MECHANIC AUTO BODY REPAIR

NSQF LEVEL - 3

TRADE THEORY

SECTOR: AUTOMOTIVE

(As per revised syllabus July 2022 - 1200 Hrs)

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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

Sector : Automotive

Duration : 1 Year

Trade : Mechanic Auto Body Repair - Trade Theory - NSQF Level - 3 (Revised 2022)

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2022 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Mentor Councils comprising various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai has now come up with instructional material to suit the revised curriculum for **Mechanic Auto Body Repair- Trade Theory - NSQF Level - 3 (Revised 2022) in Automotive Sector under Yearly Pattern.** The NSQF Level - 3 (Revised 2022) Trade Theory will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 3 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 3 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

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

PREFACE

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

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

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

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

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

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

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

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

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

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MEDIA DEVELOPMENT COMMITTEE MEMBERS

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

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

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

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the Course of the **Mechanic Auto Body Repair** Trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF LEVEL - 3 (Revised 2022) syllabus are covered.

The manual is divided into Ten modules.

Module 1 **Workshop safety practices**

Module 2 **Hand and power tools**

Module 3 **Basic electricity**

Module 4 **Hydraulics, pneumatics and auto industry development**

Module 5 **Vehicle construct on technology and compressor air system**

Module 6 **Welding technology**

Module 7 **Auto body sheet metal repair techniques**

Module 8 **Auto body paint technology**

Module 9 **Auto body plastic repair technology**

Module 10 **Auto body parts and unibody/frame alignment**

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 Diesel Trade. The contents are sequenced according to the practical exercise contained in NSQF LEVEL - 3 syllabus on Trade practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

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

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

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

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No	Learning Outcome	Lesson No
1	Check & perform Measuring & marking by using various Measuring & Marking tools following safety precaution (Vernier Calliper, Micrometer, Telescope gauges, Dial bore gauges, Dial indicators, straightedge, feeler gauge, thread pitch gauge, vacuum gauge, tire pressure gauge.)	1.1.01-1.2.13
2	Plan & perform basic fastening & fitting operation by using correct hand tools, Machine tools &equipments	1.2.14-1.2.19
3	Check & perform Measuring & marking by using various Measuring & Marking tools following safety precaution (Vernier Calliper, Micrometer, Telescope gauges, Dial bore gauges, Dial indicators, straightedge, feeler gauge, thread pitch gauge, vacuum gauge, tire pressure gauge.)	1.2.20
4	Plan & perform basic fastening & fitting operation by using correct hand tools, Machine tools &equipments.	1.2.21-1.2.30
5	Trace and Test all Electrical & Electronic components & circuits and assemble circuit to ensure functionality of system.	1.3.31-1.4.35
6	Check & Interpret Vehicle Specification data and VIN Select & operate various Service Station Equipments.	1.4.36-1.4.40
7	Assess damage to Vehicle and identify repair and replacement needs	1.5.41-1.5.50
8	Identify various vehicle parts and Service, Repair and Maintenance of Air compressor and Air Lines.	1.5.51-1.5.55
9	Demonstrate the proper operation and methods of welding and cutting equipment including plasma arc cutting processes.	1.6.56-1.6.65
10	Analyze minor body damage and perform repair following sequential procedures involved in metal damage repair.	1.7.66-1.8.74
11	Evaluate and repair damage plastic part.	1.9.75-1.9.78
12	Demonstrate glasses, body parts and door fitting and repairing process	1.9.79-1.10.91
13	Demonstrate knowledge of the procedures for diagnosing structural collision damage and measuring systems to identify location and extent of damage.	1.10.92-1.10.95
14	Demonstrate how to use frame straightening equipment and re-alignment procedures along with various anchoring methods and ensuring the structural integrity of the vehicle and occupant safety.	1.10.96 & 1.10.97

SYLLABUS

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 86 Hrs; Professional Knowledge 13 Hrs	Check & perform Measuring & marking by using various Measuring & Marking tools following safety precaution (Vernier Caliper, Micrometer, Telescope gauges, Dial bore gauges, Dial indicators, straightedge, feeler gauge, thread pitch gauge, vacuum gauge, tire pressure gauge.)	1. Familiarization with institute, Job opportunities in the automobile sector.(04 hrs) 2. Machinery used in Trade. (08 hrs) 3. Types of work done by the students in the shop floor. (10hrs)	Admission & introduction to the trade: Introduction to the Course duration, course content, study of the syllabus. General rule pertaining to the Institute, facilities available- Hostel, Recreation, Medical and Library working hours and time table. (03 hrs)
		4. Practical related to Safety and Health.(5 hrs) 5. Importance of maintenance and cleanliness of Workshop. (2 hrs) 6. Use of fire extinguishers. (5 hrs) 7. Demonstration on safe handling and Periodic testing of lifting equipment. (5 hrs) 8. Safety disposal of used engine oil. Energy saving Tips/Audit of ITI electricity Usage.(5 hrs)	**Occupational Safety & Health** Importance of Safety and general Precautions to be observed in the shop. Basic first aid, safety signs - for Danger, Warning, caution & personal safety message. Safe handling of Fuel Spillage, Fire extinguishers used for Different types of fire. safe disposal of toxic dust, safe handling and Periodic testing of lifting equipment, Safety disposal of Used engine oil, Electrical safety tips. Hazard identification, spatter hazard etc and countermeasure to eliminate them & importance of usage of PPEs.(03 hrs)
		9. Practice using all marking aids, like steel rule with spring calipers, dividers, scriber, punches, Chisel etc.(12 hrs) 10. Layout a work piece- for line, circle, arcs and circles.(10 hrs) 11. Practice to measure a wheel base of a vehicle with measuring tape.(5 hrs) 12. Practice to remove wheel lug nuts with use of an air impact wrench. (05 hrs) 13. Practice on General workshop tools & power tools and equipments.(10hrs)	**Hand Tools** Marking scheme, Marking material-chalk, Prussian blue. Cleaning tools- Scraper, wire brush, Emery paper, Description, care and use of Surface plates, steel rule, measuring tape, try square. Calipers-inside and outside. Dividers, surface gauges, scriber, punches-prick punch, center punch, pin punch, hollow punch, number and letter punch. Chisel-flat, cross-cut. Hammer-ball pein, lump, mallet. , Different type of -body hammers, pick hammers, , Bumping hammers, finishing hammers, dolly block, and body spoon, body picks, body pullers and pull rods, suction cup, scratch awl,

			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, Metal cutting shears- Tin snips, sheet metal cutting pliers, (Aviation snips), panel cutters, trim and upholstery tools, Door handle tool (clip pullers), Metal files-reveal file, surform file, sanding board, sanding block, spreaders and squeegees. (07 hrs)
Professional Skill 46 Hrs; Professional Knowledge 10 Hrs	Plan & perform basic fastening & fitting operation by using correct hand tools, Machine tools & equipments	14. Practice on General workshop tools & power tools and equipments. (05 hrs) 15. Practice on visual Identification of materials used in workshop.(08 hrs) 16. Trouble shooting for Air drills- Tool will not run, Tool locked up, spindle will not run, tool will not shutoff, Trouble shooting for Air hammers-tool will not run, chisel stack in nozzle.(10hrs) 17. Trouble shooting for Air ratchet-Motor runs, spindle does not turn or turns erratically, motor will not run, Trouble shooting for Air Wrenches-Tools run slowly & not at all.(10hrs) 18. Tool will not retract tool leaks under pressure. (08 hrs) 19. Handle kickback, works properly onetime but not the next.(5 hrs)	**Power Tools:-** Air powered tools - Advantage over electrical powered tools, Construction and its parts of air spray gun, Air drill, air screw drivers, air sanders-disc type and dual action(finishing) sander, Different type of air grinders, air saw, air scraper, air shear, air nibblers, air chuck, air polishers/ buffers, media blasting (sand blasting), plastic media blasting, soda blasters, maintenance of pneumatic tools. air impact wrench, air ratchet, air drill, spot weld remover air drill, spot weld cutter-drill type & Hole saw type, air chisel, air blowgun, Spray guns, wrenches- Torque wrenches, pipe wrenches, car jet washers Pipe flaring & cutting tool. Vacuum cleaner, power washers, Heat gun, Hydraulically powered shop equipment- Hand or bottle jacks, Transmission jack, service jack, Frame rack, Maintenance of hydraulic tools, hydraulic lifts. Engine crane.(10 hrs)
Professional Skill 20 Hrs; Professional Knowledge 04 Hrs.	Check & perform Measuring & marking by using various Measuring & Marking tools following safety precaution (Vernier Calliper, Micrometer, Telescope gauges, Dial bore gauges, Dial indicators, straightedge, feeler gauge,	20. Measuring practice on different components.(20 hrs)	**Systems of measurement:** Description, care & use of Micrometers - Outside and depth micrometer, Micrometer adjustments, Vernier calipers. (04 hrs)

	thread pitch gauge, vacuum gauge, tire pressure gauge.)		
Professional Skill 98 Hrs; Professional Knowledge 15 Hrs	Plan & perform basic fastening & fitting operation by using correct hand tools, Machine tools &equipments.	21. Practice on General cleaning, checking and use of nut , bolts, & studs etc.(12 hrs) 22. Removal of stud/bolt from blind hole.(08 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. Description of Riveting tools. (03 hrs)
		23. Practice on cutting tools like Hacksaw, file, chisel, OFF-hand grinding with sander, bench and pedestal grinders, safety precautions while grinding.(15 hrs) 24. Practice on Hacksawing and filing to given dimensions. (10 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., chisel, OFF-hand grinding with sander, bench and pedestal grinders, safety precautions while grinding. (03 hrs)
		25. Practice on Marking and Drilling clear and Blind Holes, Sharpening of Twist Drill.(10hrs) 26. Safety precautions to be observed while using a drilling machine. (08 hrs) 27. Practice on Tapping a Clear and Blind Hole, Selection of tape drill Size, use of Lubrication.(10hrs) 28. Use of tap extractor, Cutting Threads on a Bolt/ Stud.(10hrs) 29. Practice on making Rectangular Tray. (05 hrs) 30. Soldering and Brazing of Pipes. (10 hrs)	Drilling machine -Description and study of Bench type Drilling machine, Portable electrical Drilling machine, drill holding devices, Drill bits. Taps and Dies: Hand Taps and wrenches, Different type of Die and Die stock. Screw extractors. Hand Reamers - Different Type of hand reamers.(05 hrs) Sheet metal - State the various common metal Sheets used in Sheet Metal shop. Sheet metal operations - Shearing, bending, Drawing, Squeezing. Sheet metal joints - Hem & Seam Joints Fastening Methods - Riveting, soldering, Brazing. fluxes used on common joints. Sheet and wire-gauges. The blow lamp- its uses and pipe fittings. (04 hrs)
Professional Skill 38 Hrs; Professional Knowledge 05 Hrs	Trace and Test all Electrical & Electronic components & circuits and assemble circuit to ensure functionality of system.	31. Practice in joining wires using soldering Iron. (4 hrs) 32. Measuring of current, voltage and resistance. (03 hrs) 33. Using digital multimeter, practice continuity test for fuses, jumper wires, fusible links, circuit breakers. (6 hrs)	Basic electricity, Electricity principles, Ohm's law, Voltage, Current, Resistance, Power, Energy. Voltmeter, ammeter, Ohmmeter Multimeter, Conductors & insulators, Wires.(03 hrs)

		34. Perform voltage drop test in circuits using multimeter, measure current flow using multimeter /ammeter. (10hrs) 35. Identification of Hydraulic and pneumatic components used in vehicle. (15hrs)	Introduction to Hydraulics & Pneumatics: - Definition of Pascal law, pressure, Force, viscosity. Pneumatic Symbols. (02 hrs)
Professional Skill 25 Hrs; Professional Knowledge 03 Hrs	Check & Interpret Vehicle Specification data and VIN Select & operate various Service Station Equipments.	36. Identification of different type of Vehicle. (5 hrs) 37. Demonstration of vehicle specification data. (5 hrs) 38. Identification of vehicle information Number (VIN). (5 hrs) 39. Demonstration of Garage, Service station equipments.(5 hrs) 40. Vehicle hoists - Two post and four post hoist, Engine hoists, Jacks, Stands. (5 hrs)	Auto Industry - History, leading manufacturers, development in automobile industry, trends, new product. Brief about Ministry of Road transport & Highways, The Automotive Research Association of India (ARAI), National Automotive Testing and R&D Infrastructure Project (NATRIP), & Automobile Association. Definition: - Classification of vehicles on the basis of load as per central motor vehicle rule, wheels, final drive, and fuel used, axles, position of engine and steering transmission, body and load. Brief description and uses of Vehicle hoists - Two post and four post hoist, Engine hoists, Jacks, Stands. (03 hrs)
Professional Skill 75 Hrs; Professional Knowledge 14 Hrs	Assess damage to Vehicle and identify repair and replacement needs	41. Practice on preparation of accident report. (15hrs) 42. Preparation of Body shop repair sequence procedures. Washing of vehicle.(5 hrs) 43. Identification of different type body, chassis, Drive lines.(05 hrs) 44. Identify the location of parts and panels. (5 hrs) 45. Identify the parts of unibody design vehicle. (5 hrs) 46. Identify the front body structural components of a transverse-mounted engine of FWD vehicle. Identify the rear body structural components of a unibody sedan. (5 hrs) 47. Identify the under body front and rear section structural components of a unibody sedan. (5 hrs) 48. Identity the front, rear body structural components of mid-engine vehicle. (5 hrs) 49. Identify the parts of a full frame of pickup truck and Sports utility vehicle (SUV). (10 hrs)	**Introduction to Engine:** Description of internal & external combustion engines, Classification of IC 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, Technical terms used in engine, Engine specification.. **Vehicle construction Technology:** Definition of collision repair, body shop, classification of body shop- Independent body shop, dealership body shop, specialty body shop. Description of Repair order(RO) Description of vehicle Body and Chassis, Vehicle Frame- definition, Body- over-frame (Independent frame) construction, Hydro formed frame, Unibody construction; Major Body Sections-Front, Center, rear section, and vehicle left and right sides; Drive line configuration- Transverse engine, longitudinal

		50. Practice on use of computer-based service information, service manuals, collision repair guides, refinishing guides, vehicle dimension manual, color matching guides, parts interchange guides. (15 hrs)	engine, front-engine front wheel drive (FWD), front-engine rear wheel drive (RWD), Rear-engine rear wheel drive (RRD), Mid-engine rear wheel drive (MRD), Four-wheel drive (4WD); Body Classifications-Based on Car size, Roof designs; Body panels, Description of Unibody Panels and their parts, Unibody Design Factors, Advantage of Aerodynamic design, General unibody characteristics, Plastic parts and panels, composite unibody frame, Aluminium vehicle construction, , Body-Over-Frame Considerations -characteristics of body-over-frame vehicles, Full frame designs-Ladder frame, Perimeter frame, X-frame (or backbone frame), Crash Testing-Types of crash tests. Service information, Specifications, and Measurements - Study of Service Information, basic steps to using refinishing materials information, Vehicle paint code, study of service symbols, diagnosis charts, wiring diagram, Collision Repair Measurements. (14 hrs)
Professional Skill 41 Hrs; Professional Knowledge 06 Hrs	Identify various vehicle parts and Service, Repair and Maintenance of Air compressor and Air Lines.	51. Identify the parts of a piston type stationary compressor, Overhauling of Air compressor, Overhauling of service (FRL) unit, Drain the air receiver and the moisture separator/ regulator or air transformer. (10 hrs) 52. Check the level of the oil in the crankcase, clean air filters, Clean or blow off fins on cylinders, heads, intercoolers, After coolers. (08 hrs) 53. Check the oil filter in the air line and change the filter element if necessary, Adjust the pressure switch cut-in and cut-out settings if Needed, Check the relief valve for exhausting of head pressure each time the motor stops. Tighten belts to prevent slippage. (12 hrs) 54. Check and align a loose motor pulley or compressor. (03 hrs) 55. Check for air leaks on the compressor outfit and air piping system. (08 hrs)	**Compressor Air system :** Basic requirement for compressed air systems, Type of Compressor- Description and construction of Diaphragm compressor, piton type compressor-single stage and two stage, rotary screw air compressor, Performance of air compressor- Description of Horse power, delivery volume, displacement, Free air delivery, compressor volumetric efficiency, tank size, Air and Fluid Control Equipment - In take air filter, Distribution system, regulator, lubricator, different type air purification method, Compressor Accessories -Hose type, hose size, maintenance of hose, connectors, adapters and couplings, Air System Maintenance. Study the typical piping arrangement found in a body shop, colour coding of airline, water line and fuel line. (06 hrs)

