheel and heel clearance

Set the furrow wheel to run straight in the corner and deep enough so that the landside heel is off the bottom of the furrow. The heel of the rear plough bottom (with long landside and heel casting) should run lightly on bottom of furrow and should not carry the full downward pressure from the rear end of the plough and in such cases draft is increased through sliding friction and the plough does poor job because of lack of proper down suction. The heel of the plough can be raised or lowered by means of set screw in rear axle control arm. To make an adjustment, loose locknut on set screw and loosen bolt in rear axle control arm, turn set screw to right to raise the heel of the set screw and loosen bolt in rear axle control arm, turn set screw to right to raise the heel of the plough or to the left to lower it.

The wheel should be set so that the heel of the rear bottom will run about ¼ to 3/8 inches away from the furrow wheel. When the furrow wheel is set at the proper angle, the landside will not be forced against the furrow wheel which causes excessive draft on the plough.

To adjust loosen locknut on rear wheel control or turn real wheel stop to the right, move heel of the plough bottom closer to the furrow wall or to the left to move away from the furrow.

Field operation of Mould board plough

Before starting the operation it is necessary to be familiar with the qualities of good ploughing

i Each furrow must be perfectly straight from end to end.

ii The soil must be pulverized thoroughly from top to bottom of furrow.

iii The outline of the furrows must be in a point without break or depression.

iv All back furrows must be slightly raised and all trash completely covered.

v Furrows must be thoroughly uniform with one another.

vi Dead furrows should be as less as possible.

Remember good ploughing makes field leveled and moreover conserves the soil in better way. The sequence of operations in ploughing a field "in - lands" is:

1 Marking out

Marking with a shallow furrow the limits of the head lands and side lands and where the ridge to be. It is a good practice to use "marking pegs" for this purpose. The head land furrow should be about 3" to 4" deep for normal ploughing but for hard soil the furrow should be ploughed deeper. Head land furrows should be turned into the field to be ploughing. A recommended width of the head land is about 6 metres. Whenever possible plough the field along the longest and straightest side. This will give the longest length of the furrow, consequently reduction in area and the no. of turns as well.

a Marking of the ridges: The process of opening a field ploughing the first furrow to form the ridge round which the main ploughing will be done.

b Ploughing out the land: The sequence followed in working from one ridge to another so as to reduce time lost to the minimum ploughing a field by gathering or casting along is uneconomical. A method has to be used which ensures that the tractor and plough never run idle for more than half a land with along the head land and time awkward turns is kept to minimum.

c Finishing : Making the final runs which form the operation furrows and close up of the work.

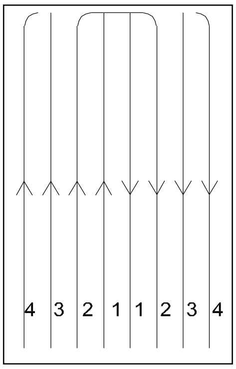
d Ploughing headland & side land: Completing the field by ploughing continuously round the main ploughing. With mounted ploughs, the head land corners can be ploughed neatly.

Methods of ploughing

Gathering (Centre to side Fig 11): Whenever a plough works round a strip of ploughed land it is said to be "gathering". The tractor and plough turns to the rig each time the headland is reached. The ridge is formed exactly midway between the two side boundaries. This is good practice for leveling the field which has low elevation in the centre.

Casting (Side to center Fig 12) : Whenever a plough works round a strip of un - ploughed land it is said to casting. The tractor and plough turn to the left each tin the head land is reached. Whenever the land is plough in this way a double width furrow will be left in the centre and is termed as "finish" or "open furrow". This is go practice for fields having higher elevation in centre.

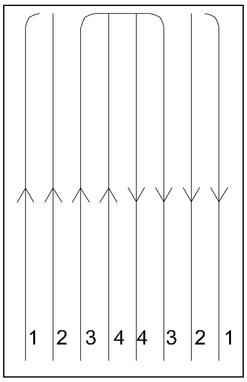
Fig 11



GATHERING

MTN1101217B

Fig 12



CASTING

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Mixed method: This is combination of both gathering and "casting application for larger fields". The whole field is divided into number of strips approximately of 20m, 30m and 40m for 2, 3 and 4 bottom plough respectively. This gives saving in fuel and time.

Mould board plough - Maintenance

Checking beams: Most of the less obvious plough setting difficulties is caused by plough being out of alignment. Plough consists of a number of beams, which together with brackets and braces form the frame of plough. No plough will do satisfactory work unless the beams and frame are true and each plough body is in the same position relative to the others and to the beams.

All the ploughs should, therefore, be checked periodically on a smooth level floor to make sure they have not been damaged by obstructions.

Bar point/share: Such of bar points or share can be checked with a straight edge.

Cross shaft: Check the position of the cross shaft and ensure that it is put back with the crank downwards on the right hand side of the plough when viewed from the rear.

Coulters: Dismantle all coulters and clean. Coulter edges must be kept sharp by grinding.

Wearing parts: All wearing parts like coulter, bar points, shares mould boards and landsides must be periodically checked and renewed when necessary.

Storage: During the off - season plough must be cleaned and stored under cover. All soil engaging parts must be coated with antirust compound.

Troubles and their remedies

S. No	Troubles	Causes	Remedies
1.	No water delivered	Pump is not primed Discharge head is too high Suction lift too high Impeller or suction pipe completely plugged Air pocket in suction line	Prime the pump Lower the discharge head Lower the suction height Clean the suction pipe and impeller Remove air by priming
2.	Enough water not delivered	Discharge head higher than anticipated Suction lift too high Impeller or suction pipe partially plugged Foot valve too small Insufficient submergence of suction inlet	Lower the discharge head Lower the suction height Clean the impeller or suction pipe Replace large foot valve Submerge inlet fully in water
3.	Not enough pressure developed	Excessive amount of air of gas in liquid Impeller diameter too small Damaged impeller	Prime the pump Change the impeller Replace the impeller

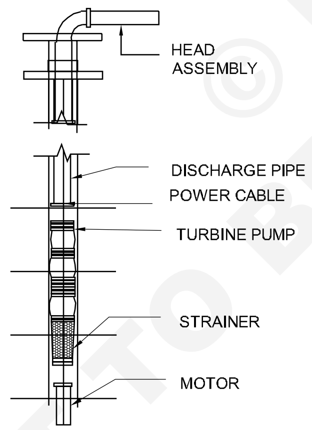
4.	Pump works for a while and then looses priming	Excessive amount of air or gas in liquid Air pocket in suction line Water seal tube clogged Water seal ring improperly located Suction lift too high Insufficient submergence of suction inlet	Pump needs priming Prime the pump Clean it Locate it in correct position Lower the suction height Submerge the suction fully in the water.
5.	Stuffing box leaks excessively	Packing is worn or improperly lubricated Packing improperly installed Incorrect type of packing Bent shaft	Replace the packing Install properly Change the packing Replace the shaft
6.	Pump noisy or vibrates	Suction lift too high Impeller or suction pipe Partially plugged Foundation not rigid Lack of lubrication Bearings worn	Lower the suction height Clean it Lay foundation strongly Lubricate the rotating parts Replace the bearings

Construction and working principle of submersible pump

Objectives : At the end of this lesson you shall be able to
- **state the components of submersible pump**
- **explain the working principle of submersible pump.**

Submersible pump (Fig 1)

Fig 1



SUBMERSIBLE PUMP

MTN110121A1

Submersible pump is nothing but a vertical multistage pump. This pump works on the same principle of variable displacement pump. The only difference is, the whole pump is submerged in water deep below the ground surface, thereby solving the problem of suction lift, since it is inside water.

Components of submersible pump

Pump construction

The submersible pump consists of motor and pump assembly, a discharge column, and a water proof cable to carry the electric current to the motor submerged in water.

Pump element : The pump element consists of a propelling shaft made of stainless steel generally and on it is mounted the impeller made of bronze which generally is a closed type. Sometimes a semi - open type is also used.

Electric motor : The submersible electric motor has the same diameter as pump bowl, but much longer than an ordinary motor. It may be dry or wet type squirrel cage induction motor. In dry type, the motor is enclosed in a steel case filled with light oil having high dielectric strength. The wet type motor is to be filled with water during installation, which acts as a lubricant for the bearings during the first start.

Suction case with strainer : The suction case shall be fitted with a strainer made of corrosive resistant material.

Non - return valve : Non return valve is provided above the pump discharge case.

Coupling: A suitable coupling should be provided in between motor and pump.

Working principle

In this pump the water enters axially and comes out radially through the impeller i.e., the water enters through the centre of the impeller (impeller eye) and comes out through the periphery. Since it is a multistage pump. i.e. another impeller is vertically above the first or the lower impeller, so it is necessary to change the flow of the liquid axially upward (to the impeller eye of the second impeller).

The pump is close coupled to a small diameter submersible motor directly below the intake of pump. The pump element and motor operates entirely submerged in water. These pumps can lift water from a depth of 150 m.

Seed drill and their uses

Objectives : At the end of this lesson you shall be able to
- **describe the seed drill, its uses and various types of seed drills**
- **describe the components and uses of zero till drill and strip till drill.**

Seed drill

Seed drill is used for sowing seeds of small sizes viz. wheat, gram, etc. and must be capable of placing the seed at a depth where optimum soil temperature and moisture are available for germination. A good seed drill must be able to ensure metering of correct and uniform amount of seed rate at a precise depth without causing any damage to it. Now a days the seed drill have additional feature of fertilizer attachment also which ensures placement of fertilizer at a proper place along with seed.

Functions of seed drills

- It opens furrows to a uniform depth.
- It drops seeds uniformly without injury.
- It covers the seeds and compacts the soil around them.

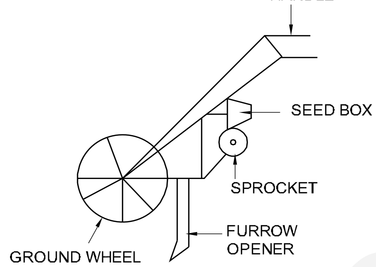
Various types of seed drill

Five types of seed drill are described below.

1 Hand seed drill

It is a manually operated implement, consists of a seed box, ground wheel, furrow opener, chain and sprocket. Seed box stores the seeds. Furrow opener is used to open the soil. Ground wheel transmits power to seed metering mechanism connected to seed box (Fig 1).