Professional Skill 102 Hrs; Professional Knowledge 25 Hrs	Demonstrate the proper operation and methods of welding and cutting equipment including plasma arc cutting processes	56. Identify the parts of an oxyacetylene welding and cutting outfit.(08 hrs) 57. Practice on Oxyacetylene welding process, Practice on Soldering and brazing. (10 hrs). 58. Practice on torch flame adjustment. (02 hrs) 59. Identify the different parts on MIG welding machine, Selection of weld specification as per manual, selection of MIG wire size. (5 hrs) 60. Compare the welding methods used in vehicle production, practice on surface preparation and setting of welding parameter, use of clamping and MIG welding of sample panel, practice on plug weld hole for body panel replacement.(10 hrs) 61. Practice on Spraying antispatter compound into a MIG nozzle will help protect the tip and prevent the wire from sticking in the gun, Practice on Flat, Horizontal, vertical and overhead welding position. (10 hrs) 62. Practice on continuous, plug, stitch, MIG spot, lap, tack welding techniques, Identify the different parts on SPOT welding machine.(20 hrs) 63. Practice on resistance spot welding process on different thickness materials. (10 hrs) 64. Practice tip dressing, tip change, chisel test nugget test for spot welding to ensure the spot weld quality.(15 hrs) 65. Practice on plasma cutting operation. (12 hrs)	**Welding:** Introduction to joining of metals, Welding characteristics, weld terminology, weld symbols, Common Auto body welding techniques- MIG, TIG, Soft brazing, Factory weld specification, Typical Auto body MIG wire sizes, Typical Auto body shielding gases, Heat affected Zone (HAZ), Auto body MIG welding -Principles & characteristics, MIG welding equipments, Welding lens, MIG operation methods, MIG welding equipment, MIG welding current, MIG Arc voltage, MIG Tip to base metal distance, MIG gun angle and welding direction, MIG shield gas flow volume, MIG welding speed, MIG wire speed, MIG gun nozzle adjustment, Heat buildup penetration, clamping tools for welding, Welding position. welding Technique- Tack weld, Continuous weld, plug weld, spot weld, lap weld, stitch weld, intermittent weld, Base welding method-Butt welds lap & flange welding, plug weld, stitch weld, MIG welding of Galvanized metals & Aluminum, Welding Aluminum, MIG weld defects, Testing the MIG weld. FCAW (Flux cored Arc welding) , TIG Welding, Resistance spot welding, Resistance spot welding components, Spot welder adjustments, Operating a squeeze-type resistance spot welder, Other spot welding functions, stud spot welds for dent removal, Oxyacetylene welding, welding & cutting equipment, types of flame and adjustment, welding torch flame adjustment, gas cutting torch flame adjustment, cutting HSS for salvage purposes, Heat crayons, Cleaning with a torch, Probable causes and remedies for flame abnormalities, Brazing, interaction of flux and brazing rods, Brazing joint strength, Brazing operations, Treatment after brazing, Soldering (soft brazing) soldering procedure, plasma arc cutting, operating a plasma arc cutter. Advantage and disadvantage over different type of welding methods. (25 hrs)

Professional Skill 66 Hrs; Professional Knowledge 15 Hrs	Analyze minor body damage and perform repair following sequential procedures involved in metal damage repair.	66. Practice on minor repair of damaged car. (5 hrs) 67. Practice on using a hammer and dolly straighten damage on a door. (8 hrs) 68. Using long spoon to pry out a fender to allow for hammer straightening. (8 hrs) 69. Using Pry picks remove small dents in hard-to-reach areas. (09 hrs) 70. Practice on Using dent puller to pull out minor damage along a lip in the fender. (8 hrs) 71. Using a spot weld dent puller remove dents in steel Panels. (8 hrs) 72. Perform Paint Stripping using single action sander, Abrasive selection.(05 hrs) 73. Carry out maintenance of single action sander.(05 hrs) 74. Perform Body Filler application & Sanding to ensure body repair quality. (10 hrs)	**Sheet metal repair.** Automotive sheet metal, basic steps for correcting minor sheet metal damage, Low carbon steel, high strength steels (HSS)- Type of HSS- High tensile strength steel (HTSS), Type of loading- Tensile, compress, shear, cleavage, peel, Properties of sheet metal- Yield strength, Compressive strength, shear strength, torsional strength, effect of impact forces (Yield point), elastic deformation, plastic deformation, work hardening, Classifying body damage- direct damage, indirect damage, work hardening, analyzing sheet metal damage, Buckles- simple hinge buckles, pressure forces, single crown panels-door dings, Determining the direction of damage - metal straightening technique- using body hammer, Bumping dent with dollies, Hammer-on-dolly method, Hammer-off-dolly method, picking dents, unlocking on a hammer & dolly, straightening with body spoons, other metal straightening method-paint removal, pulling dents, spot-weld dent pullers, metal shrinking, stress reliving, stretched metal, Principle of shrinking , shrinking steel panel with heat, Kinking, shrinking a gouge, filing the repair area, working Aluminum panels, working Aluminum with hammer and dolly, straightening aluminum with hammer, filling and grinding aluminum, straightening aluminum by heat shrinkage, Paint less dent removal method. of paint-pain pigments, paint binders, paint solvents, Paint additives, Definition of Drying, curing, flash, retarder, accelerator, catalyst, adhesion promoter, blending solvent, Toners, Primers & sealers- self-etching primer, UV primer Requirement of body filler, components of body filler (filler & hardener), mixing ratio of filler and hardener, tools used for mixing and application - Spatula, Board, application process, drying of body filler using conventional procedure and infrared drier, scuffing, sanding of body filler, defects in body filler application, final finishing of body panel. (15 hrs)

Professional Skill 23 Hrs; Professional Knowledge 07 Hrs	Evaluate and repair damage plastic part.	75. Identify the thermoplastics, thermosetting plastics. (5 hrs) 76. Identify common automotive plastics used in the industry. (5 hrs) 77. Practice on using chemical adhesive bonding techniques to repair of minor cuts and cracks. (5 hrs) 78. Practice on using heat to reshape plastics, (08 hrs)	Repairing Plastics Introduction to plastics, Types of Plastics- Thermoplastics, thermosetting plastics, safety points observed while working with plastic repair, common automotive plastics identification, plastic repair, chemical adhesive bonding techniques- repair of minor cuts and cracks, repair of tears, and punctures, using the right adhesive, Flexible part repair- Plastic welding, Hot air plastic welding, High speed plastic welds, plastic welder setup shutdown, and servicing, Airless plastic welding, ultrasonic plastic welding, plastic welding procedures, general plastic welding, techniques, Plastic tack welding, plastic welding procedures, airless melt-flow plastic welding, plastic stitch-tamp welding, single-sided plastic welds, two sided plastic welds, repairing vinyl, using heat to reshape plastics, ultrasonic stud welding, reinforced plastic repairs. (07 hrs)
Professional Skill 100 Hrs; Professional Knowledge 20 Hrs	Demonstrate glasses, body parts and door fitting and repairing process	79. Practice on Hood removal as per procedure. (5 hrs). 80. Practice on Hood adjustment, Hood-to-hinge adjustment, hood height adjustment, hood latch mechanism, hood latch adjustments, and Bumper replacements. (10 hrs) 81. Practice on Fender removal, installing fenders, fender adjustments, grille service, Trunk lid adjustments, panel alignment, Truck bed service. (20 hrs)	Hood, Bumper, Fender, Lid, And Trim Service Part removal Sequence, Hood service- Hood removal, Hood adjustment, Hood-to-hinge adjustment, hood height adjustment, hood latch mechanism, hood latch adjustments, Bumper replacements, Fender service- Fender removal, installing fenders, fender adjustments, grille service, Trunk lid adjustments, panel alignment, Truck bed service, sound- Deadening pads, custom body panels, installing body trim and moldings, removing adhesive held moldings, installing adhesive body sine moldings. (07 hrs)
		82. Practice on removing windshield, Practice on windshield rubber gasket service. (5 hrs) 83. Practice to align windshield into position during Installation(5 hrs) 84. Practice on using a sealer gun to apply adhesive to windshield glass. (08 hrs)	Door, roof, and glass Service Vehicle Glass Technology- Introduction, type of glass- laminated, plate glass, tempered glass, glass service- removing windshield molding, windshield rubber gasket service, Glass adhesive-full cut-out method, glass adhesive, partial cutout

		85. Identify the basic parts of a door assembly. (5 hrs) 86. Practice on door removal. Practice on repair of modern power window regulator, door lock & latch, Door & Door glass adjustments, servicing welded door hinges, bolted door hinge adjustment. (10hrs) 87. Practice on Door glass adjustment, door trim panel installation tailgate glass service, station wagon tailgate adjustment, rear view mirror service, roof panel service. (12 hrs)	method, windshield wiper service, rear and quarter window service, service doors-door construction, manual & power regulators, checking door operation, door removal, door weather strip service, Door inner trim panel Door window regulator service, door lock & latch service, Door reinforcements, panel adhesive technology, Replacing bonded door skins, replacing SMC(Sheet molded compound) Door skins, Door & Door glass adjustments, servicing welded door hinges, bolted door hinge adjustment, Door glass service- Door glass adjustment, door trim panel installation tailgate glass service, station wagon tailgate adjustment, Glass element repairs, rear view mirror service, roof panel service, fastened roof panel service, convertible top service, Sun roof service. (8 hrs)
		88. Identify the different parts of Passenger Compartment, practice on seat service. (5 hrs) 89. Front seat service, Rear bench seat service, seat cover service, carpeting service, dash panel service, console service. (5 hrs) 90. Instrument cluster service, Headliner service, locating air and water leaks(5 hrs) 91. Checking drain hoses, wind noise, repairing leaks, Rattle elimination, Fixing rattle. (05 hrs)	Passenger compartment Service Major parts of Passenger Compartment - dash assembly, instrument cluster, seat assemblies, interior trim, steering column assembly, headliner assembly, carpeting, weather stripping, Interior trim-pillar trim panels, dash panel, door trim panels, Glass trim panels, sill plates, Introduction to Paint: Primer-sealer, top coats, paint material types-Lacquer, enamel, water base, Content interior trim service- procedure, roll bars, seat service- Front seat service, Rear bench seat service, seat cover service, carpeting service, dash panel service, console service, Instrument cluster service, Headliner service, locating air and water leaks- checking drain hoses, wind noise. (05 hrs)
Professional Skill 70 Hrs; Professional Knowledge 13 Hrs	Demonstrate knowledge of the procedures for diagnosing structural collision damage and measuring systems to identify location and extent of damage	92. Practice on use of trame gauge, upper body dimensioning. (25hrs) 93. Measurement of the front body, measurement of the body side panel, measurement of the rear body Damage Using Gauge Measuring Systems, Strut Centerline Gauge. (15 hrs) 94. Identify the condition of collision, influence of impact on a body-over-frame vehicle, visually determine the extent of impact damage.(15hrs)	Major Body/ frame damage Measurement Vehicle measurement-collision repair process, diagnostic procedure for collision damage, impact and its effects on a vehicle-Determining the condition of collision, influence of impact on a body-over-frame vehicle, Frame deformation-sideway damage, sag damage, mash damage, diamond damage, twist damage, impact effect on unibody vehicles- primary damage area, secondary damage area, collision damage sequence, visually determine

		95. Inspecting for damage from passengers & luggage, Universal Measuring Systems, Computerized Measuring Systems. (15hrs)	the extent of impact damage, inspecting for damage from passengers & luggage, body dimensions- body dimension charts, vehicle measuring basics, measurement importance, Gauge measuring system- trame gauge, upper body dimensioning, measurement of the front body, measurement of the body side panel, measurement of the rear body, digital tram gauges, dimensional references, the centre panel, zero planes, diagnosing damage, measuring Vehicle Impact and Its Effects on a vehicle, Visually Determining the Extent of Impact Damage, Measurement of Body Dimensions, Gauge Measuring System, Tram Gauges, Digital Tram Gauges, Centering Gauges. (13 hrs)
Professional Skill 50 Hrs; Professional Knowledge 10 Hrs	Demonstrate how to use frame straightening equipment and re-alignment procedures along with various anchoring methods and ensuring the structural integrity of the vehicle and occupant safety	96. Practice on analyzing damage- Length damage, Width damage, Height damage. (20 hrs) 97. Practice on repair method for front-end damage, rear damage, side damage, sag damage, twist damage, diamond damage, straightening strut, tower damage, stress relieving, straightening strut tower damage, stress relieving with heat, stress concentrators, Frame Straightening Equipment, anchoring the vehicle using pulling clamps and chains. (30 hrs)	Unibody/ frame alignment Realignment basics-vehicle anchoring and pulling, pulling direction, single-pull method, multiple-pull Method, visualizing front-end Collisions, rear-end collisions, side collision, rollover damage, angled impacts, unibody / Frame Straightening Equipment, in-floor straightening equipment-anchor-pot system and the modular rail frame system. portable body and frame pullers, rack (floor) straightening systems, bench straightening systems, anchoring the vehicle using pulling clamps and chains, other straightening accessories- restraint bar , door aligner, engine holder, portable hydraulic rams, strut plate, straightening and realigning techniques-sequence for a total structure realignment procedure, unibody / frame realignment safety, measuring when pulling, computerized measuring systems, procedure for planning the pull, making pulls-single-pull setup, multiple-pull setups, executing a pulling sequence, purpose of overpulling. (10 hrs)

Admission & introduction to the trade

Objectives: At the end of this lesson you shall be able to
- **introduction to the Course duration, course content, study of the syllabus.**

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 /labor market. The vocational training programmers are delivered under the aegis of National Council of Vocational Training (NCVT). Craftsmen Training scheme (CTS) and Apprenticeship Training Scheme (ATS) and two pioneer programmers of NCVT for Propagator Vocational Training.

Total number of ITIs in India as on April 2016 is about 13105 (Govt. it is 2293 + 10812 Private affiliated ITIs). They are giving training about 132 trades including Engineering and Non-engineering trades with the duration of 6 months, 1 or 2 years. The minimum eligibility for admission in ITIs 8th, 10th and 12th pass with respect to the trades and admission process will be held in every year in July.

From 2013, semester pattern was introduced in 6 months/ Semester with revised the syllabus for each semester.

Then in 2014, they introduced and implemented by "Sector Mentor council (SMC)" re-revised syllabus under 11 sectors of about 87 trades.

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

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

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

Scope of mechanic auto body repair

Objectives: At the end of this lesson you shall be able to
- **importance and scope of the mechanic Auto body repair.**

Scope of the mechanic Mechanic Auto body repair training

Mechanic auto body repair trade comes under craftsman training scheme (CTS). This trade is one of the most popular and delivered nation wide through the network of I.T.I's. 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) they Can join in Craftsman Instructor Training Scheme (CITS) to become an instructor in I.T.I's

Job Opportunities

- Mechanic auto body repair 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 auto body 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 belongs to you.
- Always attend the institute well dressed and good physical appearance.
- Be regular to attend the training without fail and avoid absent from the theory or practical classes for simple reasons.
- Prepare well before writing a test/examination.
- Avoid any malpractice during the test/examination.
- Write your theory and practical records regularly and submit them on time for correction Take care of your safety as well as other's safety while doing the practical's.

Facilities in I.T.I

Hostel, library and medical facilities are provided to I.T.I Trainee's during training period.

Time-table

Practical and theory class hours are scheduled in advance and working hours as generally 8 hrs.

Course Content in the syllabus

- Identify the various types of tools and equipment, raw materials, spares used in mechanic auto body repair trade,
- Trace and test all electrical components of circuits.
- Practice to measuring, fitting, welding, sheet metal works, mechanical and electrical and hydraulic system fault diagnosis and rectification.
- Check and interpreter vehicle specification data and VIN.
- Assess the damage of vehicle and identify repair and replacement parts.
- Evaluate and repair damage plastic parts.
- Analyze the minor body damage and repair work.

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 occupation hygiene**
- **list the types of occupational hazards.**

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

Occupational health and safety

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

Need of occupational health and safety

Health and safety of the employees is an important aspect of a company's smooth and successful functioning.

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

Occupational (Industrial) Hygiene

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

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

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

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

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

Occupational Hazards

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

Types of occupational health hazards

- 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
  - absenteeism
  - disobedience
  - aggressive behavior
- Accident proneness
- Emotional disturbances
  - violence
  - bullying
  - bullyism
  - sexual harassment

6 Mechanical

- Unguarded machinery
- No fencing
- No safety device
- No control device

7 Electrical

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

8 Ergonomic

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

Safety practice

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

Causes for accidents: Normally accidents do not just happen. They are caused. Causes for accidents are many. Some of the important causes are listed below.

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

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

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

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

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

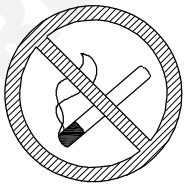
Employee's responsibilities: You will be responsible for use the equipment, A great deal is done by employers and other people to make your working life safer; but always remember you are responsible for your own actions and the effect they have on others. You must not take that responsibility lightly.

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 recognized by their shape and colour. Sometimes they may be just a symbol; other signs may include letters or figures and provide extra information such as the clearance height of an obstacle or the safe working load of a crane. The four basic categories of signs are as follows.

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

Prohibition signs

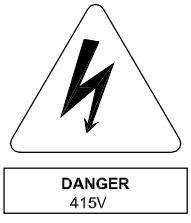


Shape	Circular.
Colour	Red border and cross bar. Black symbol on white background.
Meaning	Shows it must not be done.
Example	No smoking.

Mandatory signs

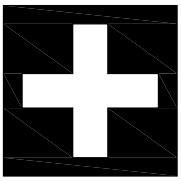
Shape	Circular.
Colour	White symbol on blue background.
Meaning	Shows what must be done.
Example	Wear hand protection.

Warning signs



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

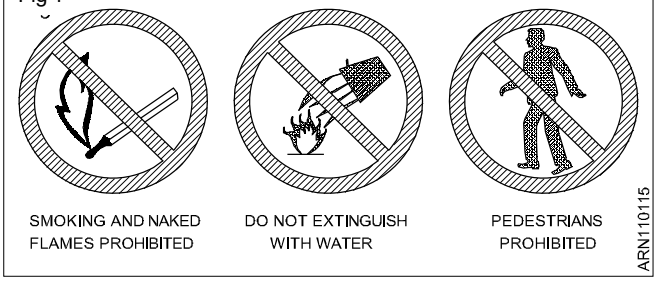
Information signs



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 1)

Fig 1



Mandatory signs (Fig 2)

Fig 2

Questions about your safety (Fig 3)

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?

Fig 3

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

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

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

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

- Stop the machine before changing the speed.
- Disengage the automatic feeds before switching off.
- Check the oil level before starting the machine.
- Before starting the machine, move the ram by hand to ensure that the ram or tool-handler does not strike the work piece 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 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.**

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 labor 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 part.

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 programmer with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table1.

Table1

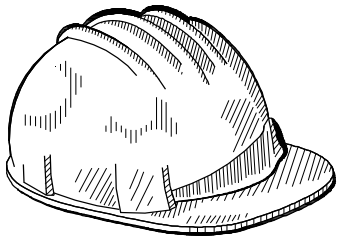
No.	Title
PPE 1	Helmet
PPE 2	Safety footwear
PPE 3	Respiratory protective equipment
PPE 4	Arms and hands protection
PPE 5	Eyes and face protection
PPE 6	Protective clothing and coverall
PPE 7	Ears protection
PPE 8	Safety belt and harnesses

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

Types of protection	Hazards	PE to be used
Head protection (Fig 1)	1 Falling objects	Helmets
	2 Striking against objects	
	3 Spatter	
Foot protection (Fig 2)	1 Hot spatter	Leather leg guards
	2 Falling objects	Safety shoes
	3 Working wet area	Gum boots
Nose (Fig 3)	1 Dust particles	Nose mask
	2 Fumes/ gases/ vapours	
Hand protection (Fig 4)	1 Heat burn due to direct contact	Hand gloves
	2 Blows sparks moderate heat	

	3 Electric shock	
Eye protection (Fig 5, Fig 6)	1 Flying dust particles	Goggles
	2 UV rays, IR rays heat and High amount of visible radiation	Face shield Hand shield Head shield
Face Protection (Fig 6, Fig 7)	1 Spark generated during Welding, grinding	Face shield Head shield with or without ear muff
	2 Welding spatter striking	
	3 Face protection from UV rays screen	Helmets with welders for welders
Ear protection (Fig 7)	1 High noise level	Ear plug, Ear muff
Body protection (Fig 8, Fig 9)	1 Hot particles	Leather aprons

Fig 1



HELMET

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Fig 2

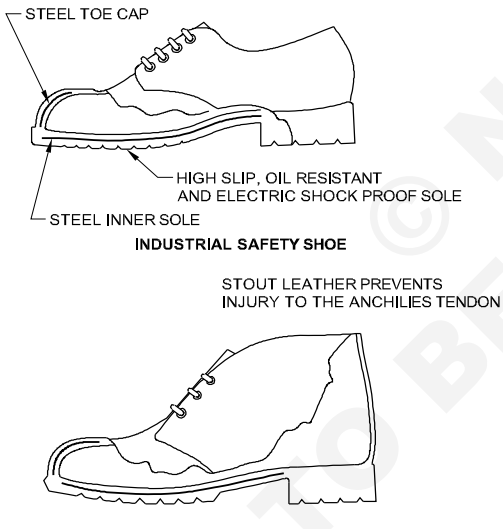

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Fig 3

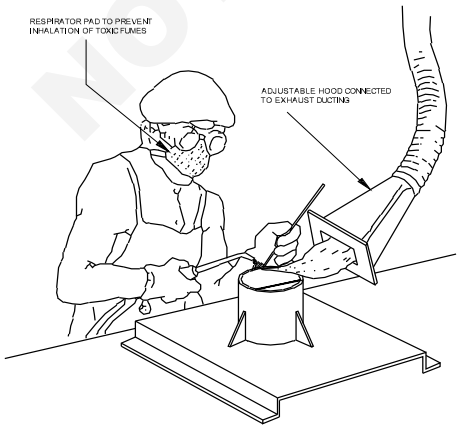

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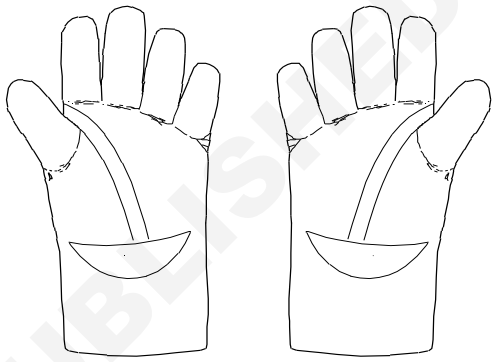
Fig 4



GLOVES

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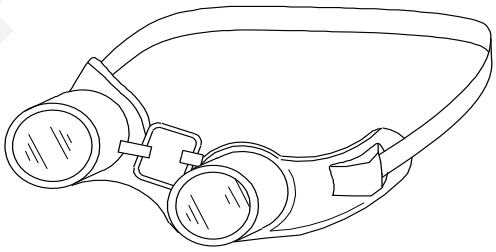
Fig 5



GOGGLES

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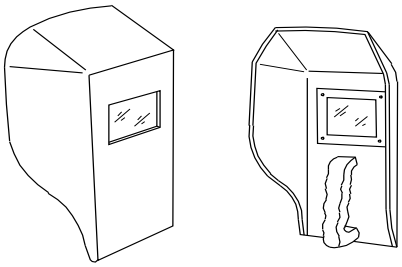
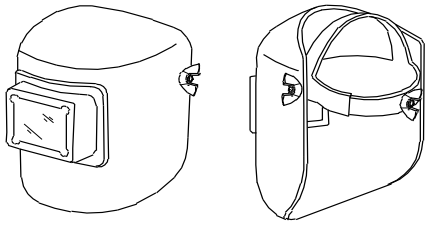
Fig 6



HAND SCREEN

ARN110126

Fig 7



WELDING HELMET

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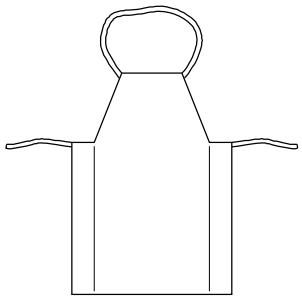
Fig 8



APRON

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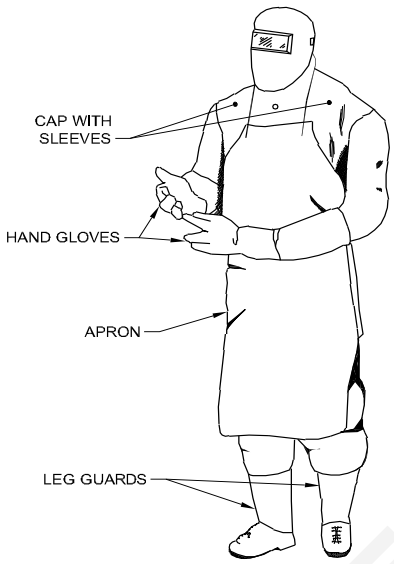
Fig 9



LEG GUARDS

ARN110129

Safe handling of fuel spillage

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

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

Safe handling of fuel

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

2 Fuel should not be stored near the working hot engine.

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

4 No smoking is allowed when refueling to the engine.

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

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

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

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

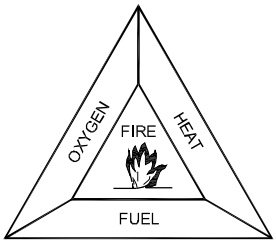
9 Stationary engine fuel tank should be position away from any source of direct heat to the fuel tank.

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



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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 vapor when heated, and it is this vapor which ignites. Some liquids do not have to be heated as they give off vapor at normal room temperature say 15°C, eg. petrol.

Oxygen: Usually exists in sufficient quantity in air to keep a fire burning. Extinguishing of fire: Isolating or removing any of these factors from the combination will extinguish the fire. There are three basic ways of achieving this.

– Starving the fire of fuel removes this element.

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

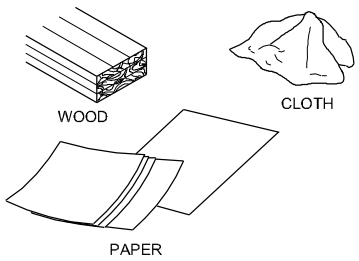
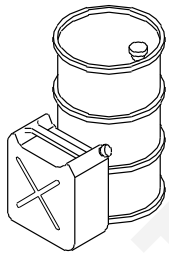
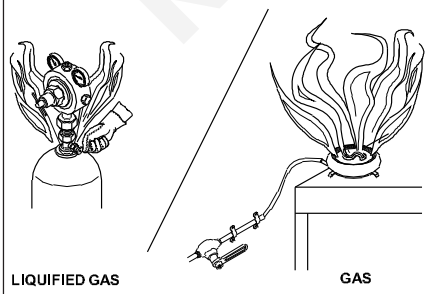
– Cooling - use water to lower the temperature.

Removing any one of these factors will extinguish the fire.

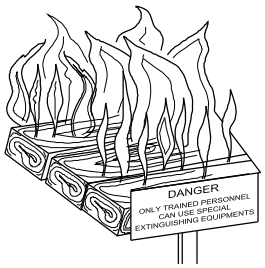
Preventing fires: The majority of fires begin with small outbreaks which burn unnoticed until they have a secure hold. Most fires could be prevented with more care and by following some simple common sense rules.

Accumulation of combustible refuse (cotton waste soaked with oil, scrap wood, paper, etc.) in odd corners are a fire risk. Refuse should be removed to collection points. The cause of fire in electrical equipment is misuse or neglect. Loose connections, wrongly rated fuses, over loaded circuits cause overheating which may in turn lead to a fire. Damage to insulation between conductors in cables causes fire.

Clothing and anything else which might catch fire should be kept well away from heaters. Make sure that the heater is shut off at the end of the working day. Highly flammable liquids and petroleum mixtures (thinner, adhesive solutions, solvents, kerosene, spirit, LPG gas etc.) should be stored in the flammable material storage area. Blowlamps and torches must not be left burning when they are not in use. Extinguishing fires: Fires are classified into four types in terms of the nature of fuel. Different types of fire have to be dealt with in different ways and with different extinguishing agents. An extinguishing agent is the material or substance used to put out the fire, and is usually (but not always) contained in a fire extinguisher with a release mechanism for spraying into the fire. It is important to know the right type of agent for extinguishing a particular type of fire; using a wrong agent can make things worse. There is no classification for 'electrical fires' as such, since these are only fires in materials where electricity is present.

Fuel	Extinguishing
CLASS 'A' FIRE 	Most effective ie. cooling with water. Jets of water should be sprayed on the base of the fire and then gradually upwards.
CLASS 'B' FIRE  FLAMMABLE LIQUIDS AND LIQUIFIABLE SOLIDS	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.
CLASS 'C' FIRE 	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.

CLASS 'D' FIRE



METALS

The standard range of fire extinguishing agents is inadequate or dangerous when dealing with metal fires.

Fire on electrical equipment.

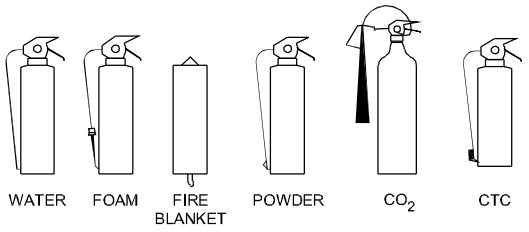
Halon, Carbon dioxide, dry powder and vapourising liquid (CTC) extinguishers can be used to deal with fires in electrical equipment. Foam or liquid (eg. water) extinguishers must not be used on electrical equipment under any circumstances.

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 use based on the class of fire**
- **describe the general procedure to be adopted in the event of a fire.**

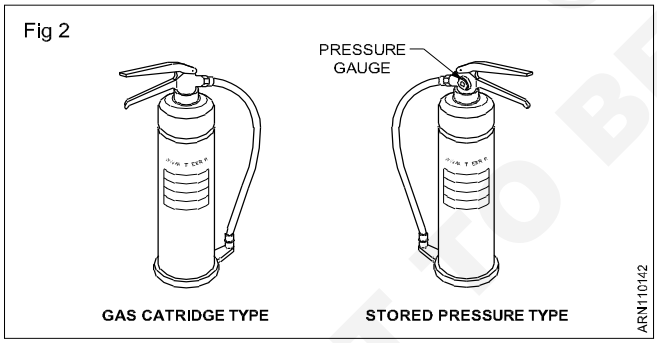
Many types of fire extinguishers are available with different extinguishing 'agents' to deal with different classes of fires. (Fig 1)

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.

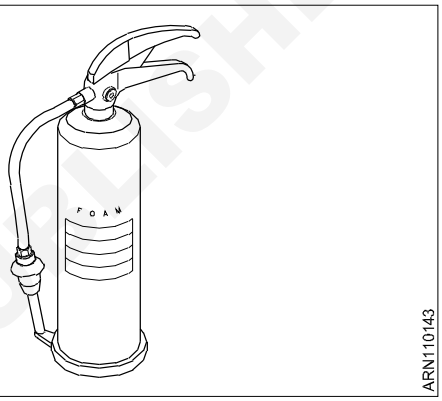
Foam extinguishers (Fig 3): These may be of stored pressure or gas cartridge types. Always check the operating instructions on the extinguisher before use.

Most suitable for

– flammable liquid fires

– running liquid fires.

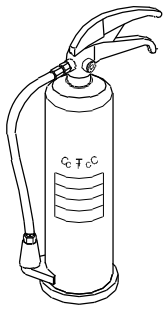
Fig 3



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

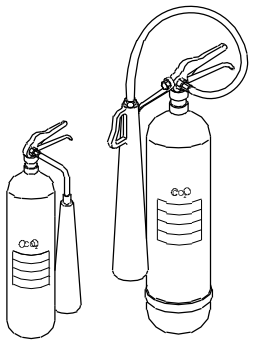
Dry powder extinguishers (Fig 4): Extinguishers fitted with dry powder may be of the gas cartridge or stored pressure type. Appearance and method of operation is the same as that of the water-filled one. The main distinguishing feature is the fork shaped nozzle. Powders have been developed to deal with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

Fig 4



Carbon dioxide (CO_2): This type is easily distinguished by the distinctively shaped discharge horn. (Fig 5). Suitable for Class B fires. Best suited where contamination by deposits must be avoided. Not generally effective in open air. Always check the operating instructions on the container before use. Available with different gadgets of operation such as - plunger, lever, trigger etc.

Fig 5



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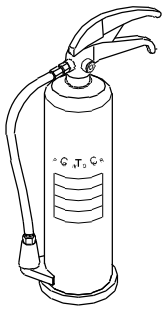
Halon extinguishers (Fig 6): These extinguishers may be filled with carbon-tetrachloride and Bromo chlorodifluoro methane (BCF). They may be either gas cartridge or stored pressure type. They are more effective in extinguishing small fires involving pouring liquids. These extinguishers are particularly suitable and safe to use on electrical equipment as the chemicals are electrically non-conductive.

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

The general procedure in the event of a fire

– Raise an alarm.

Fig 6



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– 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.

Safe disposal of toxic dust

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

Introduction The Automobiles produces fumes containing unburnt gases such as carbon-monoxide, nitrogen oxide and other gases which are harmful to human health. Hence a systematic and scientifically designed methods are adopted for safe disposal of such toxic waste. Dust from vehicle components to be blown into the air, since such dust floating in air for many hours, may cause harm to people who breath unknowingly. Brake and clutch components produces dust, when used compressed air jet to clean them. While cleaning conforming the PPE to safety regulation & policies. This includes overall coat, Face mask, safety goggles for eyes earmuffs & earplug for ear protection, rubber gloves &barrier cream for hand and valued 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.

Safe handling and periodic testing of lifting equipments

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

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

Lifts and cranes Safety precautions for handling of lifts and cranes

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

Periodic testing of lifting equipment

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

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.

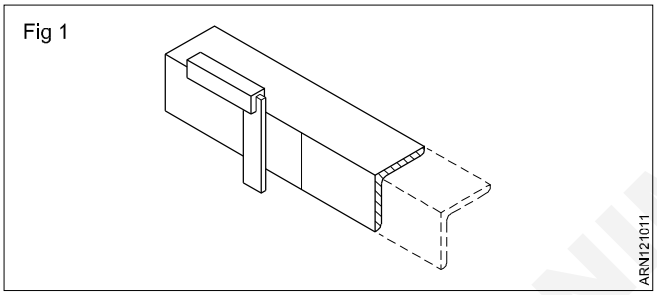
Whitewash

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 oxidized surfaces. (Fig 1)

Fig 1



Whitewash is not recommended for work pieces of high accuracy.

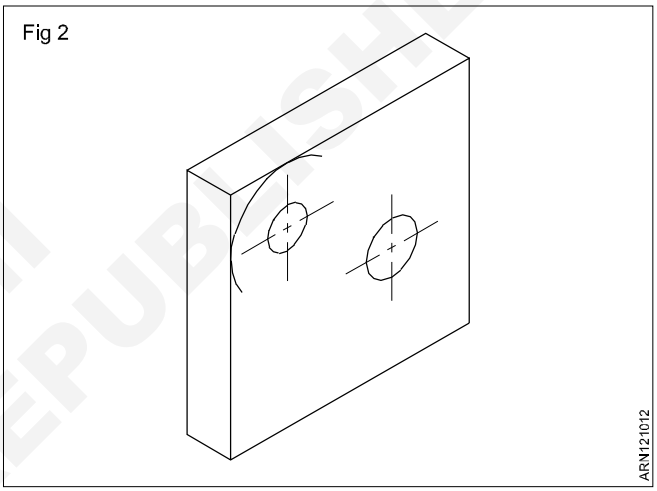
Cellulose Lacquer

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

Prussian Blue

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

Fig 2



Cleaning tools

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

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

The General Cleaning Tools are

1 Wire brushes

2 Emery sheets.

Wire Brushes

Wire brushes are generally used for cleaning the work surfaces.