Fig 1



HAND SEED DRILL

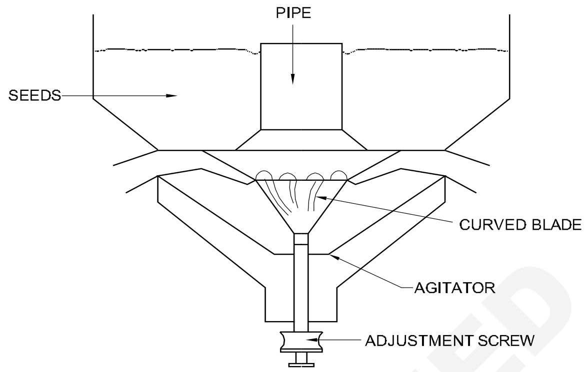
2 Centrifugal seed drill

Seeds placed in a cylindrical hopper pass through a series of openings into a funnel - shaped iron shield. In this, funnel is a rotating cone with welded curved vanes on the inside. Seeds enter through an adjusted opening in the bottom of the rotating funnel; centrifugal force causes the seeds to rise and to be ejected into the seed tubes, which can be opened or closed as desired. The drilling rate is little affected by ground surface, slope or forward speed (Fig 2).

3 Pneumatic seed drill

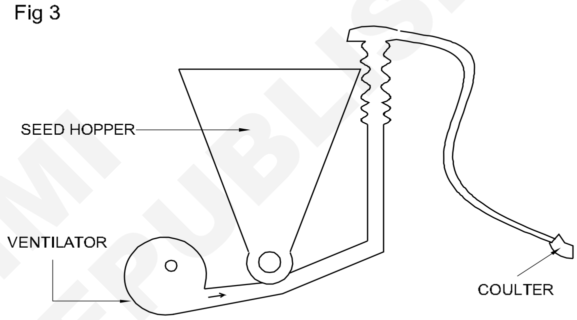
An air - stream produced by a fan to convey the seeds to a distribution head. At this head, a number of delivery tubes are fixed which direct the seeds to the furrow - openers a variant of this system is used as granulate distributor (Fig 3).

Fig 2



CENTRIFUGAL SEED DRILL

Fig 3

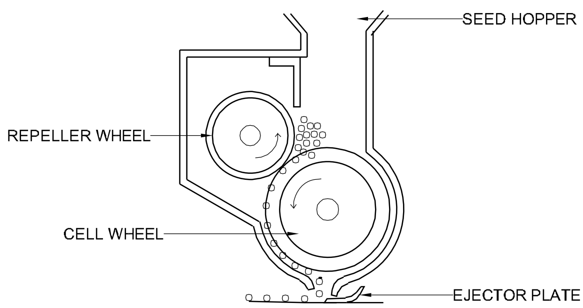


PNEUMATIC SEED DRILL

4 Cell wheel precision seeder

The types exist with vertical and slanting discs. Vertical cell wheels have one or more rows of holes at the circumference. The cell wheels turn in the same direction as the wheels of the drill and repeller wheel removes the superfluous seeds at the bottom of the sowing mechanism where the seeds must fall down, an ejector plate empties the cells (Fig 4).

Fig 4



CELL WHEEL PRECISION SEEDER

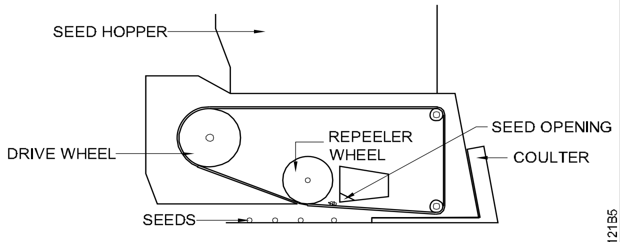
Both types of precision drills can adopt by using different belts or cell wheels and by the modification of the velocity of the belt or cell wheel the seed spacing wheel by a gearbox. The drills require round, calibrated or pelleted seeds.

For accurate drilling it is very important to choose the right belt or cell wheel with holes with a diameter matching that of the seeds. It is essential that every hole is filled with only one seed.

5 Rubber belt precision seeder

It traveling opposite the driving direction where the seed is leaving the band is transporting the seeds from the hopper to the delivery opening. A repeller wheel turns opposite to the direction of the belt and removes the superfluous seeds (Fig 5).

Fig 5

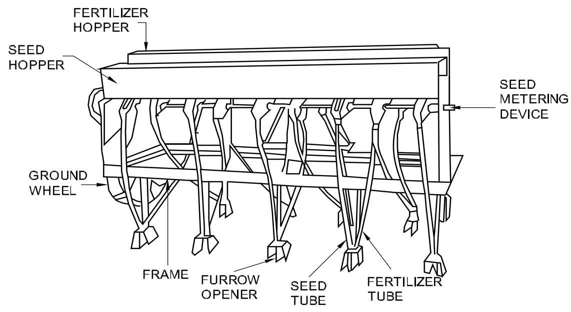


RUBBER BELT PRECISION SEEDER

Zero till drill seed cum fertilizer drill (Fig 6)

The seed cum fertilizer drill machine consists of seed box, fertilizer box, seed metering mechanism, fertilizer metering mechanism seed tubes, furrow openers, seed rate adjusting lever and transport cum power transmitting wheel. The fluted rollers are driven by a shaft. Fluted rollers, which are mounted at the bottom of the seed box, receive the seeds into longitudinal grooves of fluted roller and expel them in the seed tube attached to the furrow openers. By shifting the rollers sideways, the length of the grooves exposed to the seed, can be increased or decreased and hence the amount of seed sown is changed. The seed cum fertilizer drill is popular in northern region of the country. Seed cum fertilizer drills are used for sowing of wheat and other cereal crops in already prepared field (Fig 6)

Fig 6

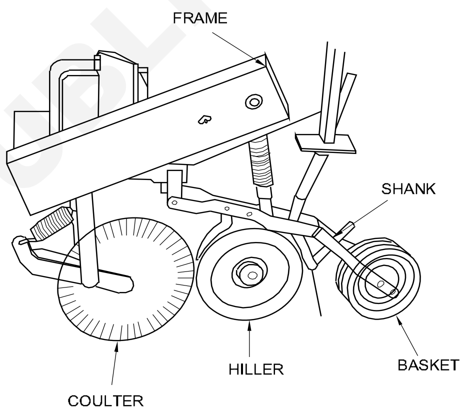


ZERO TILL DDRIL - SEED CUM FERTILIZER DRILL

Strip till drill

It consists of coulter, hiller basket, shank and frame. Strip tillage refers to a system where strips 5 to 20 cm in width are prepared to receive the seed whilst the soil along the intervening bands is not disturbed and remains covered with residues. The system causes more soil disturbance and provides less cover along the rows than zero tillage (Fig 7).

Fig 7



STRIP TILL DRIL

Types of seed metering devices and furrow openers

Objectives : At the end of this lesson you shall be able to
- **state the types and uses of seed metering devices**
- **state the types and uses of furrow openers**
- **seed and fertilizer metering mechanism.**

Seed & fertilizer metering devices

These metering mechanisms are placed in the bottom of the seed and fertilizer boxes to meter the desired quantity of seeds and fertilizers. The different types of metering devices, which are in use for seed cum fertilizer drill, are as under. Three types are given below.

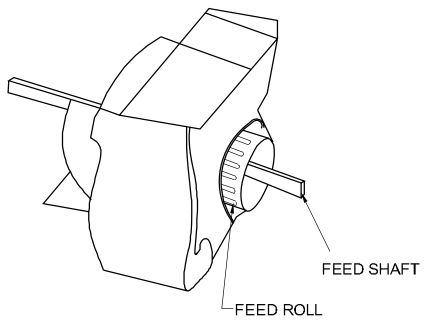
1 Fluted roller

Fluted roller or fluted wheel is the most common metering device. It is made of aluminum or plastic coated body containing a roller, which contains 8 - 12 longitudinal grooves on its outer periphery. The roller along with its body is mounted on a square shaft. These grooves receive the seeds from the seed box and deliver it into seed tube through seed holes. The side ways movement of fluted roller on its shaft can regulate the quantity of the seeds. The side way movement of the rollers grooves exposed to the seed inside the body, which results in regulation of seed rate to be delivered. For different sizes of seeds, an adjustable spring loaded baffle plate is provided (Fig 1).

2 Internal double run mechanism

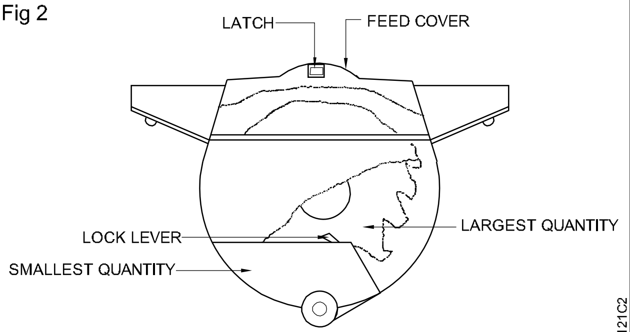
In this type of metering mechanism a double feed wheel is used. One face of the wheel has large openings for large size of seeds, whereas the other face has a smaller opening for small size of seeds. When one side is being used, the seed is prevented from flowing through the other side by using a special cover or gate that can be easily installed from the inside of the seed box. Changing the speed of the internal seed wheel by selecting the suitable gear ratio for driven and drive gear can regulate the seed rate (Fig 2).

Fig 1



FLUTED FEED TYPE

Fig 2

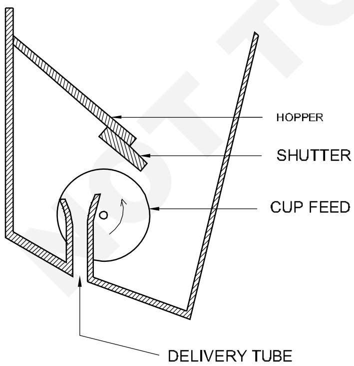


INTERNAL DOUBLE RUN TYPE

3 Cup type

In this type of metering mechanism a revolving disc containing fingers or cups on its periphery, which picks up the seeds and delivers them to the seed tube. These are used in drills for crops where seeds are easily damaged due to rough mechanical handling. The size of spoon depends on the seed size and the seedling rate depends on the number of cups and its rotating speed (Fig 3).

Fig 3



CUP TYPE

Types of furrow openers

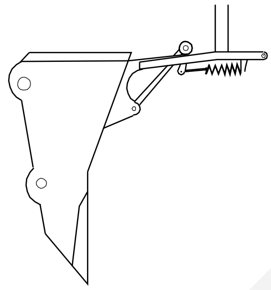
Furrow opening unit

It is used to open a furrow in the soil at uniform depth. The different types of furrow openers in use are as follows.