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

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

Applications

1 Wire brushes can be used for cleaning uneven Surfaces

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

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

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

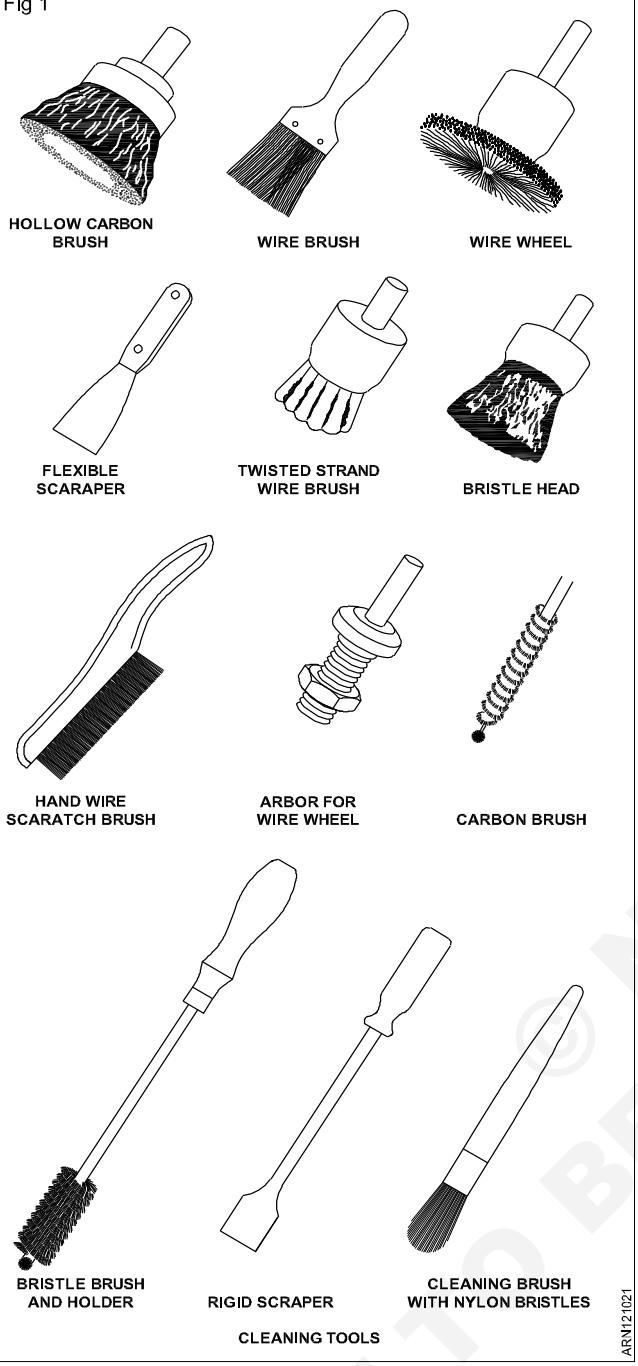
5 Nylon bristles with impregnated abrasive brush can be used for Engine boring

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

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

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

Fig 1

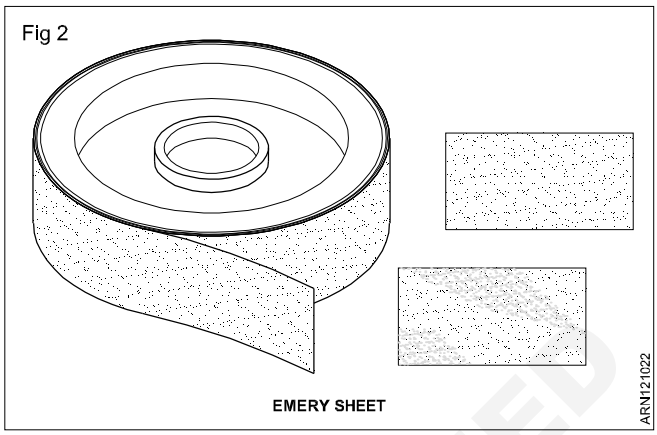


Safety precautions

Steel wire brushes should be used carefully on soft metals. It should not make any scratches on the finished surface.

Emery Sheet (Fig 2)

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.

Scraper

Objectives: At the end of this lesson you shall be able to
- **name the different types of scrapers**
- **state the features of each type of scraper**
- **state the precautions to be observed while uses scraper.**

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

Application

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

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

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

Type of scrapers

1 Flat scraper

2 Special scraper

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

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

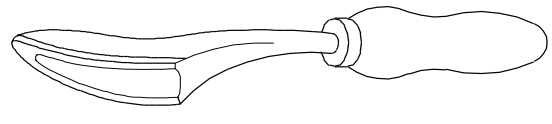
Special Scraper: Special scraper is available for scraping and finishing curved surfaces. They are

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

Half round scraper

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

Fig 1



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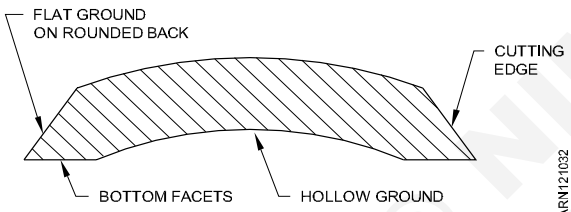
The round bottom face is curved and is hollow in the middle.

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

Fig 2



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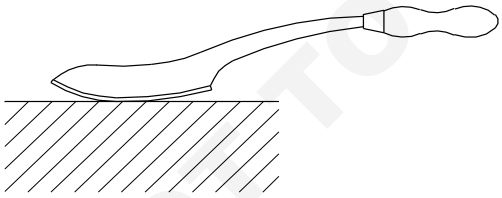
The cutting angle is between 45° and 65°.

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

Fig 3



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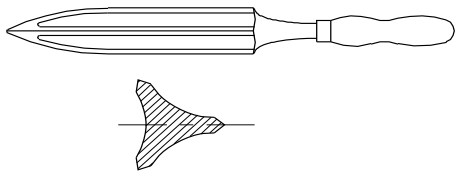
Three- square scraper (Fig 4)

Fig 4



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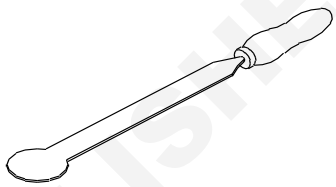
This scraper is used for scraping small diameter holes and deburring the edges of holes.

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

Bull nose scraper (Fig 5)

Fig 5



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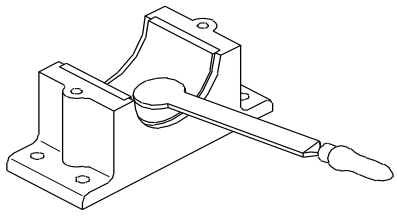
This scraper has the cutting edge shaped into a flat circular disc. The cutting edge forms about two thirds of the circle. It is useful for scraping large bearings. (Fig 6) This scraper can be used in a longitudinal direction like a flat scraper or with a circumferential movement like a half round scraper. This dual action helps to prevent ridges on the scraped surfaces.

Fig 6



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Always use scrapers with firmly fitted handles.

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

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

Surface plates

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

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

Surface plates - their necessity

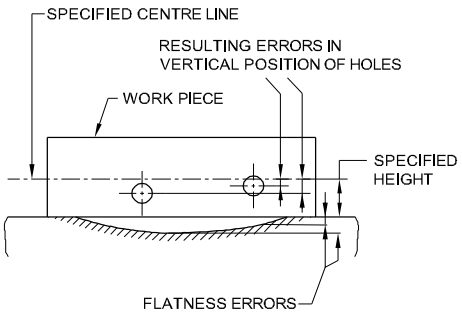
When accurate dimensional features are to be marked or to be checked it is essential to have a datum plane with a perfectly flat surface. Marking using datum surfaces which are not perfectly flat will result in dimensional in accuracies. (Fig 1) The most widely used datum surfaces in machine shop work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

Materials and construction

Surface plates are generally made of good quality cast iron which are stress-relieved to prevent distortion. The

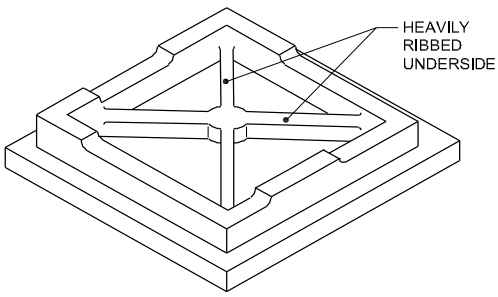
work-surface is machined and scraped. The underside is heavily ribbed to provide rigidity. (Fig 2)

Fig 1



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

Fig 2



CAST IRON SURFACE PLATE

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

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

Other materials used

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

Classification and uses

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

Specifications

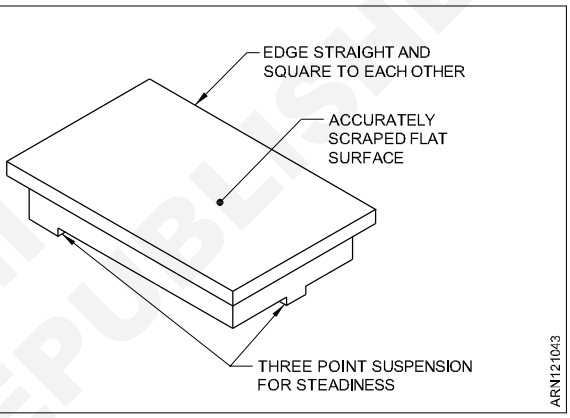
Cast iron surface plates are designated by their length, breadth, grade and the Indian Standard number.

Example

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

Marking-off tables (Fig 3)

Fig 3

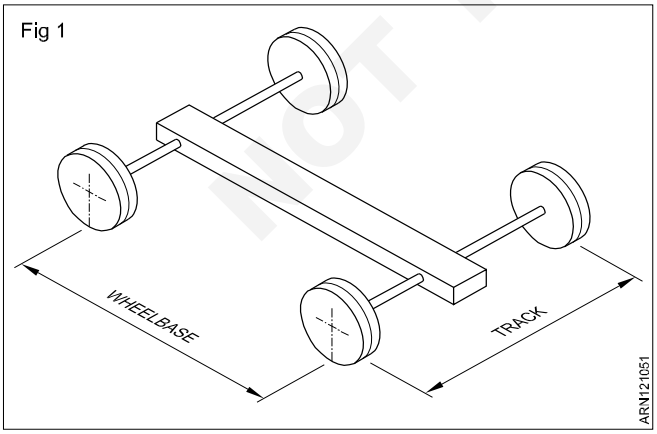


Wheelbase, wheel track and measuring tape

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

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

Fig 1



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

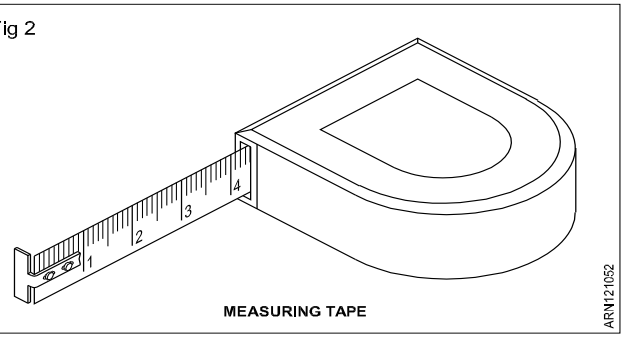
Measuring tape is a flexible ruler. It is made of ribbon cloth plastic fiber glass metal strip with lines for measurements. It is very common measuring tool used by many people. The available range are 3m, 5m and 10m.

Types

1 Plastic Tape (Fig 3)

2 Metal Tape (Fig 2)

Fig 2



MEASURING TAPE

Fig 3

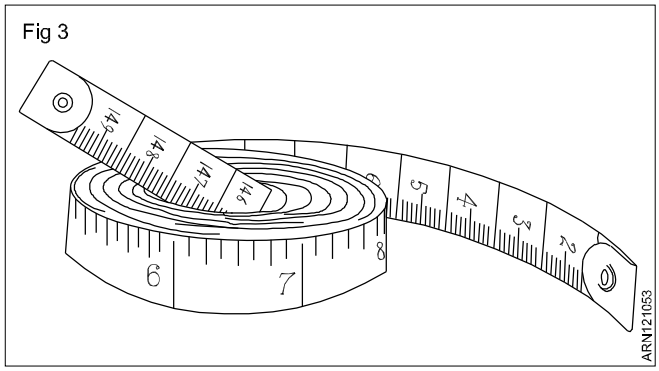
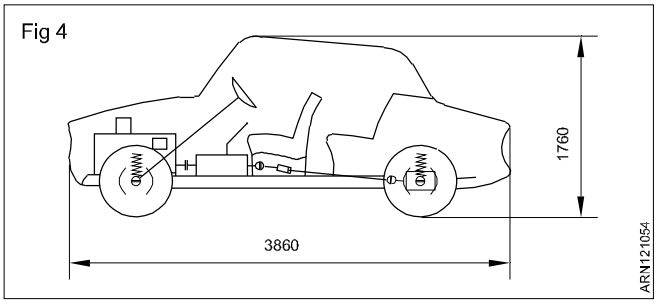


Fig 4



3 Fiber glass

4 Ribbon cloth

Application

Dress makers

Civil Engineers

Mechanical Engineers

Surveyors

Carpenters

Medical field

Accuracy

Measuring tapes are marks in metric and British system.

The accuracy in metric system is 1mm and in British system is 1/8".

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

Length measurement

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

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

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

Base Unit

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

METRE (m) = 1000 mm

CENTIMETRE(cm) = 10 mm

MILLIMETRE (mm) = 1000 mm

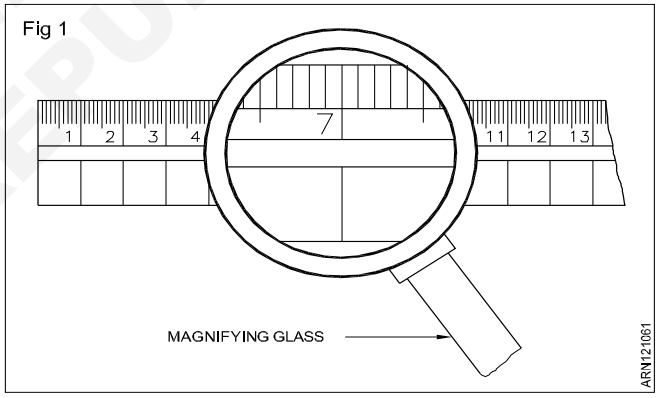
MICROMETRE (m) = 0.001 mm

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.

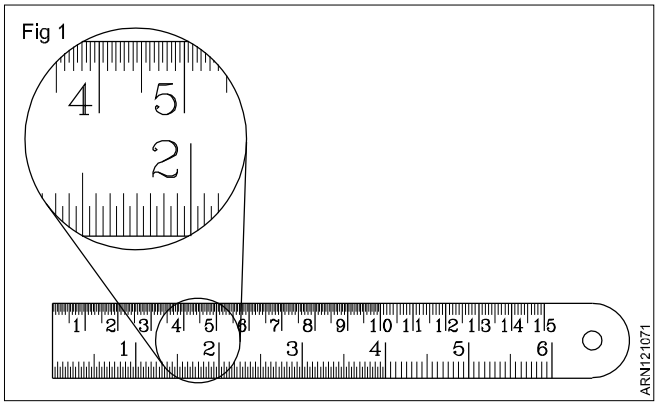
Engineer's steel rule

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.

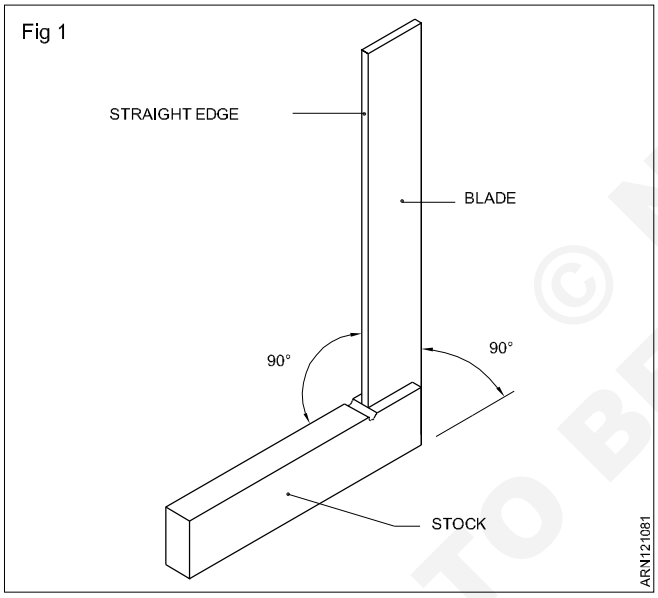
These are used for carrying out marking on heavy components. On certain types-parallel lines are engraved in both directions at a set distance.

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°) of a surface.