Hoe type

It is fitted with single point or reversible type shovels followed by single or double delivery boots, attached to it. It is suitable for light medium soil, free of excessive trash. This type of opener has a good penetration and when its shanks are equipped with automatic tripping mechanism (spring loaded) then it is very much suitable for stony and root infesting soil (Fig 4)

Fig 4

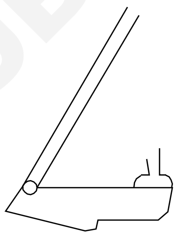


HOE TYPE

Stub runner type

The sword shaped furrow opener with sharp edge cuts the soil in a neat furrow with minimum disturbance upto shallow or medium depth. It is used in corn drills in rough and trashy ground (Fig 5).

Fig 5

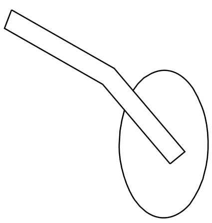


STUB RUNNER TYPE

Single disc opener

A slightly curved disc, set to run at a slight where between penetrations is needed and seedbed contains the thrashes and for better penetration, more suitable for shallow and medium seeding (Fig 6).

Fig 6

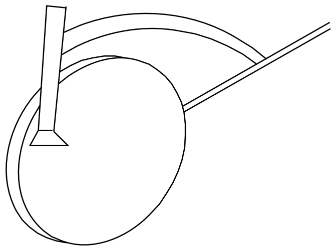


SINGLE DISC TYPE

Double disc opener

In this type of furrow opener two disc facing each other at a slight angle from a cutting edge where it penetrates into the soil. The discs rotates as they are moved forward leaving a small centre ridge which causes seed to be deposited into row at about 25mm apart. These openers are especially suitable or deep sowing at relatively higher speeds. It is an idle furrow opener for sowing small seeds in trashy seed bed (Fig 7).

Fig 7



DOUBLE DISC TYPE

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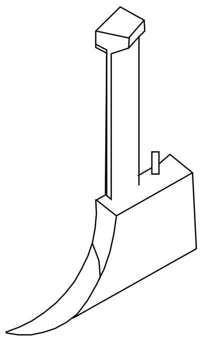
Chisel furrow openers

It is an opener made of a body with bar shape and has a sharp point projecting over the shoe. This type of furrow openers is especially suited for very hard and cloddy soils (Fig 8).

Fig 8



CHISEL FURROW OPENERS

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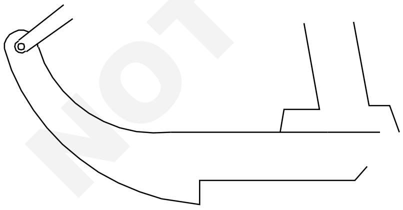
Full runner type

It is used for medium depth and seed beds free from trashes. It consists of a covered runner with sharp edge (Fig 9). Due to its length, if compacts the bottom of the furrow they are commonly used for maize, cotton and vegetable planters.

Fig 9



FULL RUNNER TYPE

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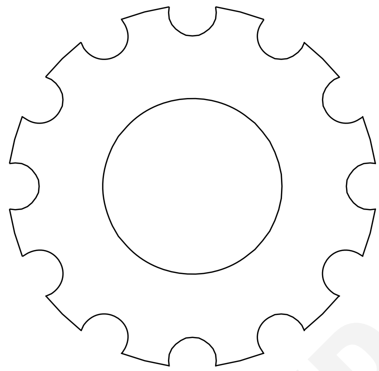
Horizontal plates

They horizontal seed plates have got suitable notches or holes called "cell". Depending upon the type of notches on the plates it is of three types edge drop flat drop hill drop

Edge drop

The carries the seed on edge in the cell of the plate (Fig 10).

Fig 10



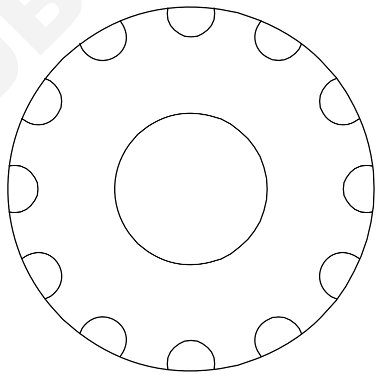
EDGE DROP

MTN110121CA

Flat drop

The flat drop carries the seed on a flat in the cell of the plate. Only one seed is allowed in the cell at each time (Fig 11).

Fig 11



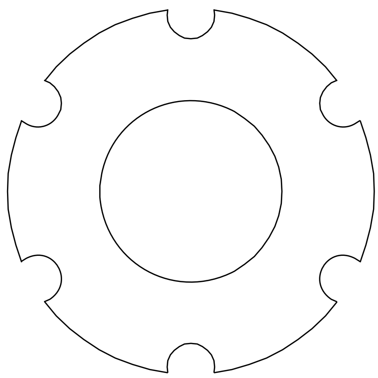
FLAT DROP

MTN110121CB

Hill drop

In hill drop, the cells round the edge of the plate are large enough to admit several seeds at a time (Fig 12)

Fig 12



HILL DROP

MTN110121CC

Power transmission: Planters are classified as tractor operated animal drown an manually operated according to type of power unit.

In tractor operated machines, power to drive metering devices is transmitted from rear drive wheels, transport - cum - depth control wheels or PTO in case of pneumatic planters. In animal drawn planters power is transmitted by means of the transport wheel, transport - cum - depth gauge wheel, press wheel etc. These drive wheels, which are in use, are of normally three types plain wheel, lugged wheel and pegged wheel.

The power from wheel may be transmitted by means of gears, chains and sprockets or V - belts. The belt drive is cheapest. Roller - chain drive is preferred because they are readily available and have no slip. But under dusty conditions V - belt drive is preferred over chain drive. A combination of chain and gear drive is used in tractor mounted machines.

Gear drive: Cost iron or plastic gears are extensively used to transmit power on the planters. However cast iron gears have a rough finish and are not accurate to use. Recent advancement in plastic industry has helped to produce good quality plastic gears which functions well enough.

Belt drives: Power transmission also uses belt drive, mostly V - belts. It has an advantage of being low cost, having low noise, shock absorbing and requires no lubrication.

Chain drives : The chain and sprocket drives are used to transmit power from the ground wheel to metering device. A counter shaft drive is provided so that power from one shaft can be transmitted to different metering units.

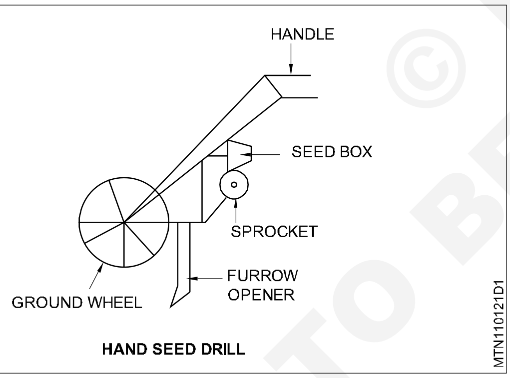
Construction details of seed drill cum fertilizer drill

Objectives: At the end of this lesson you shall be able to
- **describe the construction details of hand seed drill**
- **explain the construction details of cell wheel precision seeder**
- **describe the construction details of rubber belt precision seeder.**

Hand seed drill

It is a manually operated implement, consists of a seed box, ground wheel, furrow opener, chain and sprocket. Seed box stores the seeds. Furrow opener is used to open the soil. Ground wheel transmits power to seed metering mechanism connected to seed box (Fig 1).

Fig 1



HAND SEED DRILL

The machine consists of a seed box attached to the mainframe of a hand wheel hoe. A fluted roller assembly is provided at the bottom of the seed box. Fluted roller is rotated with the help of chain and sprockets from the ground wheel. The seed rate can be adjusted with the help of a lever provided on the seed box. The fluted roller used for sowing rapeseed and mustard has 8 flutes. Each flute is 3 mm wide and 2 mm deep. The diameter of the fluted roller is 50 mm and its length, 32 mm. For operation, the machine is pulled by rope attached to the hook of machine by one man and other person steers the machine by holding it by the handle.

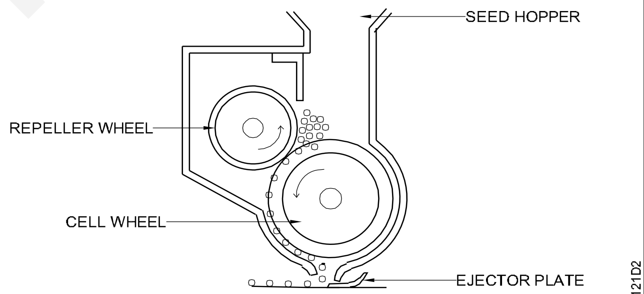
Uses

Manual hand seed drills are used for sowing rapeseed and mustard. By changing the fluted roller position, other crops like wheat, moong etc. can also be sown. It is also suitable for inter - row sowing.

Cell wheel precision seeder

The types exist with vertical and slanting discs. Vertical cell wheels have one or more rows of holes at the circumference. The cell wheels turn in the same direction as the wheels of the drill and repeller wheel removes the superfluous seeds at the bottom of the sowing mechanism; where the seeds must fall down, an ejector plate empties the cells (Fig 2).

Fig 2



CELL WHEEL PRECISION SEEDER

The cell wheel rotates underneath the hopper one seed drops into each hole. To prevent other seeds not completely in the hole from leaving the chamber, a repeller wheel rotates against the cell wheel. The seed is carried by the belt or wheel to a point where it can drop out into the slot in the soil made by the coulter.

Correctly graded seed must be used in a precision seeder so that there is room for only one seed in each hole and seeds do not project above the hole resulting in damage.

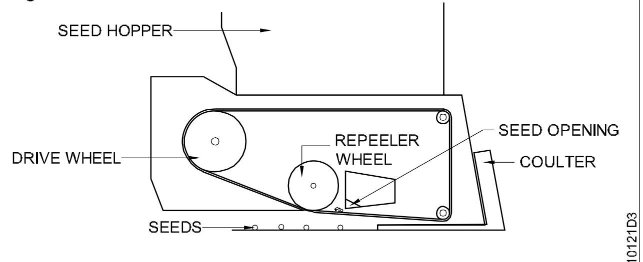
Drive to the mechanism is either by v belt from the land wheel of each unit or by gears and shafts from a master land wheel. Like random seeder, high speed of operation can cause seeds to be missed and the recommended speed is 2 miles per hour.

Seed spacing and the type of seed sown is altered by changing the seed cell wheel for one that has differently spaced holes or different sized holes for other seeds.

Rubber belt precision seeder: It traveling opposite the driving direction where the seed is leaving the band is transporting the seeds from the hopper to the delivery opening. A repeller wheel turns opposite to the direction of the belt and removes the superfluous seeds (Fig 3).

The operation of rubber belt precision seeder is similar to cell wheel precision seeder. The main difference between them is the wheels are connected through a belt in rubber belt precision seeder, where as in cell wheel precision seeder they are connected directly.

Fig 3



RUBBER BELT PRECISION SEEDER

Calibration and adjustments of seed drill

Objectives: At the end of this lesson you shall be able to
- **state the calibration of seed drills**
- **describe the adjustments of seed drills.**

Calibration of seed drills

Before taking a seed drill or planter into the field it is very essential to calibrate its metering mechanism to obtain the required seed rate per hectare or per acre of the crops to be planted. The following steps are followed in calibrating the seed drill.

Jack up the seed drill and mark a reference point on the ground wheel.

Measure the diameter of ground wheel. Let us say it is 'D' meter.

Measure the working width of the drill or planter let us say it is 'W' meter.

W = n x d

Where,

n = number of tynes

d = distance between two tynes (m)

Workout the circumference of ground wheel (π x D)

We assume that the planter or drill has to be used in a field having length x breadth as 100 x 100 square meter.

Workout the revolution of the ground wheel required to travel a distance of 100 m

$$= \frac{100}{\pi \times D} = X$$

Now give the 'X' revolution to the wheel and collect the seeds from all the furrow openers separately. Weigh all the collected seed separately. It should be noted that there should not be large variation in the weight of the seed collected from the different furrow openers. Let's say the total weight of the seeds collected from all furrow openers is 'P' kg.

Workout the total number of revolutions required to cover one hectare of field.

$$= \frac{100 \times 100}{\pi \times D \times W} = Y$$

Workout the total amount of seed for 'Y' revolutions for 'X' revolutions 'P' kg. of seed are collected.

$$\text{Therefore for Y rev.} = \frac{P}{X \times Y} = G\,(kg)$$

Thus by substituting the valve of 'P' and 'X' revolution and we can obtain the quantity of seed to be used in the field. Thus the process is repeated by suitably adjusting the lever on the indexing device till we get the seed rate, recommended for a particular crop under planting or sowing.

Adjustments seed drill

Adjust the lever on indexing device to obtain desired seed rate. Change the seed metering devices according to land and seed used. Lift the equipment and rotate the drive wheel to ensure that seeds are falling freely from the metering device. Check the penetration indexing mechanism for placement of seed position.

The metering unit in the hopper should always be covered with seed. The delivery rate of the seed is influenced by the forward speed, in such cases speed has to be limited to 7 km. h-1. To prevent displacement of the seed in the furrow the coverers and rear wheel should not press too hard. The sowing depth should be adapted to the seed size and soil conditions. Do not reverse during operation to prevent the furrow opener being filled with soil.

Operation of seed drill

Objective : At the end of this lesson you shall be able to
- **describe the operation of seed drill.**

Operation of seed drill

In order to have a good quality work the seed and the fertilizer should be placed at uniform depth and uniform quantity in all the furrow openers without casing any damage to the seeds, in such a manner that the fertilizer should not come in direct contact with the seed. No furrow opener should be left opened and soil cover should be compacted firmly to promote easy germination. This can be obtained by carrying out the following operation procedure

– Employ the standard hitching procedure for mounted implements. Reverse the tractor to seed cum fertilizer drill. Attach the left link, then the right link by adjusting the length of the right left arm, the top link and stabilizer chain after centering the equipment.

– After the equipment is hitched to the tractor make the preliminary adjustment and carry out the daily maintenance.

– Now fill the seed and fertilizer boxes ¾ th of its capacity, also assure that seed and fertilizer are free from clods etc.

– Lift the equipment and rotate the drive wheel to ensure that seed and fertilizer are falling freely from the metering device, seed tube into the furrow opener.

– Take the equipment to the field; select the point from where the operation is to be started. As the tractor enters the field, lower the equipment using the position control levers.

– Check that the drive wheel is touching the ground fully, if not, lengthen the top link. Then continue driving the tractor for about 10 meters distance and stop again. Check to see the drop of seed and fertilizers. Also check the penetration of furrow openers. If the desired depth is not obtained adjust the position control lever, till the desired depth of planting is obtained. Continue the above sequence of operation at the other end of the field to assure best efficiency or output from the equipment.

– Once the check and adjustments have been made, divide the field into lands of approximately 25 - meter width and mark the land at both the ends along with the field. The headland should be 1.5 times of the total length of tractor with equipment attachments from the outer end of field for mounted type drills. Now start the operation along one side of the first land leaving a strip of land equal to the headland. Make the adjustment in the depth if necessary and level the settings. At the end of the first pass take a left - hand turn in the headland at a distance slightly greater than the most convenient turning circle of the tractor. After the second pass again take a left hand turn and continue the operation on the left side of the first pass. Continue in the same manner and finish the operation on the whole land.

Maintenance and storage of seed drill

Objectives : At the end of this lesson you shall be able to
- **describe the maintenance of seed drill**
- **describe the storage of seed drill**
- **troubleshoot and take remedial action.**

Maintenance of speed drill

The following care should be taken for smooth and efficient functioning of seed - cum - fertilizer drill.

– Check the suitability of metering systems in respect to the seed and fertilizers to be used.

– Ensure the calibration of metering system to obtain the desired seed rate of the crop to be taken under cultivation.

– Ensure the placement of seeds at proper depth.

– Ensure the coverage of seeds and compaction of soil cover.

– Check the performance of the attachment.

Maintenance schedule

Daily

– Clean the furrow openers, covering device and seed tube.

– Apply grease to all existing grease points.

– Check that all the nuts and bolts are properly lightened.

– Remove the remaining fertilizer and clean the fertilizer system.

– Ensure the replacement of the parts, if any broken.

Periodically

– At the end of the season check the entire machine and make a list of broken and worn out parts and ensure its repairs of replacement.

– Thoroughly clean the seed and fertilizer hoppers and then apply a coating of heavy oil on moving parts.

– Clean the furrow openers, tubes and the metering system.

– Fertilizer system should be thoroughly cleaned by flushing with water, dried properly and a oil coating should be applied inside and outside of the fertilizer attachment.

– Roller chains should be removed, tagged and stored in a can of light oil.

– Detachable link chain should be coated with oil.

– If the seed drills have pneumatic wheel then the drill planter unit should be jacked up for its storage in a clean dry place, provided with proper sheds.

Storage of seed drill

Clean each part of the machine, reapply grease to the seed - metering clutch, and coat each rotary blade with old engine oil or paint, before storing the seed drill for a long time. Store the seed drill in a dry, well - ventilated room. Keep the approximate tools with the machine during storage to ensure that they will be available when needed again.

Precautions

– Operator must ensure the leveling of the seed drill cum fertilizer with respect to the ground.

– The seed drill should always be operated at optimum speed in order to ensure uniform metering of seeds and fertilizer.

– After entering in to the field the operator must select suitable method of operation keeping in view the topography of the field.

– Before the operator starts the operation metering mechanism lever should be locked properly at calibrated scale.

– Before starting the operation the operator should check the slippage/skidding of the ground wheel. He should ensure that it should not be more than that desired level which has been already taken into the consideration at the time of calibration.

– Depth of sowing should be kept uniform throughout the operation by locking the position control lever.

– Operator should ensure the proper and smooth working of agitator.

– Adjustment of marker should be kept uniform throughout the operation. It should be checked and readjusted if required after every turn.

– Check that all working parts have been protected properly by providing the guards or cover.

– Grain and fertilizers tanks should be checked at regular interval so that they should not become empty during sowing.

– When the tractor is in operation, the operator should not allow any person to sit on the tractor or to stand on the drill.

– No adjustment either on tractor or on drill should be made during operation.

– Operation should be done by the skilled operator only.

Periodic maintenance of tractor

Objectives: At the end of this lesson you shall be able to
- **maintenance of tractor accessories**
- **listout the service interval of tractor**
- **engine components may become dirty or plugged when operating in extreme heat, dust or other severe conditions.**

Tractors operate in the field in most arduous operating conditions. The engine, clutch, transmission is severely strained causing fasteners loose, Filters may get choked due to dusty condition. Hence the items requiring attention due to normal wear and tear (as prescribed by manufacturer) must be attended as per their prescribed schedule. Timely attention saves from break-down and severe damage.

Using a tractor maintenance is a great way to keep the arm tractor operating smoothly. Maintain the following system maintenance of tractor accessories.

Maintenance of tractor accessories

Carry not periodical maintenance of tractor (10hrs, 50hrs, 100hrs, 250hrs, 500hrs and 1000hrs) refer your tractor ser hand book.

– Check the engine oil.

– Check the engine oil.

– Check the transmission fluid/hydraulic oil, steering oil level.

– Check the coolant in the radiator/ reservoir tank.

– Check for any bleeding in the fuel system

– Check the battery electrolyte level.

– Check that the right temperature is maintained in the gauge.

– Check for right oil pressure.

– Check that hour meter is adjusted correctly.

– Carry out visual inspection of all tractor parts.

– Check the working of fuel (system, lubrication system air intake and exhaust system components.

– Check for belt tension.

– Replace the defective parts using hand tools.

– Check for play setting of the clutch, and brake pedal

– Check the foot steerage control systems.

– Maintain the proper clearance between working parts.

– Properly lubricate in all lubricant, points of tractor.

Recommended oil and filling capacity of a standard tractor

Unit	Fill capacity	Reclubricant	Renewal
Engine oil	8.6 Lts	CRB Prima Plus	300 hrs
Transmission oil*	42	TRACT ELFSG	1200 hrs
Steering oil	0.7 Lt		1200 hrs
Hydraulic units *			
Power steering fluid	1.5 Lt	150 - VG - 46/48	1200 hrs
Radiator coolant	11 Lts		2 Years

*** Including hydraulic unit**

Service maintenance schedule

Use the following timetables to perform routine maintenances on tractors. However the manufacturer's guideline on service and maintenance is to be strictly adhered to.