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

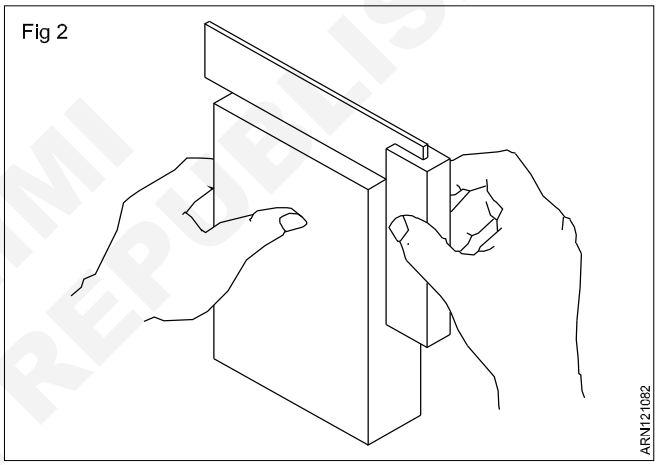
Uses

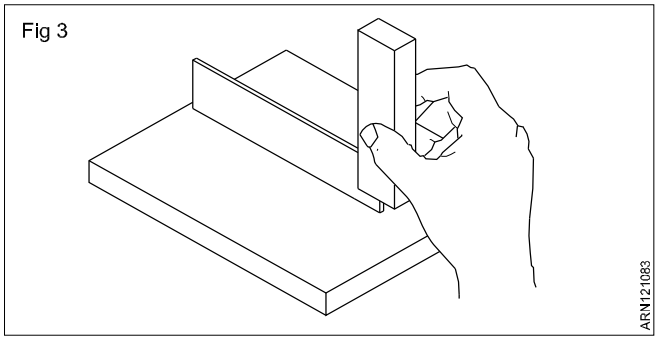
The try squareness is used (Figs 2 & 3)

- check flatness of surfaces (Fig 3)
- mark lines at 90° 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.





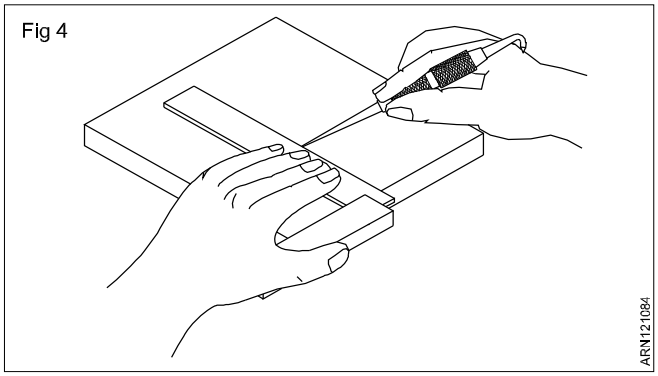
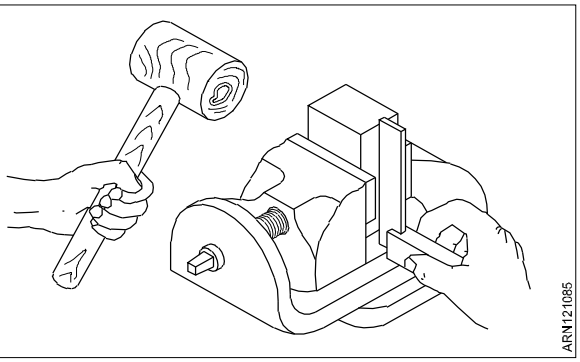


Fig 5



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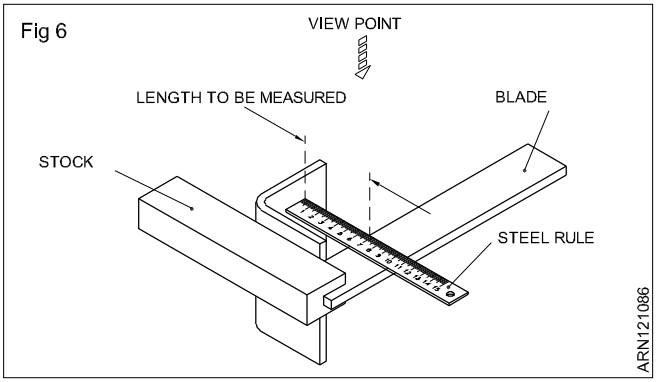
Use of a try square and steel rule.

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

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

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

Fig 6



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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.

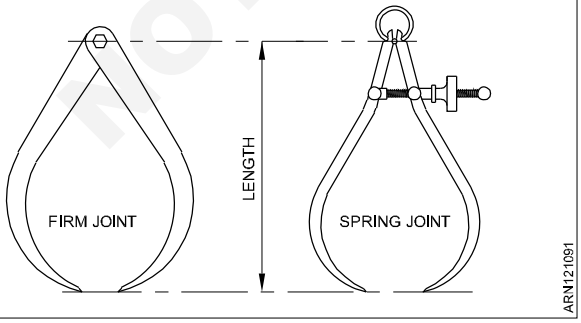
Types of joint

The commonly used calipers are:

- firm joint calipers
- spring joint calipers.

Firm Joint calipers (Fig 1)

Fig 1



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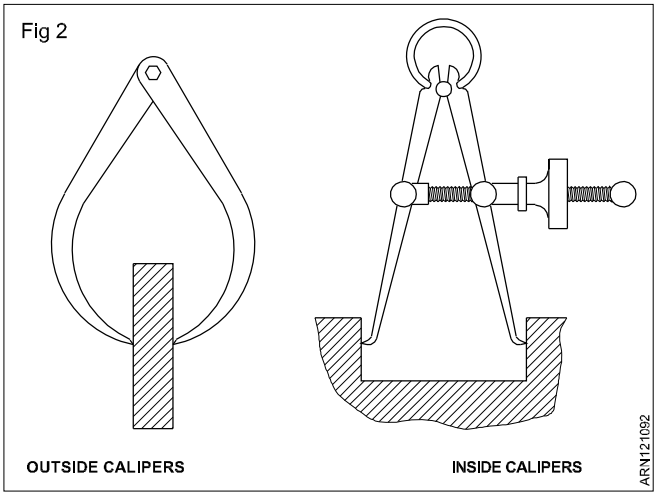
In the case of firm joint calipers, both legs are pivoted at one end. To take measurements of a workpiece. It is opened roughly to the required size. Fine setting is done by tapping the caliper lightly on a wooden surface.

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 2



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

The accuracy of the measurement taken depends very much on the sense of feel an touch. While measuring the

job, you should get the feel when the legs are just touching the surface.

Types of legs

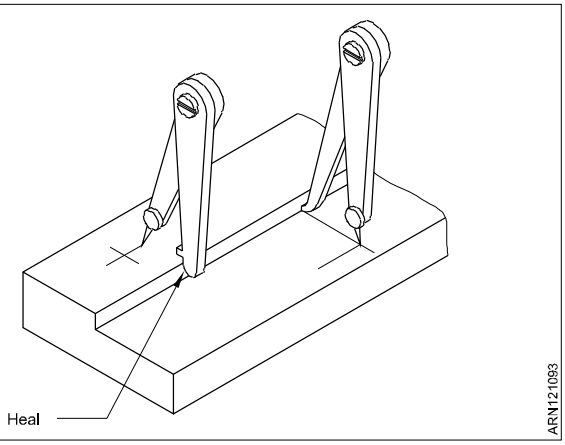
Outside and inside calipers are differentiated by the shape of the legs.

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

Calipers are use along with steel rules, and the accuracy is limited to 0.5 mm; parallelism of jobs etc. can be checked with higher accuracy by using a caliper. (Fig 3)

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

Fig 3

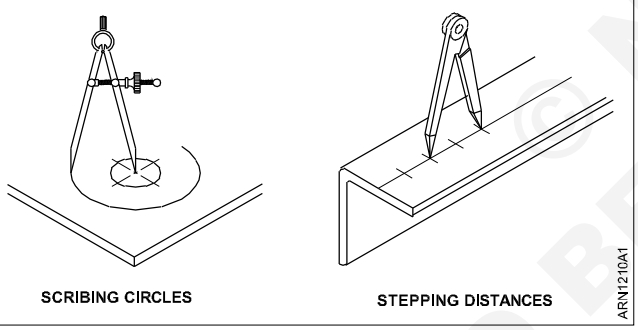


Dividers

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)

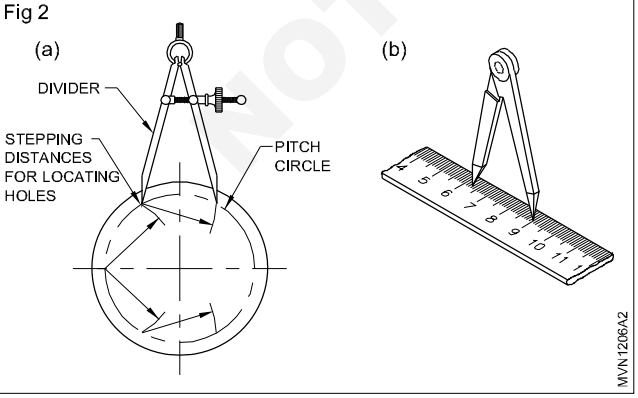
Fig 1



Dividers are available with firm joints and spring joints.

The measurements are set on the dividers with a steel rule. (Fig 2 a,b)

Fig 2



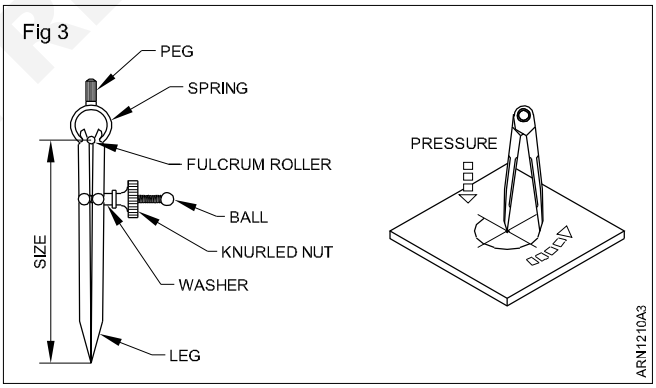
The sizes of dividers range between 50 mm to 200 mm.

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.

Fig 3



Dividers are specified by the type of their joints and length. The divider point should be kept sharp in order to produce timelines. Frequent sharpening with an oil stone is better than sharpening by grinding. Sharpening by grinding will make the points soft.

Do not sharpen the divider points on grinding wheels.

Surface Gauges

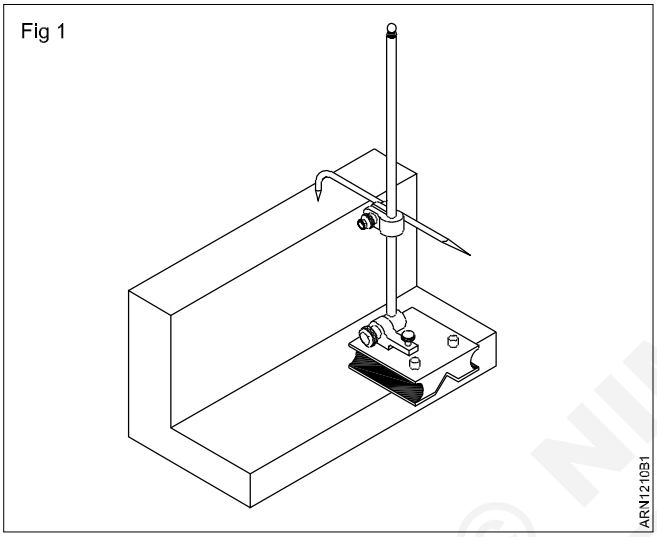
Objectives: At the end of this lesson you shall be able to
- **state the constructional features of surface gauges**
- **name the types of surface gauges**
- **state the uses of surface gauges**
- **state the advantages of universal surface gauges.**

The surface gauge is one of the most common marking tools used for scribing lines parallel to a datum surface

Types of surface gauges

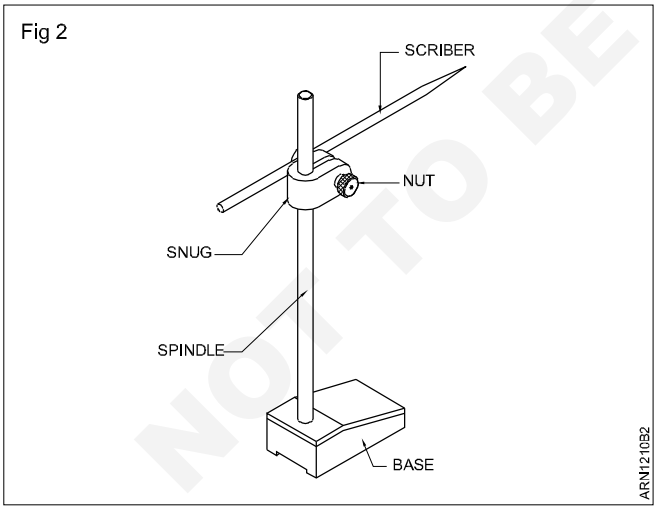
- Surface gauges/scribing blocks are of two types.
- Fixed
- Universal (Fig 1)

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

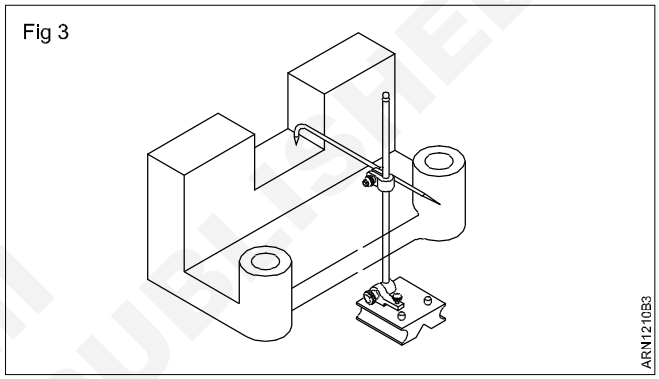
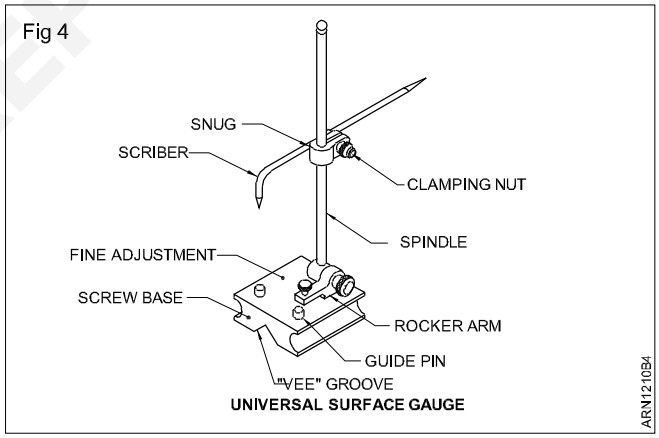


Fig 4



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

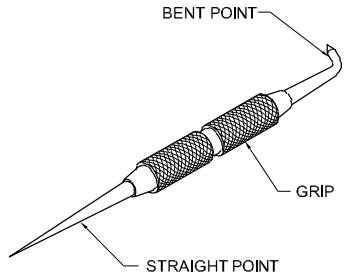
Objectives: At the end of this lesson you shall be able to
- **state the features of scribers**
- **state the uses of scribers.**

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).

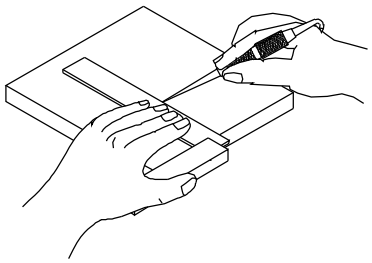
Fig 1



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

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

Fig 2



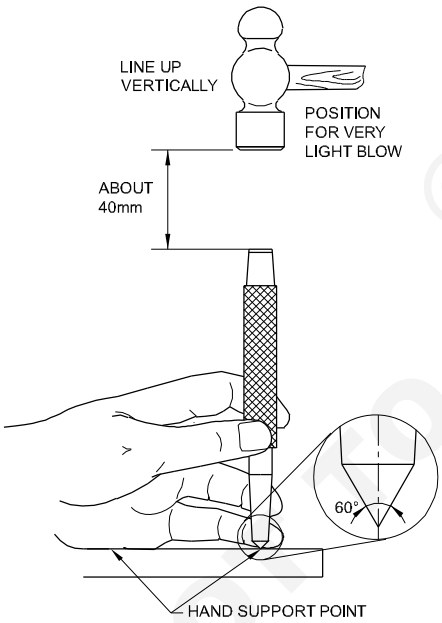
Scriber points are very sharp, and they are to be handled very carefully. Do not put the scriber in your pocket. Place a cork on the point when not in use to prevent accidents. (when it is not in use)

Punches

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)

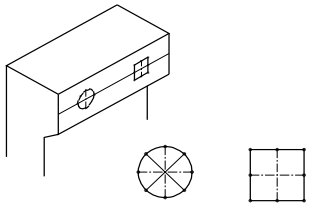
Fig 1



Prick punches

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

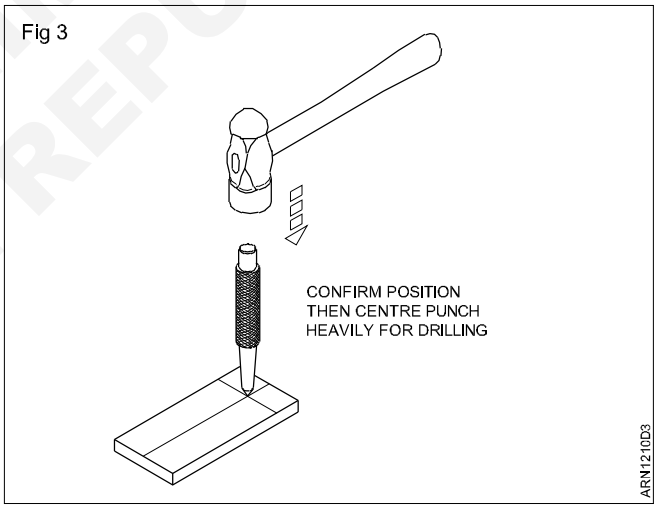
Fig 2



This makes it easier to see accurate marking out lines.