After first 10 hours

- Check wheel bolt torque.
- Check cab rollover protection system mounting hardware torque.
- Check windshield wiper arm mounting hardware torque.

Every 10 hours or daily

- Test safety systems.
- Check engine oil level.
- Check transmission oil level.
- Check air filter rubber dust unloading valve.
- Check radiator coolant level.

Every 50 hours

- Check front axle oil level.
- Lubricate machine.
- Check cab protection system mounting hardware torque.
- Clean or replace cab air filters.

Every 200 Hours

- Change engine oil and filter.
- Inspect alternator belt.
- Check air restriction indicator light.
- Check wheel bolt torque.

Every 400 Hours

- Change engine oil and filter.
- Change transmission oil and filter.
- Clean transmission suction screen.
- Replace fuel filter.

Every 600 Hours

- Check engine low idle speed.
- Check air filter intake hoses and clamps.
- Change front axle oil.
- Check front axle thrust bolt torque.
- Check brake adjustment.

Yearly

- Change engine oil and filter if less than 200 hours of operation.
- Drain water from fuel tank and replace fuel filter.
- Check all hoses and clamps.

Every 1200 Hours

- Check and clean inline hydraulic filter.
- Check engine valve clearance.
- Change engine oil, steering box oil and transmission oil.

Every two years or 2000 Hours

- Flush and replace factory coolant. Flush cooling system and replace engine coolant.
- Service fuel injection nozzles as needed.

As needed

- Replace alternator belt.
- Replace air filter elements (see air restriction indictor)
- Replace cab air filters.
- Replace light bulbs
- Replace fuses.
- Clean and replace battery.
- Replace radiator hoses and clamps.
- Check tyre air pressure.
- Clean fuel tank overfill reservoir.
- Drain water and sediment from fuel tank, and service water separator.
- Check and adjust front wheel toe-in
- Check and clean grille and side screens.
- Check and clean radiator cooling screen.
- Clean debris from engine compartment.
- Adjust all cables to acquire appropriate travel for engagement (cabs).

Chassis & Greasing (CG) points of a standard tractor.

Chassis & Greasing (CG)

1 CG : Front Axle Pivot Pin Grease Nipple
2 CG : Front Wheel Hub (RH) Grease Nipple
3 CG : Front Wheel Hub (LH) Grease NIpple
4 CG : Brake Shaft (LH)
5 CG : Brake shaft (RH)
6 CG : Differential Lever
7 CG : Clutch Petrol Shaft
8 CG : Brake Shaft Outerside Nipple
9 CG : Antifriction Bearing
10 CG : Stabilizer Swivel (RH)
11 CG : Lateral Stabilizer (LH)
12 CG : Lateral Stabilizer (RH)
13 CG : Stabilizer Swivel (LH)
14 CG : Steering Knuckle Post (RH)
15 CG : Steering Knuckle Post (LH)
16 CG : 3 Point Linkage Level Screw (LH)
17 CG : 3 Point Linkage Level Screw (RH)
18 CG : Top Link Bracket (Bell Crank)
19 CG : Front Wheel Hub Cap (LH)
20 CG : Front Wheel Hub Cap (RH)

Grease specification - Multipurpose lithium base grease conform to NLG 113 to be used

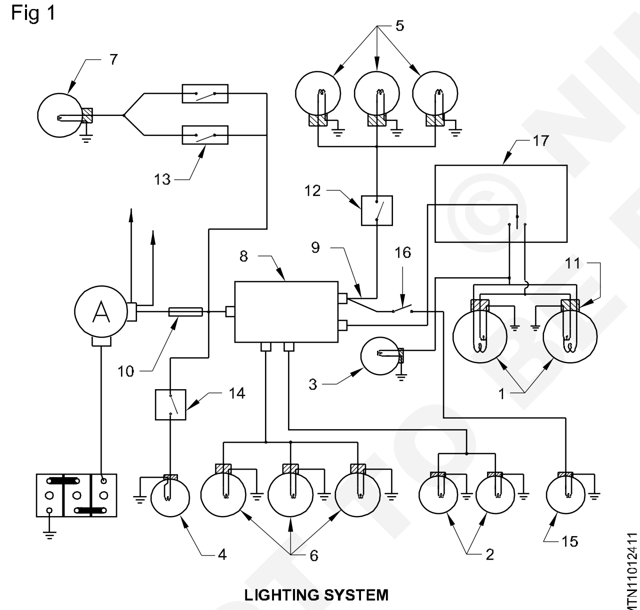
Lighting circuit

Objectives: At the end of this lesson you shall be able to
- **explain the headlight circuit**
- **explain the parking light circuit**
- **explain the panel instrument light circuit**
- **explain the top/dome light circuit**
- **explain fog light circuit**
- **explain stop/brake light circuit**
- **explain tail light circuit**
- **explain the reverse lights circuit**
- **explain the flasher lights circuit.**
- **discuss Trouble shooting.**

A layout of wiring diagram of tractor

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 head lamp (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
- parking light circuit
- panel light circuit
- top light circuit
- fog light circuit
- stop light circuit
- reverse 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-focussed 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 headlight 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).

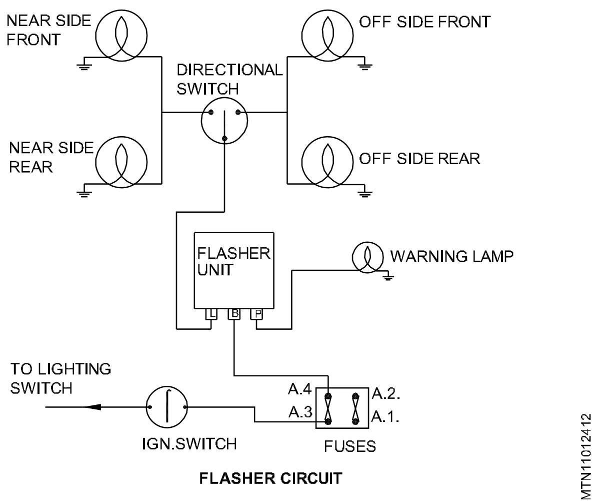
Stop light circuit: In order to give indication to the traffic behind the vehicle for slowing down or for stopping the stop/brake lights (4) are fitted. It consists of a lamp (4) and brake switch (14), fitted on the master cylinder or air valve. When the brake pedal is pressed, the switch is made to 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)

Flasher lights circuit [(Turn signal lights (Blinker lights)] (Fig 2)

Fig 2



FLASHER CIRCUIT

A turn signal is used to indicate to other motorists, when a turn is about to be made. These signal lights are operated by a small control lever mounted on the left or right side of the steering column housing just below the steering wheel. When you intend to turn right, a right turn is signalled by pushing the lever up. Pushing the lever downwards indicates a left turn. The turn signal filament of the front parking light and the brake light filament of the rear bulbs as well as indicator lights on the dash will flash at a rate of 80 to 100 flasher per minute. These lights are also called "blinker lights". These blinker lights are more noticeable to other users of the vehicle on road and provide a warning to the approaching vehicles during cornering.

All Tractors and Automobile manufacturers, use one wire systems in which vehicle frame and other metal parts are employed as the second wire. (ground or return wire)

One-wire systems are simpler and less expensive than their two-wire counterparts, but require very careful handling and systematic inspection of the condition of wiring insulation, for even a single ground fault here presents real fire hazard.

The direction of current flow is taken to be in accord with the conventional theory, i.e., current is assumed to be flowing from the positive terminal of the storage battery or alternator and through insulated wires to loads, and then to the negative terminal of the battery or alternator via the ground wire (the frame).

To facilitate the laying out of the wires and to provide for better protection, individual wires are taped together in bundles. The wires are color coded in order to facilitate their tracing in the bundles. Wire ends are equipped with lugs or connectors, which makes it easier to connect the wires to the various electrical system components.

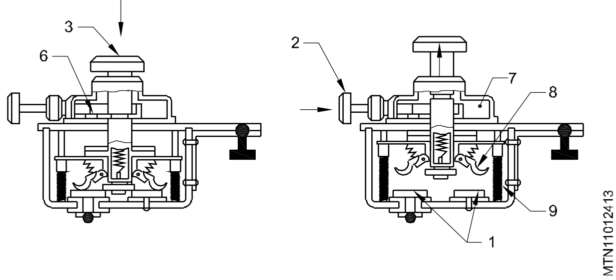
The point of connection to the power supply sources is essential. The principle here is to connect directly to the battery only such components as draw much current and operate for a short period only (e.g. the starter motor, cigar-lighter) and also those which must be operatable in emergency situations (e.g., the horn, cowl light, inspection lamp). The other loads are connected to the alternator. In this case, the loads are connected as dictated by the character of their operation connected directly to the alternator are such loads as draw little current and operate for a long period of time; the loads that are operative only when the engine is running are connected through the IGN switch. All the lighting equipment is energised through the main light switch.

Battery-Ground-Master switch (Fig 3)

This is a special switch fitted on to the tractor. When the battery is installed on a vehicle, the negative terminal is connected to the "ground", i.e, the chassis frame, via a battery ground switch, also known as the master switch. The purpose of the battery ground switch. (Fig 3) is to disconnect the battery from the electrical system when the engine is stopped for any lengthy period of time, or when the vehicle is parked, in order to reduce the self-discharge of the battery, avoid accidental short-circuiting, and diminish fire hazard. The battery ground switch is installed in the driver's cab and is placed in the "ON" position by depressing larger button 3. As the button is depressed, movable contacts 8 are tightly pressed against stationary contacts and are held in this position by locking plate 6 loaded by spring 7. The plunger of the larger button is provided with an annular groove, and as the plunger moves past the locking plate, the spring forces the plate to enter the groove and thus lock the plunger in position.

To disconnect the battery from the system, one has to depress smaller button 2. This will cause the locking plate to move against spring pressure and leave the annular groove in the plunger of the larger button, thus releasing the plunger. Now, return springs 9 will move the plunger together with the movable contacts back to its initial ("OFF") position.

Fig 3



Components of lighting circuit

Objectives: At the end of this lesson you shall be able to
- **list out the components of the lighting circuit**
- **explain the construction of the lamps**
- **explain the construction of the switch**
- **explain the construction of the fuse**
- **explain the construction of the circuit breaker.**

Components of lighting system/circuit

The main components of the lighting systems are

– bulbs

– switches

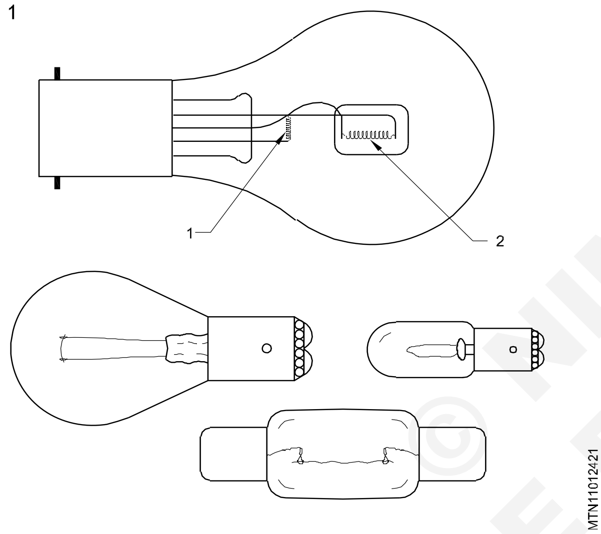
– wiring harness

– fuse of circuit breaker.

Functions of the components

Bulbs (Fig 1)

Fig 1



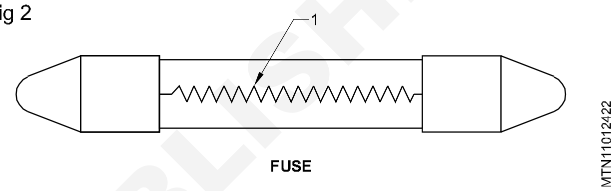
The bulbs are generally fitted in their respective holders.

The bulbs produce illumination that is essential on the road and inside the vehicle. There are various types of bulbs used in a vehicle. The bulb has a filament inside which produces light when connected to the power supply. The head lamp bulb has a normal driving filament (1), which produces a straight beam covering long distance on the road. Thin beam makes visibility difficult for the drivers of the approaching vehicles from the front. Therefore, an anti-dazzle filament (2) is provided whose light beam falls on the ground near to the vehicle (Fig 1a). The anti-dazzle filament is used by a dipper switch provided in the driver's cabin.

Switches: The lamp switches are fitted on the panel board. A separate switch is fitted for each group of lamps. The switches are operated manually. The switch opens and closes the electric circuit. The headlight switch is of pull and push type (single pull or double pull type) or toggle type which controls the headlamps, parking lamps, tail-lamps, rear number-plate lamp, panel instrument lamp etc. The stop light switch is operated by fluid or air pressure.

Fuses (Fig 2)**:** Fuses are of catridge type The fuse wire is soldered with nickel plated brass end caps. The whole unit is enclosed in a glass tube. Fuses are used for protecting the electrical accessories and the circuit against the effects of excessive current and short circuits. Separate fuses are used for each group of circuit. Current passes through the fuse to the appliances. A fuse consists of a fuse element (1) which is made of lead-tin alloy for low current upto 5 amps and tin-copper alloy for high current above 5 amps. In case of excessive current, the fuse

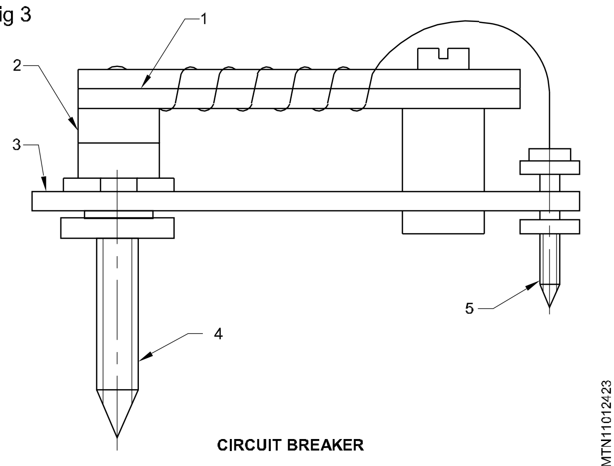
Fig 2



element will melt, and thereby, protect the appliance from any damage.

Circuit breakers (Fig 3)**: T**hese 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 circuit. When this type of device is used in the lighting circuit, the lamp will light and then go out. Thus giving an indication of a faulty circuit. The circuit breakers are made in ratings upto 50 amps.

Fig 3

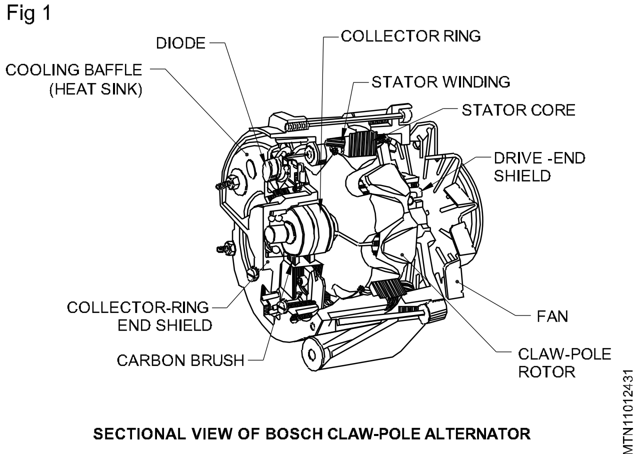


Alternator

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)

Fig 1



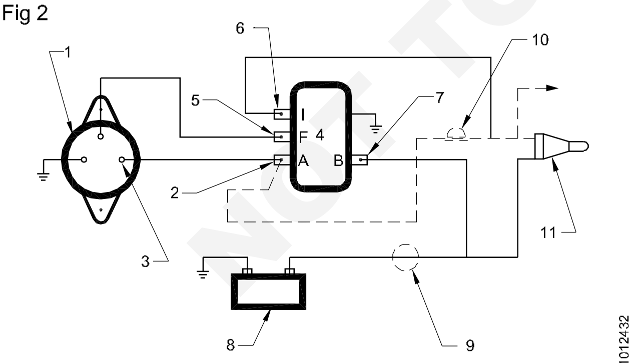
SECTIONAL VIEW OF BOSCH CLAW-POLE ALTERNATOR

Right from the beginning, vehicles were fitted with dynamos for producing electricity. In present day vehicles the number of electrical accessories used has increased. Thus the demand for higher capacity generators has arisen. This can only be met by increasing the capacity of the generator and also by running it at higher speeds.

The vehicles in large cities have to, often, 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.

Alternator wiring circuit in a vehicle (Fig 2)

Fig 2



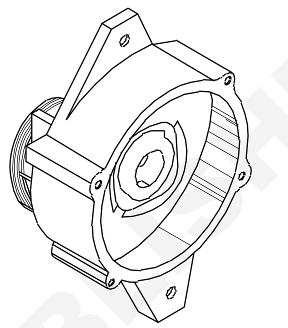
ALTERNATOR WIRING CIRCUIT IN A VEHICLE

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 indicator lamp (10). The terminal (6) of the voltage regulator (4) is connected to the Ignition terminal (SW).

Description of parts of an alternator

Drive end frame (Fig 3)

Fig 3



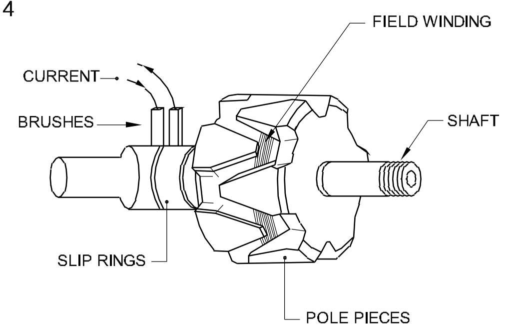
DRIVE END FRAME

The drive end frame supports a pre-lubricated sealed bearing in which the drive end of rotor shaft rotates.

The rotor and its shaft is mounted and encased between drive end frame and slip ring end frame.

The rotor assembly (Fig 4)

Fig 4

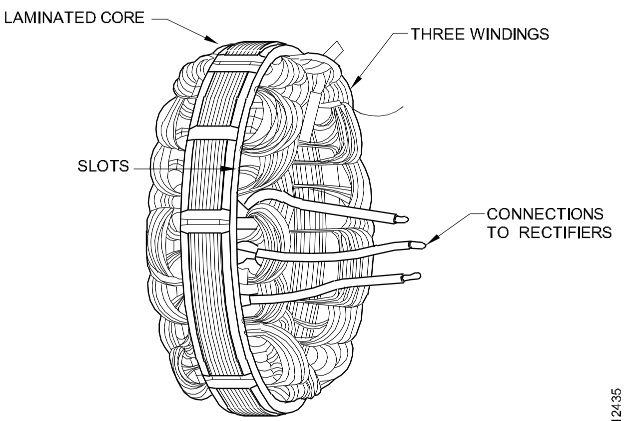


This consists of a steel shaft which carries the driving pulley and cooling fan, a cylindrical iron core, and two insulated slip rings. A large number of turns of insulated wire are wound over the core to form the field winding. Each end of the winding is connected to its own slip ring and spring-loaded brush. The winding is enclosed by two iron pole pieces with eight interlocking fingers which become 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 held between two end covers. (Figs 1 & 5)

Fig 5



STATOR ASSEMBLY

This consists of a laminated, cylindrical, iron core which is slotted to permit the fitting of three sets of insulated windings. In the lighter units these windings are start 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.

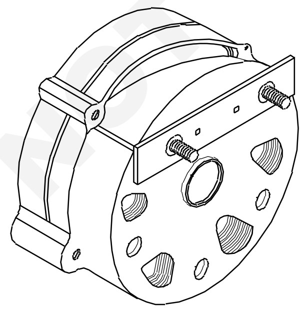
Diodes: The diodes are made of silicon and these allow current to flow in one direction only. They are so connected as to allow the current to flow from the alternator to the battery but not in the opposite direction.

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.

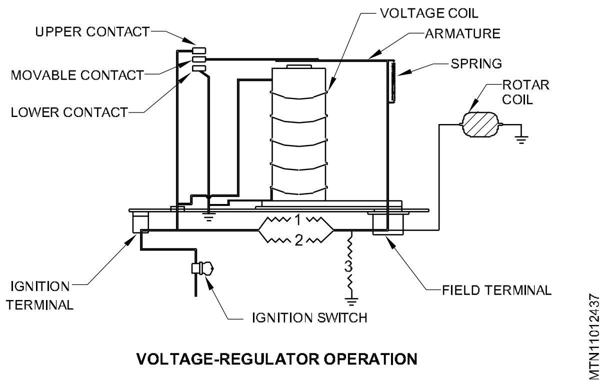
Fig 6



SPRING END FRAME

Voltage regulator (Fig 7): A voltage regulator is used to keep the output voltage of the alternator constant to prevent severe damage to the battery and other electrical accessories.