- to check the location of the centre positions before centre punching. (Fig 3)

Fig 3



- to locate the pivot points of compasses for scribing circles. (Fig 4)

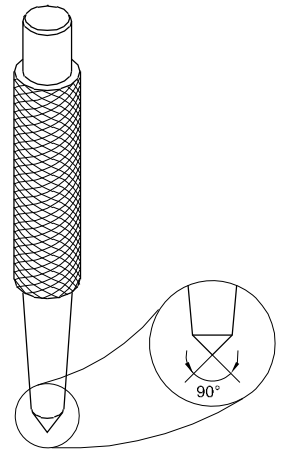
A 100 mm prick punch with a 7 mm diameter body could have a 2.5 mm diameter point ground to an angle of 60° or 30°

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 4



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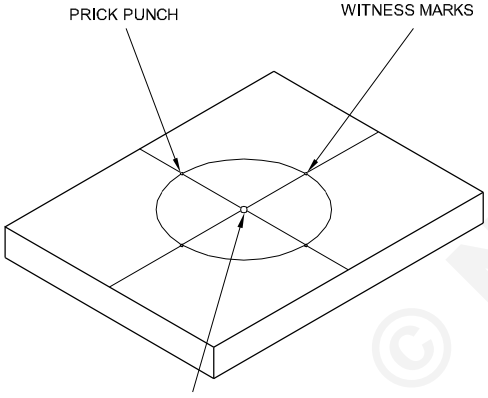
Centre punches are used

- 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



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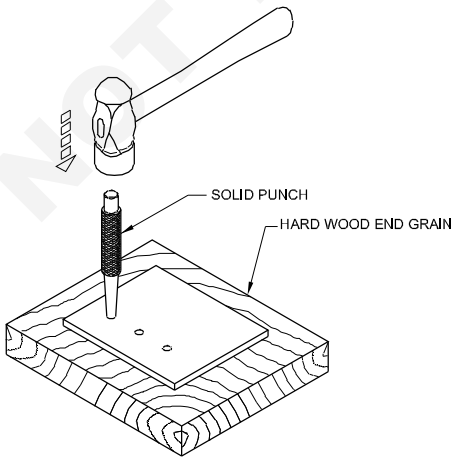
Solid punch (Fig 6)

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

Fig 6



PUNCHING HOLES FOR RIVETS WITH A SOLID PUNCH

ARN1210D6

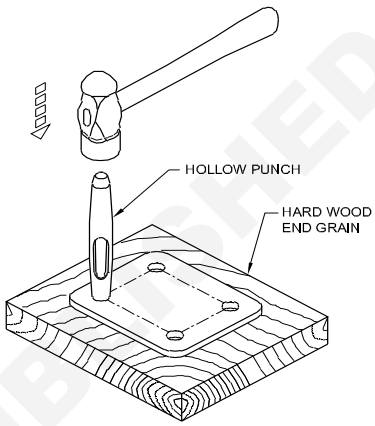
Letter and number punches: Also known as letter stamps or number stamps, letter punches are used to emboss the impression of a letter of number into a workpiece. They are most common in the reverse image, this allows the end result to be immediately readable, however they may be made as a positive image.

This is essential in the case of die or mold making and ensure that the finished product will be readable, as a die is a negative image.

Hollow punch (Fig 7)

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

Fig 7



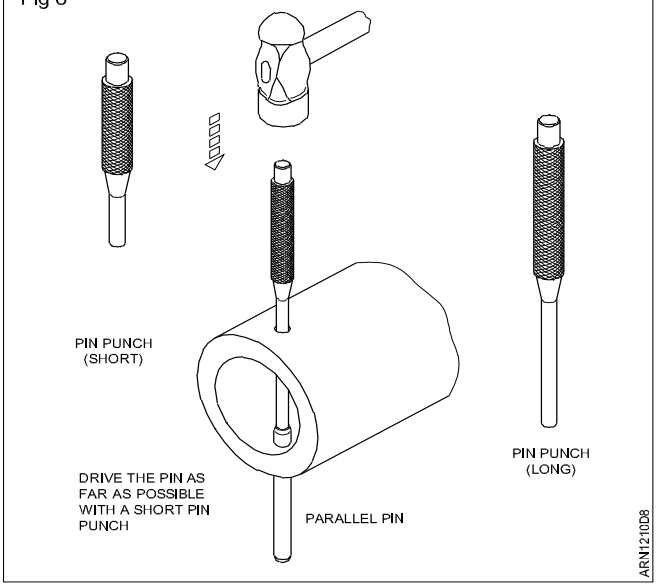
USING A HOLLOW PUNCH

ARN1210D7

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)

Fig 8



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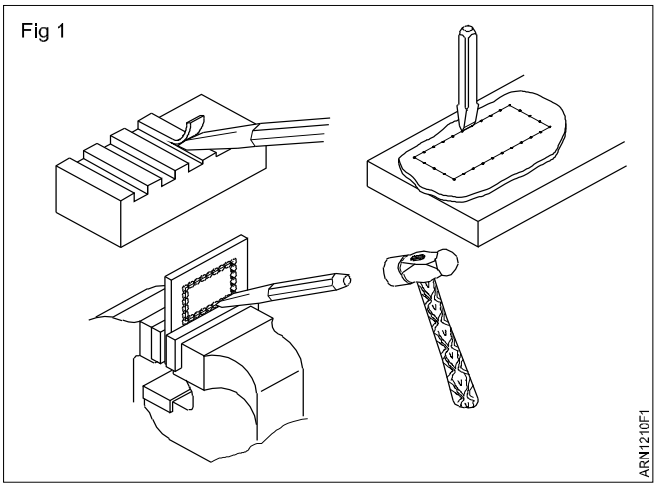
Pin punches are used to drive locating or locking pins, dowels and rivets out of their holes.

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

Chisel

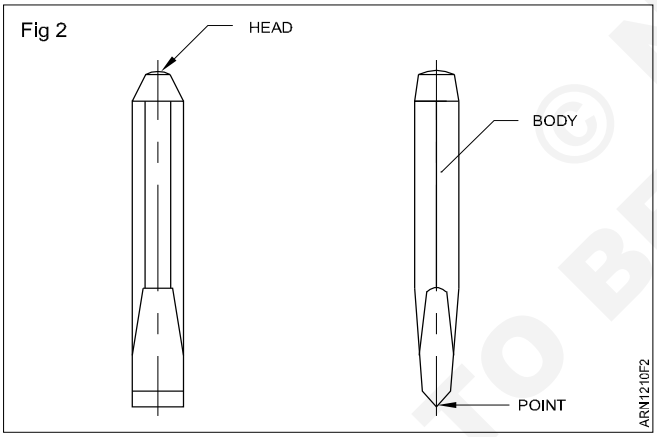
Objectives: At the end of this lesson you shall be able to
- **list the uses of a cold chisel**
- **name the parts of a cold chisel**
- **state the different types of chisels.**

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



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

Parts of a chisel (Fig 2)



A chisel has the following parts.

- Head
- Body
- Point or cutting edge

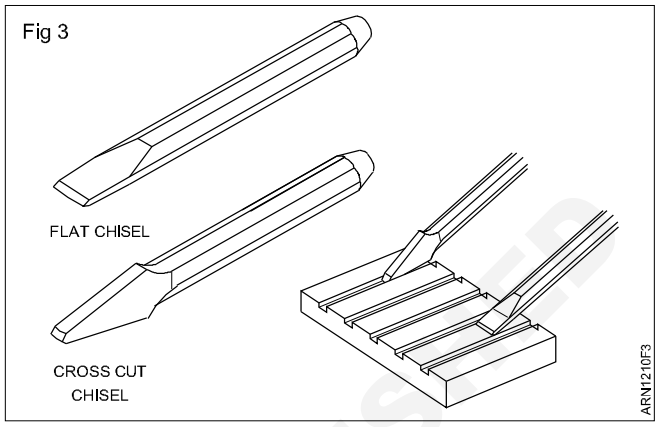
Chisels are made from high carbon steel or chrome vanadium steel. The cross-section of chisels is usually hexagonal or octagonal. The cutting edge is hardened and tempered.

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 chisel (Fig 3)

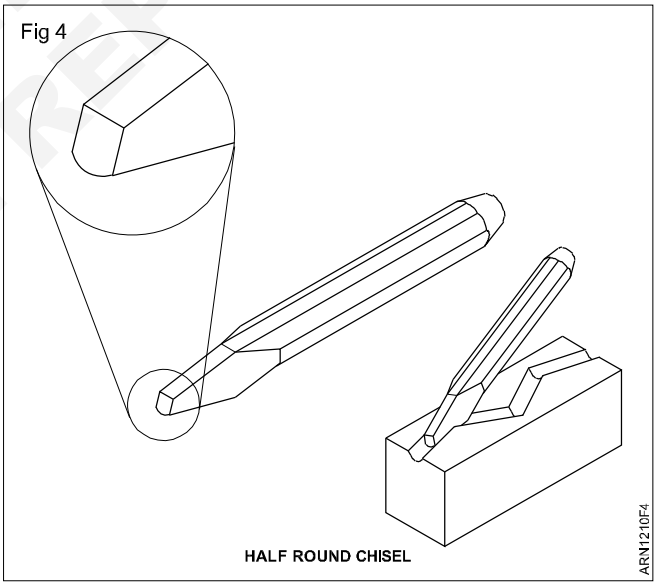


They are used to remove metal from large flat surfaces and chip excess metal of weld joints and castings.

Cross-cut or cape chisels (Fig 3)

These are used for cutting keyways, grooves and slots.

Half round nose chisels (Fig 4)



They are used for cutting curved grooves (oil grooves)

Diamond point chisels (Fig 5)

These are used for squaring materials at the corners.

Web chisels/punching chisels (Fig 6)

These chisels are used for separating metals after chain drilling.

Chisels are specified according to their

- length
- width of cutting edge

- type
- cross-section of body

Fig 5

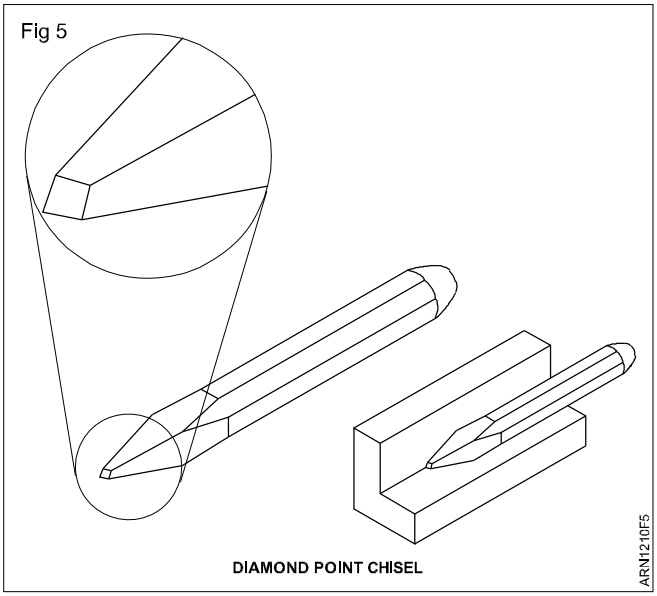
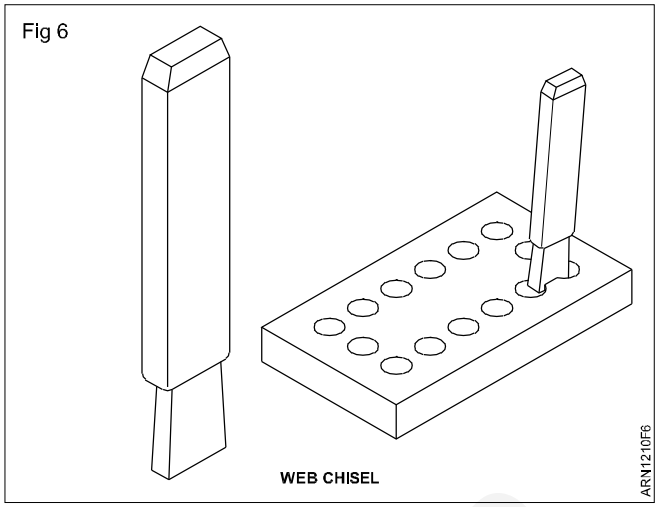


Fig 6



The length of the chisels ranges from 150mm to 400mm.

The width of the cutting edge varies according to the type of chisels.

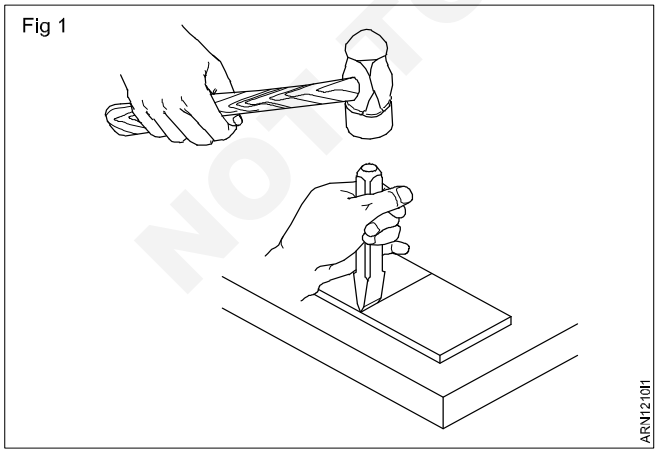
Hammers

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

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

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

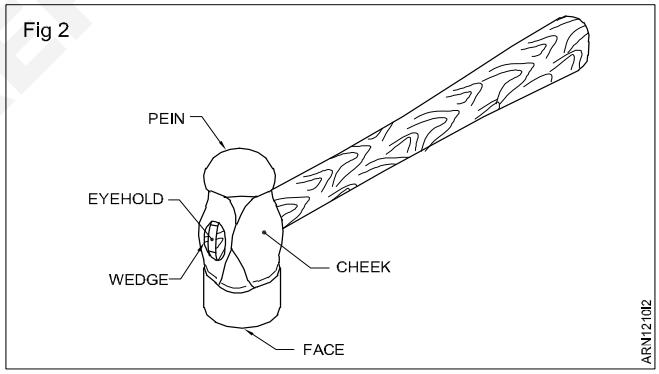
Fig 1



Major parts of a hammer (Fig 2)

The major parts of a hammer are a head and a handle. The head is made of drop-forged carbon steel, while the wooden handle must be capable of absorbing shock.

Fig 2



The parts of a hammer head are the

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

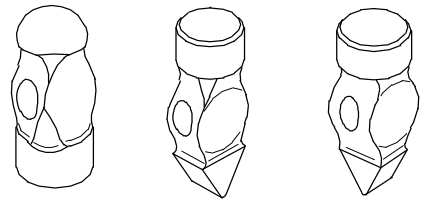
The face is the striking portion. Slight convexity is given to it avoid digging of the edge.

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

- ball pein
- crosspein
- straight pein

The face and the pein are hardened.

Fig 3



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

This portion of the hammer-head is left soft.

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

Fig 4

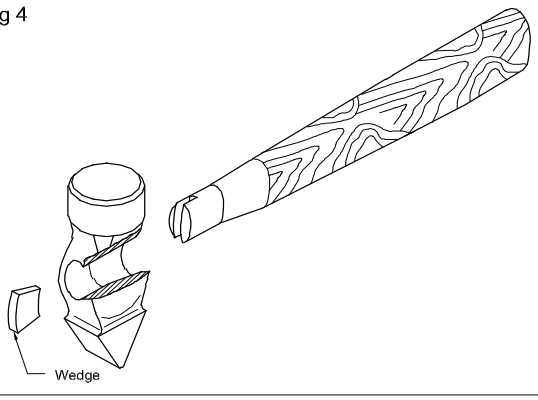
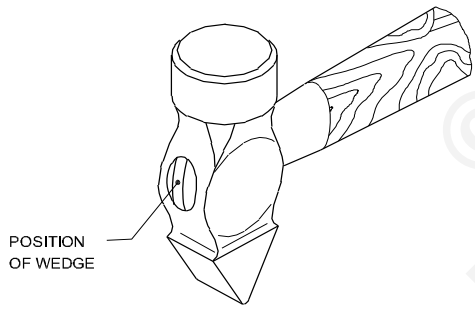


Fig 5



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

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

Before using a hammer: Make sure the handle is properly fitted

Select a hammer with the correct weight suitable for the job

Check the head and handle for any cracks

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

The figure shows the different parts of a hammer (Fig 6).

The handle is fitted in the eye-hole of the hammer.