Fig 7



VOLTAGE-REGULATOR OPERATION

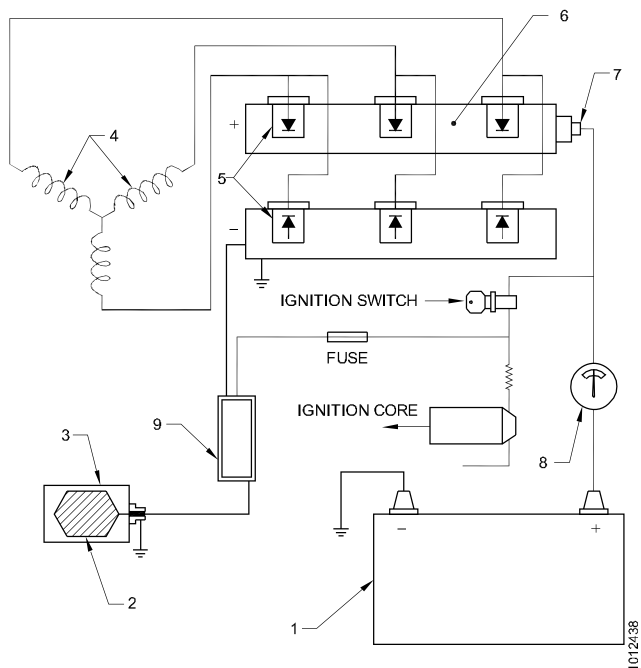
The voltage regulator is fitted outside or inside the alternator.

Current regulator: Most automobile alternators do not require a current regulator because they have been provided with current limiting action. The stronger magnetic field produced in the stator windings due to increase in the current flow results in this action. This magnetic field counteracts the rotating field and at one stage the stator and the rotating fields are practically in balance and hence higher outputs are prevented.

Also no current regulator is required because the alternator is inherently self-limiting. Since the alternator diodes have a high resistance to the flow of current in one direction, they are connected in a manner which will not allow current to flow from the battery to the alternator and no circuit breaker is required.

Operation of alternator (Fig 8)**:**When the engine is started, the belt drives the rotor (3) assembly.

Fig 8



ALTERNATOR CHARGING CIRCUIT

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 rotor magnets pass through each stator coil (4) in a given time, the generation of current will be more, since they form 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 the charging.

Common trouble in alternator

Objectives: At the end of this lesson you shall be able to
- **state the precautions to be followed while using alternators**
- **state the common troubles and their remedies in alternators.**

Precautions to be followed while handling alternators

- Ensure all connections are tight and clean.
- Ensure that there is no open circuit in the charging circuit.
- Observe correct polarity when refitting battery in the vehicle. Reversed battery connections may damage the rectifier and the vehicle wiring.
- Do not short or ground any of the terminals of the alternator or regulator.
- Do not allow water to seep into the alternator.
- Do not operate the alternator unless it is connected to a load.
- Disconnect the battery, alternator and regulator before carrying out any arc welding on the vehicle.
- The alternator should not be mounted near the exhaust manifold without suitable heat protection.
- Do not attempt to polarise the alternator.
- The field circuit must never be grounded on this system between the alternator and the regulator.
- Maintain belt tension.

Common troubles and remedies in alternator

Objectives: At the end of this lesson you shall be able to
- **state the causes and their remedies for no charge when engine is running**
- **state the causes and their remedies for low output voltage**
- **state the causes and their remedies for excessive output (charging at high rate)**
- **state the causes and their remedies for noisy alternator.**

Trouble	Causes	Remedy
1 No charge when engine is	Blown fuse wire in regulator.	Locate cause and rectify and then replace fuse.
	Drive belt loose.	Adjust belt tension.
	Broken drive belts.	Replace
	Wornout or sticky brush.	Rectify. Replace
	Open field circuit.	Rectify.
	Open charging circuit.	Rectify.
	Open circuit in stator winding.	Rectify
	Open rectifier circuit	Rectify
	Defective diodes.	Replace
	Worn or dirty slip rings.	Replace
	Loose connections.	Tighten
2 Low voltage output from alternator.	Drive belt loose.	Adjust belt tension
	Faulty regulator.	Replace
	Grounded stator.	Rectify
	Low regulator setting.	Adjust regulator
	Shorted rectifiers.	Replace
	Loose connections on alternator.	Tighten
	High resistance in charging system.	correct it
	Slip rings dirty and worn out.	Clean/replace

3 Charges at high rate.	Voltage regulator’s setting too high.	Reset
	Regulator voltage winding open.	Replace
	Poor regulator ground connection.	Rectify
	Sticky regulator contacts.	Rectify
4 Alternator noisy.	Loose mountings.	Tighten
	Worn out/Loose fan belt.	Replace
	Worn out/damaged bearings.	Replace
	Open or shorted stator winding.	Rectify
	Shorted rectifier.	Replace
	Fan mountings loose mountings	Tighten fan’s
	Brushes not seating Properly	Rectify
	Loose drive pulley	Tighten

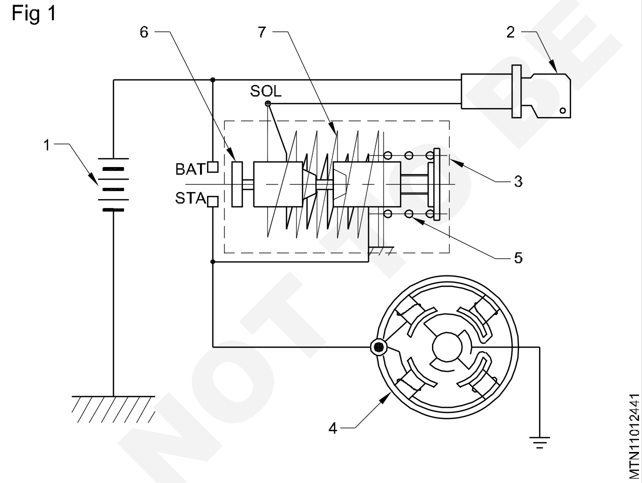
Starting system

Objectives: At the end of this lesson you shall be able to
- **explain starting circuit**
- **explain the need of starter motors**
- **explain the construction of a starter motor**
- **explain the functions of a starter motor**
- **explain the functions of a starter drive unit**
- **explain the need of a solenoid switch**
- **explain the functions of the solenoid switch.**

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 turns the engine flywheel till the engine starts.

Description of a starting circuit (Fig 1)

Fig 1



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, disconnection the starter motor from the battery.

Starter motor: The engine crankshaft must be rotated at a speed of a minimum 100 r.p.m to start the engine. This action is called engine cranking. As it is hard to rotate the engine at that speed by hand or with a lever, a starter motor is used to crank the engine.

Location of the starter motor: The starter motor is fixed in the rear side of the engine, when the starter is switched on the starter motor’s pinion engages with the flywheel ring gear and rotates the flywheel.

Principle

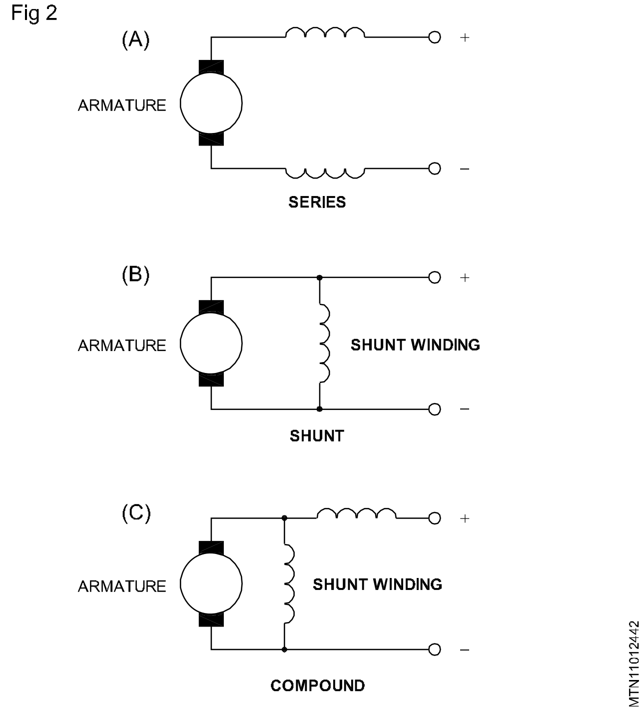
When a current is passed through an armature coil which is placed between two stationary magnets an e.m.f is induced and the armature coil starts rotating.

Construction

Three kinds of DC starter motors are used. (Fig 2)

– Series
– Shunt
– Compound

Fig 2



In automobiles the series wound type is generally used. In this the field and armature coils are connected in series. This enables the motor to produce a high starting torque. The armature windings (1) are fixed in slots and their ends are soldered to the commutator segments (2). The pole shoes (3), two or four in number, are screwed to the yoke (4) and they have field windings (5). These windings help to produce the magnetic field. The insulation pieces are placed between the pole shoes (3) and metal yoke (4). Copper segments are provided with mica insulation in between the commutator brushes (6).

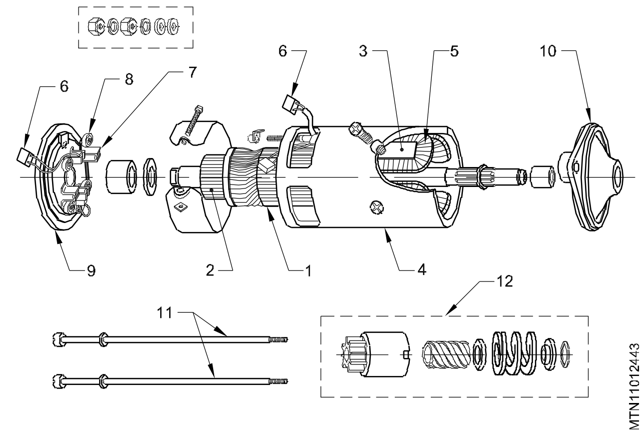
These brushes (6) slide in the brush holders and are kept in contact with the commutator with the help of small springs (8). The brushes (6) are given a curvature at the bottom to have more contact with the commutator (2). The armature is supported either on bushes or coil.