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

Fig 6

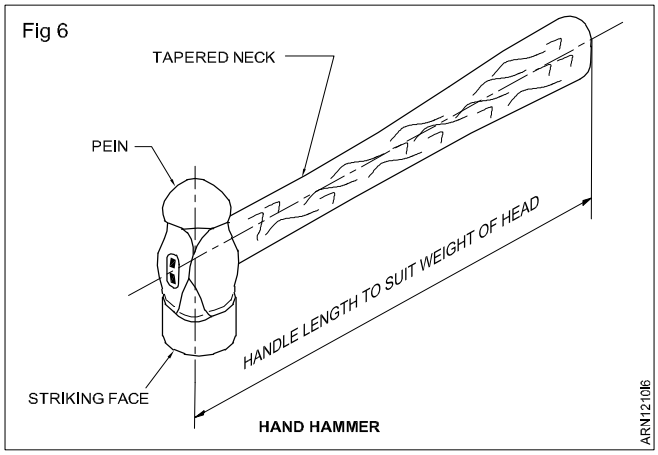
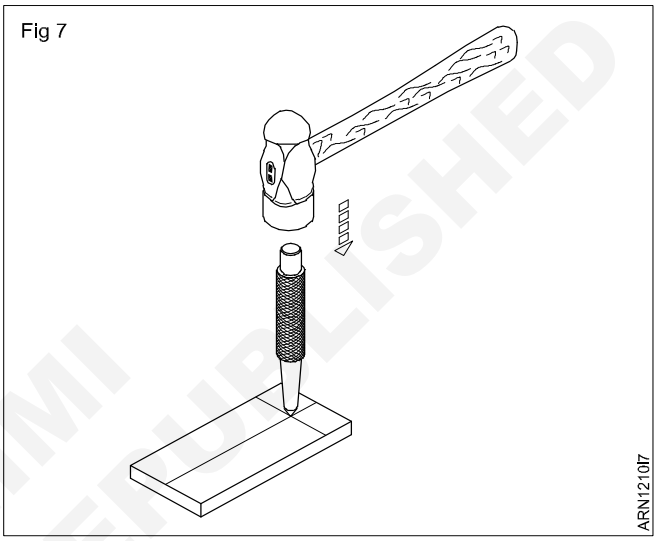
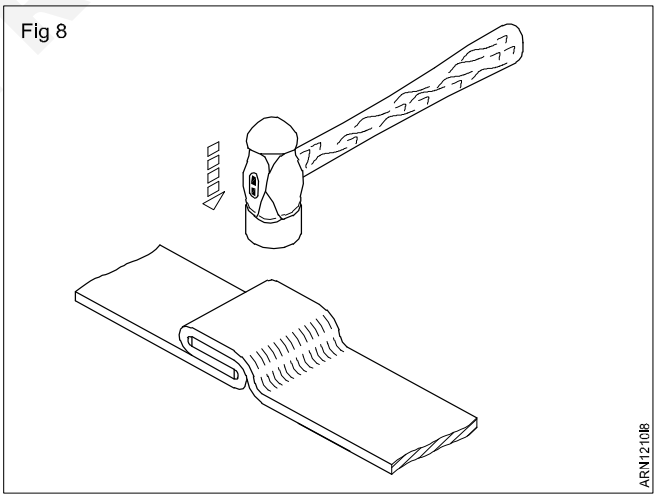


Fig 7



Ball pein hammer (Fig 8)

Fig 8



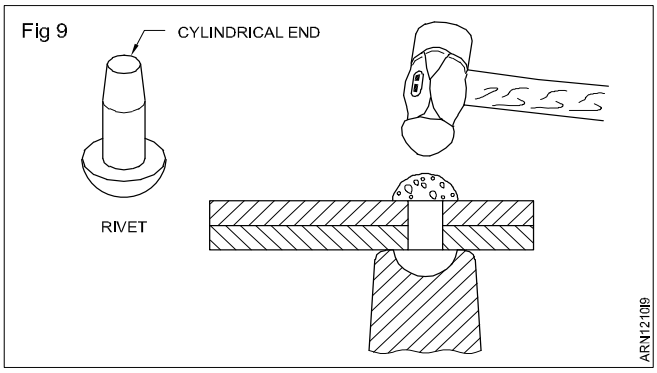
A ball pein head is used to spread metal in all directions.

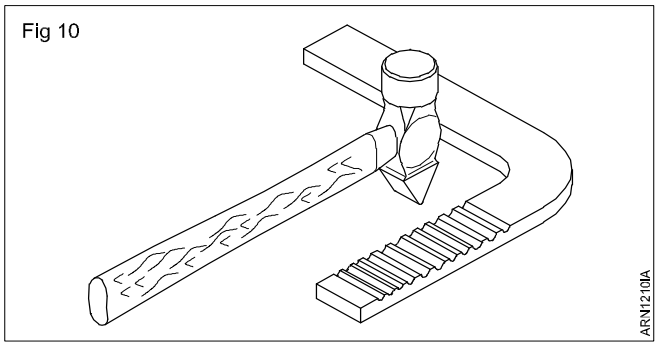
This hammer has a semi-spherical pein suitable for riveting. (Fig 9)

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

Cross pein hammer (Fig 10)

A cross pein head is used to spread metal in one direction in the line of striking. This has a blunt wedge-shaped pein at right angles to the axis of the handle.

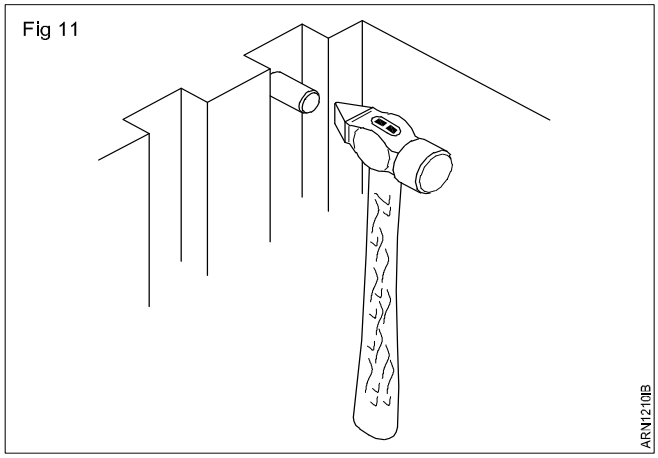




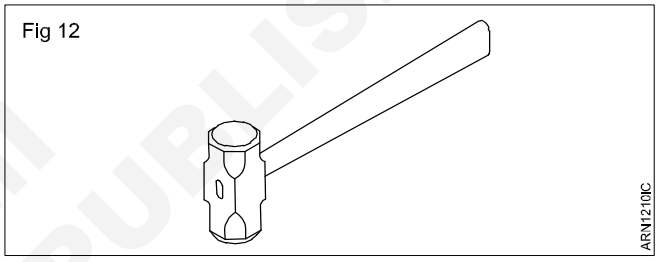
Straight pein hammer

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.



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



Wooden Mallet

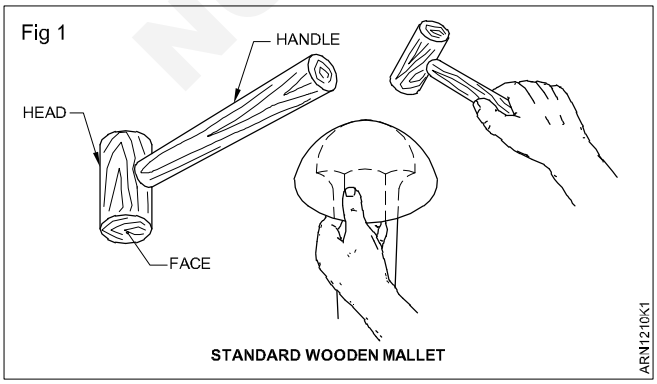
Objectives: At the end of this lesson you shall be able to
- **name the different types of mallets**
- **state the uses of each type of mallets**
- **state the metal body tools.**

Mallets

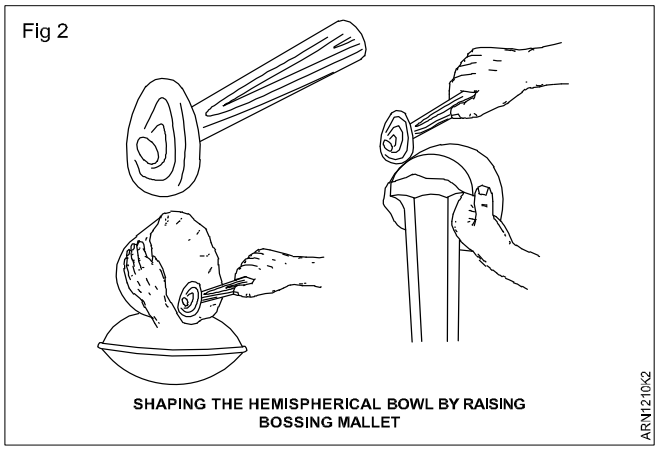
Mallets are soft hammers and are made of raw hide, hard rubber copper, brace, lead or wood, and are used to strike a soft and light blow on the metal.

Types and uses

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

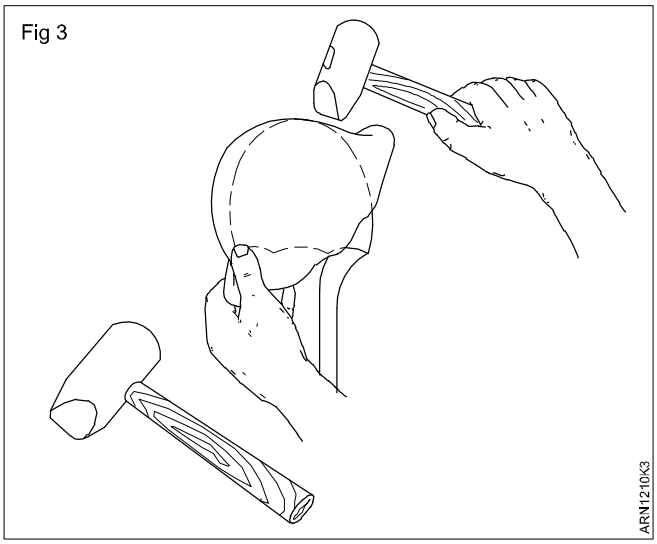


Bossing mallets (Fig 2) are used for hollowing panel beatings etc.



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

Fig 3



Door trim pads

1 Sedan door trim pads are used to conceal the lower portions of the inside panel of doors. The pads are usually prefabricated and assembled to the door as one unit. They are held in place by sheet metal screws and various types of spring clips

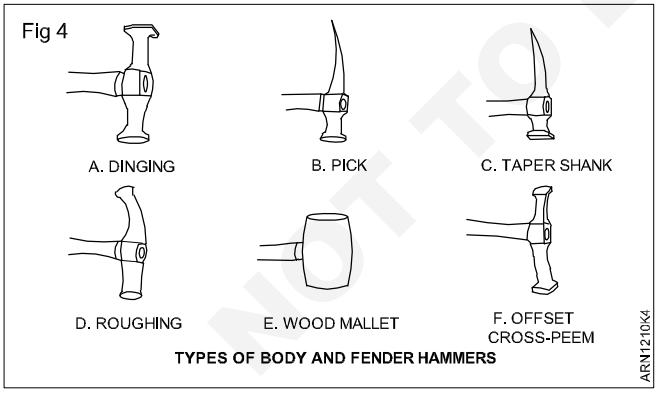
2 Combat-type of vehicle doors are made in one piece. The only opening in the door (loading hole) is covered by a piece of sheet metal and is secured in place by sheet meal screws.

Metal body tools (Fig 4)

a Hammers

1 Dinging hammer (A) : It is a general purpose hammer for use on any body panel. It has a 1 $\frac{3}{8}$ inch square and 1 $\frac{9}{16}$ inch round face, and is made from drop forged alloy steel which has been beat treated

Fig 4



TYPES OF BODY AND FENDER HAMMERS

2 Pick hammer (B): The painted shank of this hammer is used to raise small, low spots when cross filling. It has a 1 $\frac{9}{16}$ inch round face and a curved shank tapering to a point. The bullet type pick hammer (not shown) is designed for use on all industrial metal finishing and general dinging work.

3 Taper shank hammer (C): Designed for the latest metal bodies and fenders, it is used for reshaping all beads, moldings, headlamp insets, reveals, and louvers. It has a wide chisel face for rapid pick surfacing in large areas.

4 Roughing hammer (D): Its curved shank reaches places not accessible to hammers of ordinary design, and its round face is ideal for working an extra heavy-gauge metal.

5 Wooden mallet (E): It is for use in connection with hot-metal shrinking, and for dinging soft metal such as aluminum, copper and brass. It will not chip under ordinary usage.

6 Offset cross-peen hammer (F): Its offset square face affords ample clearance without danger of striking adjoining panels. Its high crown cross-peen is designed for deep and narrow panels and return contours. The high crown may also be used in conjunction with the shrinking dolly to cold-shrink panels or sink welds.

b Dollys (Fig 5)

1 Heel dolly (A) : It is shaped like the heel of a shoe, round face on one side and flat on the other. It may be used as a general purpose dolly.

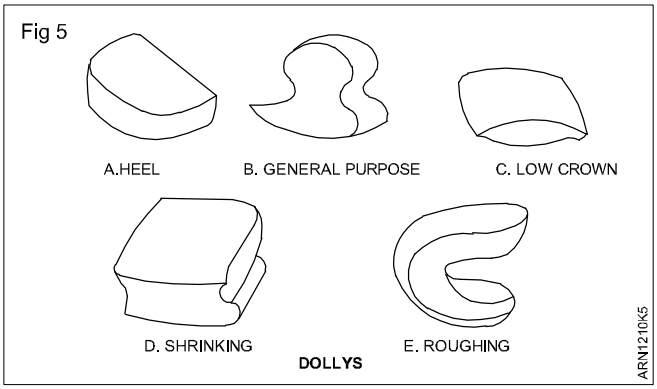
2 High crown (General purpose) Dolly (B): It is precision ground for high-crown contours and is used in general body repair work. This tool is made from drop forged alloy steel.

3 Low crown dolly (C): It is used on all low crown panels. The hooks on the dolly are used on fender beads, drip moldings, and sharp, concaved moldings.

4 Shrinking dolly (D): It is a specially designed combination high and low crown dolly. It has nine distinct contour combinations for hot and cold shrinking. It has wide and narrow trenching grooves for sinking welds.

5 Heavy duty roughing dolly (E) (Fig 5): It has a convenient grip and greater height to furnish extra backing for heavy duty hammering. It may be used in place of a roughing hammer for roughing out small dents. The lip at the end of its face is useful for reshaping turned-under flanges,

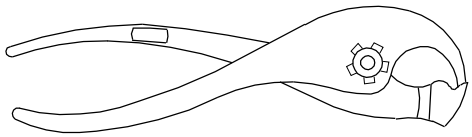
Fig 5



DOLLYS

C Drip molding pliers (Fig 6): Their accurately formed working faces permit extremely rapid roughing out for finishing with a suitable spoon. Made from drop forged steel, they are indispensable for pulling out crushed drip moldings.

Fig 6



DRIP MOLDING PLIERS

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D Body spoons (Fig 7): Body spoons are generally used for driving high spots back to their normal position without disturbing the surrounding surface. The working surface of each spoon is designed for a specific purpose. The more common varieties of spoons are the followings.

1 **Cowl bracket (Fig 7A):** Designed especially to hook over the fender brackets, it is used to work over cowl strainers and cowl brackets from post to dash and either high or low crown surfaces. It may be used as dolly, so the wheel can be kept on when reaching a dent.

2 **Double end and lower beck quarter panel spoon (Fig 7B):** It is used for removing dents on quarter panels around rear pillars, behind inner construction, and behind back panel strainers. It may be used for removing dents from behind sills.

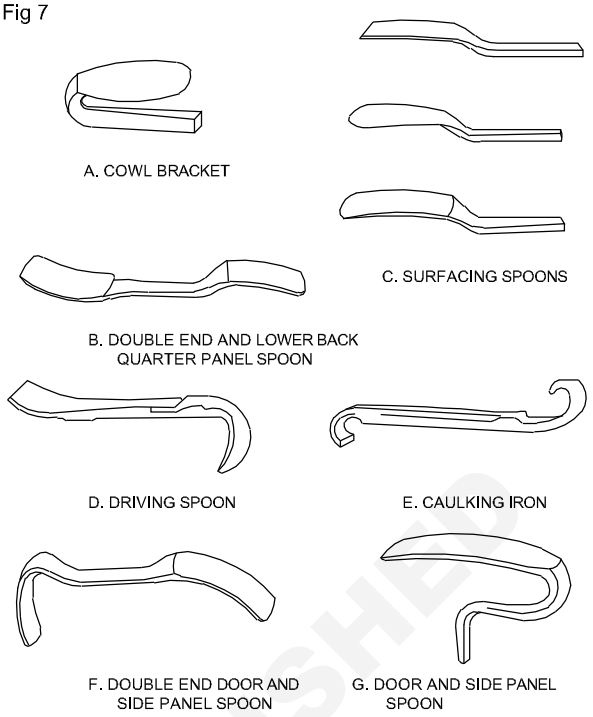
3 **Surfacing spoon (Fig 7C):** It is used for spring hammering operations with either the mallet or bumping hammer, and surface finishing. It is useful on all fender repairs and on high crown areas.

4 **Double end heavy duty driving spoon (Fig 7D):** This is a general purpose utility spoon with a wide variety of uses. It is used to set inside seams of front fenders, bumping top rail panels, headlamp housings, hood louvers, and straightening drip molding and back panels. It may be used for general basing work, lighting hinge pins, raising low spots, and for work around the ventilator in the cowl assembly.

5 **Caulking iron (Fig 7E):** A caulking iron is sometimes called a fender beading tool. It is a specially designed double end, heavy duty beading tool used for straightening all reverse bead on fenders with no wire, and turned under flanged edges. It may be used on return flanges or holds, and for aligning inner construction on body panels. Its hammer pads provide a base for hammering operations.

6 **Double end door and side panel spoon (Fig 7F):** Its precision ground face sakes it useful as a dolly block in direct hammering. It is designed to reach the har-to-get places behind innde construction on doors and cowl panels.

Fig 7



TYPES OF BODY AND FENDER SPOONS

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7 **Special door and side panel spoons (Fig 7G):** The unusual length of this spoon, together with its shape, enables the workman to reach far behind construction and remove bumps from doors and trunk lids without cutting out the inner construction.

E File bolder and blade

1 **Adjustable file bolder:** This tool quickly adjusts from an extreme concave to an extreme convex profile. It has maximum utility for filing a wide variety of contours: round oval corners, upper and lower bracket panels, cowls, hoods, and top rail panels. It is used for flat work, high and low crowns, and on sweep surfaces.