The commutator end is covered by a bracket called commutator end bracket (9). At the drive end, it is covered by the drive end bracket (10). Both the brackets are connected by through bolts (11). At the drive end in the armature shaft, a drive mechanism (12) is fitted.

Operation of starter motor: 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. (Fig 3)

Once the engine starts running under its own power it attains a speed upto 4000 r.p.m (depending upon the design). Since the flywheel ring to starter pinion ratio is

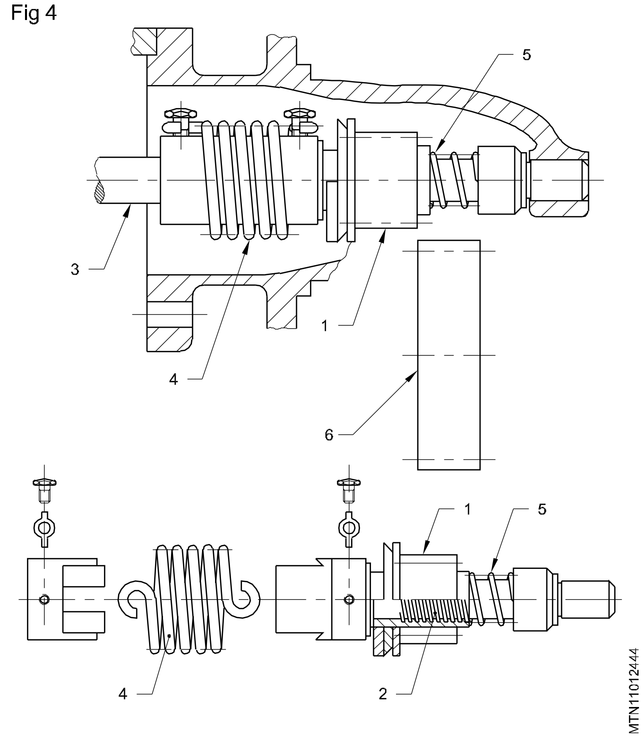
Fig 3



very high, the starter pinion will rotate at a much higher speed than the engine. This speed will damage the starting motor by throwing the windings out of the armature slots and also the commutator segments due to centrifugal force. In order to prevent this it is necessary to disengage the starter pinion from the flywheel ring gear once the engine has started. To achieve this three types of drive mechanisms are used.

Bendix drive: 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 95) 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 4)

Fig 4



When the motor is switched on, the drive head rotates with the armature shaft (3). This motion is transmitted to the sleeve. The pinion (1) rotates along with the sleeve and travels forward to come in mesh with the flywheel ring gear (6). Now the engine's crankshaft rotates and the engine is started. When the engine speed increases the pinion (1) is thrown back to its original position due to inertia.

Over running clutch drive: The shift lever (2) is used by the over-running clutch to slide the pinion along the armature shaft (3) for meshing into or out of the flywheel teeth (4). The shift lever (2) is operated either by a solenoid (5) or by manual linkage. 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. (Figs 5&6).

Fig 5

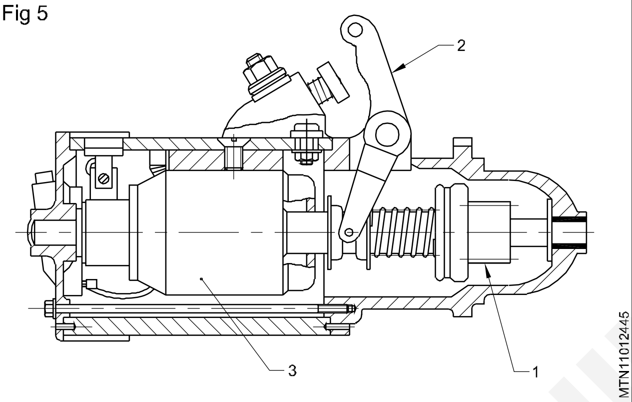
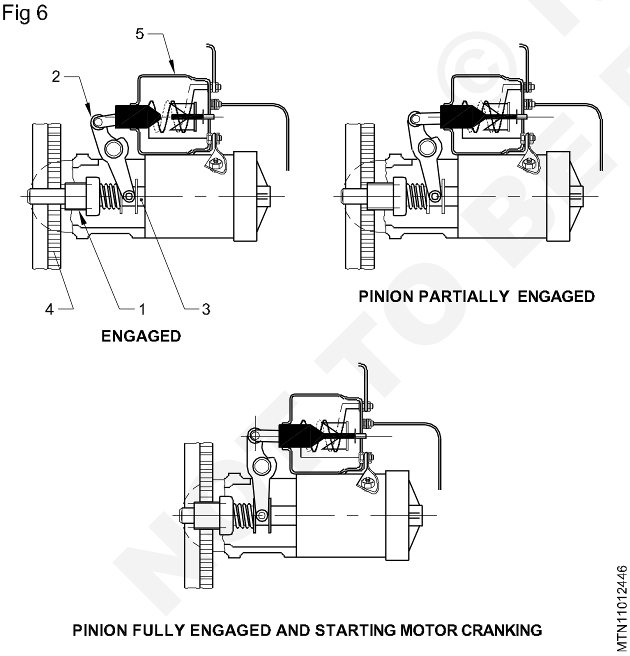


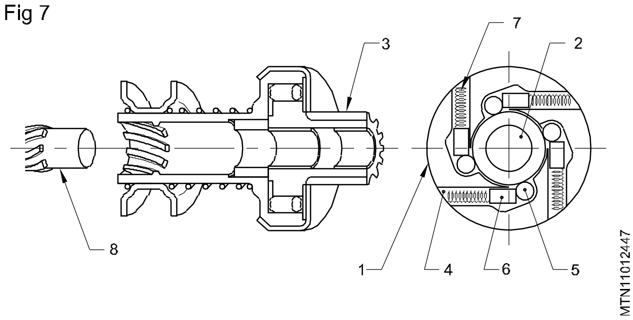
Fig 6



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. (Fig 7)

The pinion gear (3) is fastened to a collar (6) 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.

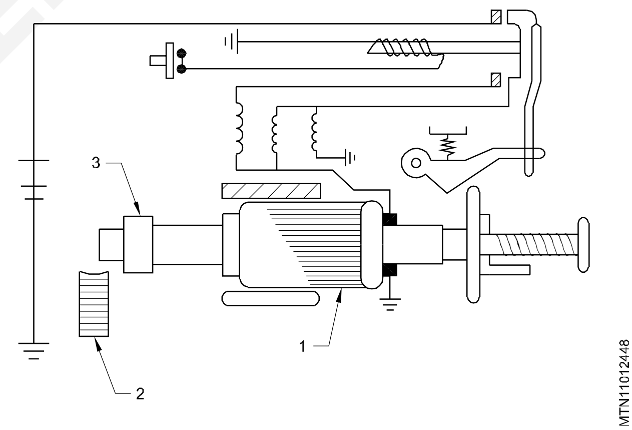
Fig 7



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: This type of drive allows its armature (1) to slide in order to enable its pinion to come in mesh with the flywheel ring gear (2). When the starter switch is operated, the solenoid coil is energised. This completes the circuit of the shunt winding and also of an axillary series field winding. The armature is pulled due to the magnetic field and the pinion (3) engages with the flywheel ring gear (2). A clutch is provided between the armature (1) and pinion (1). When the starter switch is released, the armature returns to its original position by the return spring. Since the pinion (1) is still in mesh with the flywheel (2). (Fig 8)

Fig 8

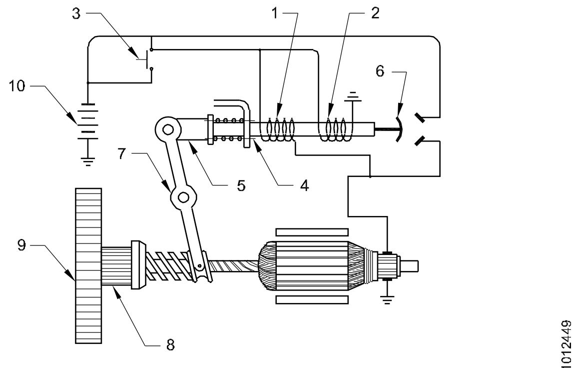


It rotates at very high speed but the clutch prevents the rotation of the armature at the pinion's speed and prevents damage to the armature. The pinion is held in mesh until the starter switch is released by the auxiliary shunt winding. When the engine starts, the current falls down and the magnetic 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.

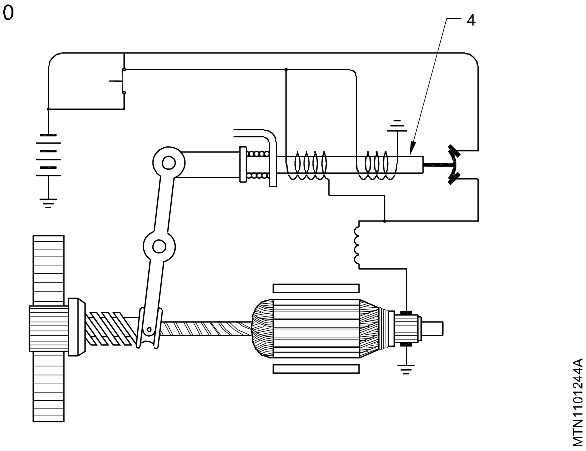
Construction of solenoid switch: (Fig 9) In a solenoid there are two windings, a pull-in winding (1) and a hold-in

Fig 9



CONSTRUCTION OF SOLENOID SWITCH

Fig 10



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 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 10)

Function of solenoid switch: When the starter switch (3) is turned, current flows from the battery to the solenoid windings (1) and (2). This energises the windings which pull the plunger (5). The plunger (5) operates the shift lever 97) to engage the pinion (8) on the flywheel ring gear (9). Then it closes the circuit between the battery (10) and the starting motor.

Common troubles and remedy in starter circuit

Trouble	Remedies
Heavy starter cable terminal worm unit solenoid coil defective sleeve operating lever bend	Replace Replace the solenoid Replace/Replace
Pinion gear teeth wornout	Replace the pinion
Armature short circuit	Rewinding/Replace
Cummulator wornout	Reground / Replace
Carbon brush wornout	Replace
Carbon brush spring tension week	Replace
Field winding short circuited	Rewinding
Pinion gear returning spring broken	Replace
Starter motor mounting loose connection	Tighten
Solenoid plunger jam	Check the fork lever
Plunger contact point pitted/burnt	Clean/Replace

Note:

Battery: Refer Excercise No. 1.3.20