2 **Vixen file blade:** This blade is detachable from the holder and is different from any other type file. These blades are accurately machined with unbroken cutting edges about 1/8 of an inch apart. Each cutting edge is curved with the cutting edge on the convex side. This blade has the cutting edges on each side, and the teeth run in opposite directions of each other to allow the blade to be turned over when one side becomes dull and unusable.

3 **Maple solder paddle:** This paddle is made from maple wood because it does not split as easily as other woods. It is used to shape hot solder to the desired shape. It is used with motor oil, beeswax, or tallow to prevent the hot solder from sticking to the face of the paddle.

5 Metal body equipment

a Hydraulic body jack (Fig 8)

1 Types

a Direct acting jack: This type jack has the power unit or hydraulic pump integral with the ram. The action may be only one direction, or it may work in either direction, push-pull.

b Remote controlled jack: In this type jack, the hydraulic power supply is separated from the ram unit of the jack. The two units are connected by a reinforced rubber hose. (Fig 8A)

2 Remote controlled jack components

a Pump (Fig 8B): It is hand-operated, with all controls on the unit. The pump also serves as the reservoir for hydraulic oil. The oil level should be periodically checked.

b Ram (Fig 8V): Threads on the ram are for attaching other jack attachments. If the jack is used without attachments, a thread protector must be used on the top of the ram body.

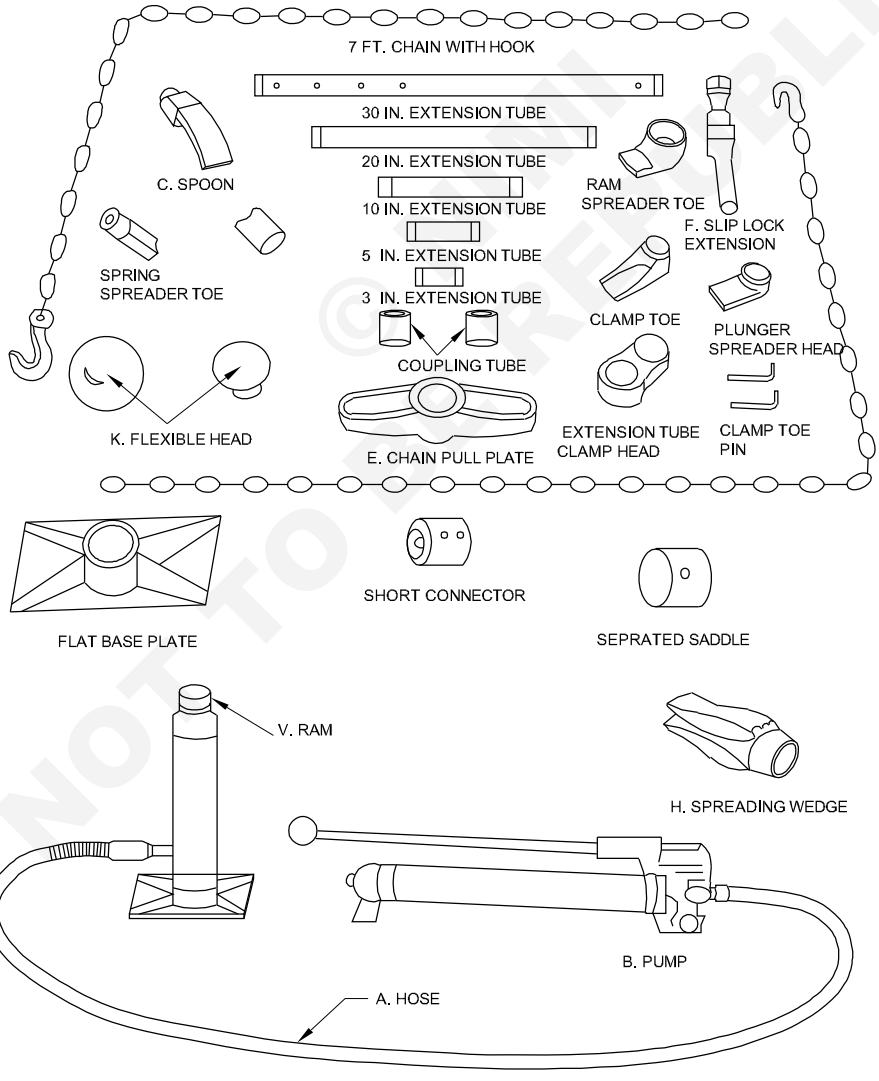
c Flexible rubber heads (Fig 8K): Two sizes of rubber heads suit most body needs. Rubber heads are generally used on dry painted surfaces because they will not slip or mar the surface. These heads should not be used in or near oiled surfaces as they can slip and cause further damage. Internal threads are provided for other jack attachments.

d Chain pull plate (Fig 8E): This plate is used in most pulling operations. The plate has internal threads with slots on both sides for securing chains. It attaches to the ram body.

e Slip lock extension (Fig 8F): This tool gives six inches of prompt adjustment in pushing out large areas. A double friction lock holds securely at desired lengths, and is adjusted by a convenient double trigger release.

f Rocker spoon (Fig 8G): Specially designed for body work, it is held and locked in place by a hexagon pin.

Fig 8



HYDRAULIC BODY JACK AND ATTACHMENTS

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It may be set in may different positions. The selection of the spoon position is governed by the curvature of the body, the body bend or dent, and amount of working space.

g **Spreading wedge (Fig 8H):** This tool is used for forcing out large or small concave areas and can be closed to one inch and opened to three inches.

h **Electric disk sander:** The disk sander may be used to remove paint, reveal low spots, shape the contours of areas built up with solder, sand down welds, remove excess solder, remove rust, and remove deep scratches by using a fine abrasive sanding disk. It may be equipped with a flexible grinding wheel to serve as a grinder on thick sections of metal.

1 **Backing plate:** In most grinding, the disk is placed directly on the slightly flexible backing plate. Hard rubber and plastic can be used as backing plates. If a 9 inch sanding disk is used, it should have a 7 inch backing plat. The 7 inch backing plate will allow the 9 inch sanding disk outer edge to be cut down when it has become worn, increasing the disk life. Sanding disks are secured in place by a flat plate nut that is screwed onto the motor drive shaft and permits easy installation and removal of the plate nut when changing torn or worn-out disks.

2 Sanding disks

a The coating abrasive disk does the cutting. Selection of the right grit and coating for each job is important.

Five different minerals are commonly used for manufacturing abrasives. Three of these, garnet, flint, and emery, are natural mineral abrasives. The other two are aluminum oxide and silicon carbide.

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.

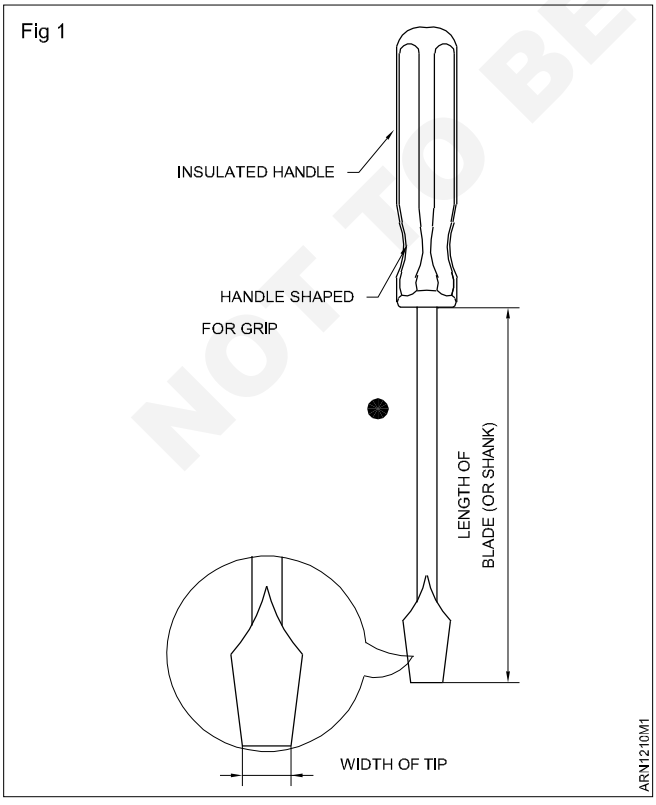
Screwdrivers are used to tighten or loosen screws which are fixed in the machine element.

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

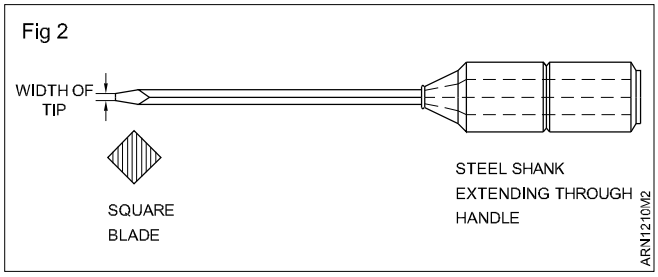
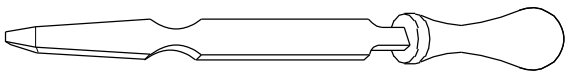


Fig 3



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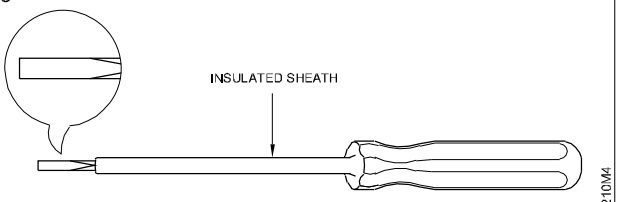
This screwdriver has a square blade for applying extra twisting force with the end of the spanner. Heavy duty screwdrivers of London pattern have a flat blade and are mostly used by carpenters.

Light duty screwdrivers (Fig 4)

Fig 4



LIGHT DUTY SCREW DRIVER

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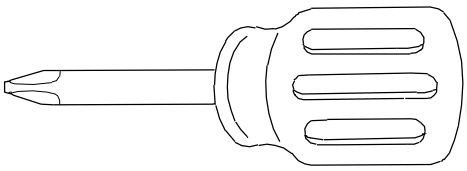
This screwdriver has a round blade with parallel tips. This screwdriver is used by electricians. The blades are sheathed in insulation to avoid short circuiting live parts.

Stumpy screwdrivers (Fig 5)

Fig 5



STUMPY SCREW DRIVER

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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)

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

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

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

Ratchet screwdriver (Fig 7)

The following are the features of ratchet screwdrivers.

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

Fig 6

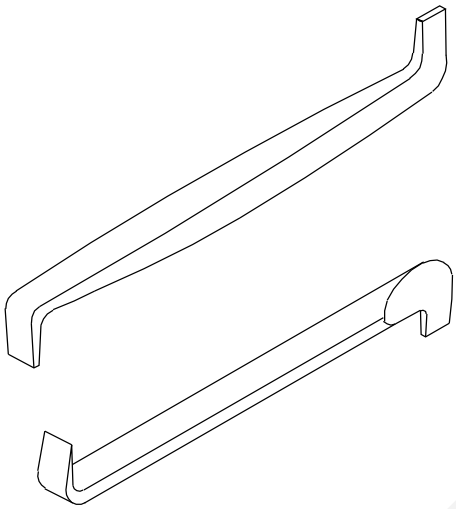

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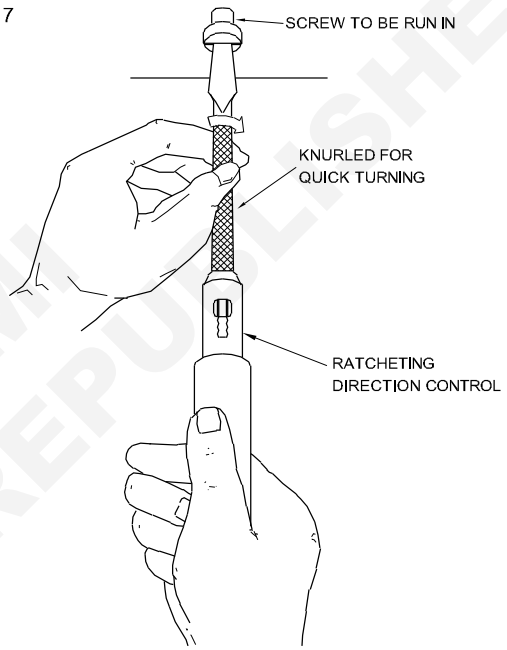
Fig 7



RATCHET SCREWDRIVER

ARN1210M7

They are used for tuning screws in confined spaces. They can be operated without changing the hand grip.

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

They are used in mass production.

Phillips (cross-recess) screwdrivers (Fig 8)

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

The end of the four flats is tapered to an angle of 53° The extreme end is ground to 110°.

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

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

Fig 8

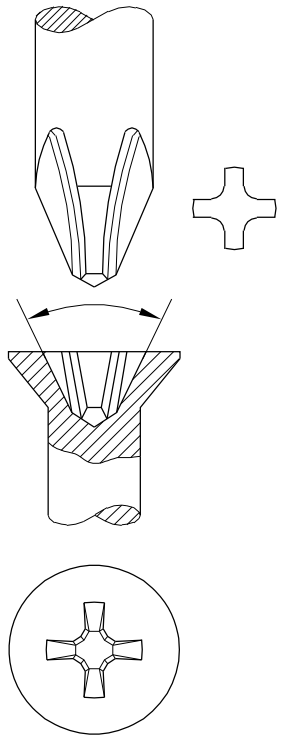


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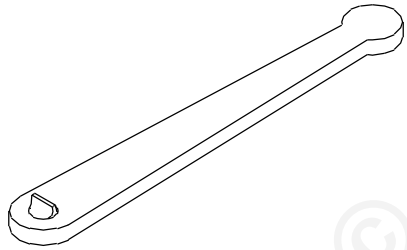
Fig 9



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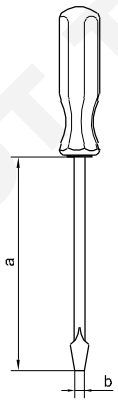
Specification

Screwdrivers are specified (Fig 10) according to the

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

Fig 10



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Normal blade length : 45 to 300mm.

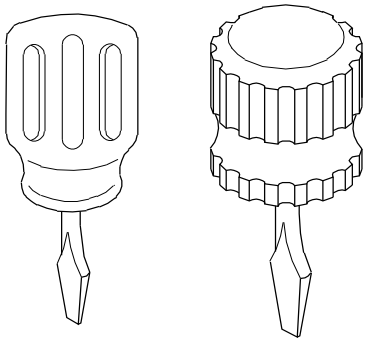
Width of blade : 3 to 10mm.

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

Screwdrivers for special uses

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

Fig 11



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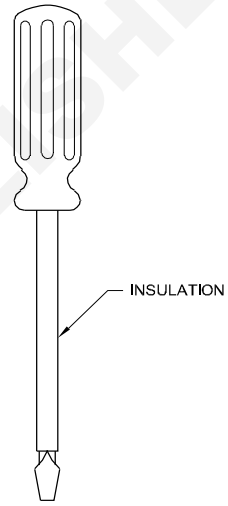
Screwdrivers with blades sheathed in insulation are available for the use of electricians (Fig 12)

Fig 12



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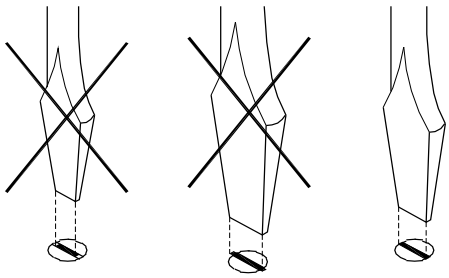
Precautions

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

Fig 13



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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 14

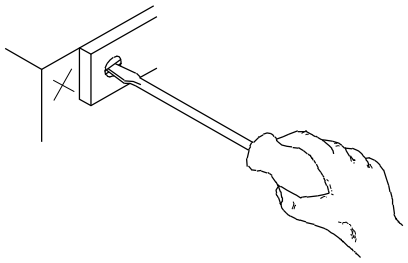

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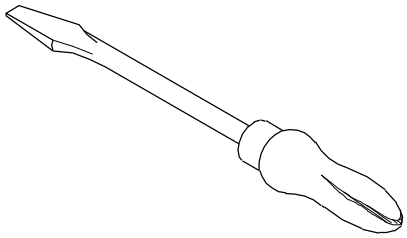
Fig 15



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

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

Specification of a screwdriver

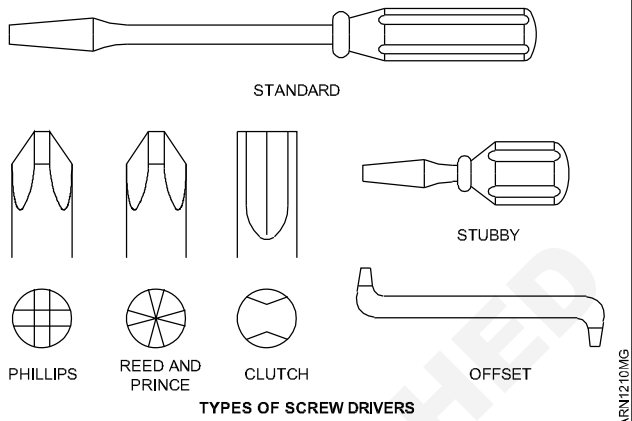
Screwdrivers are specified according to the

- length of the blade
- width of the tip

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

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

Fig 16



TYPES OF SCREW DRIVERS

ARN1210MG

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.

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

Specification of a screwdriver

Screwdrivers are specified according to the

- length of the blade
- width of the tip

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

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

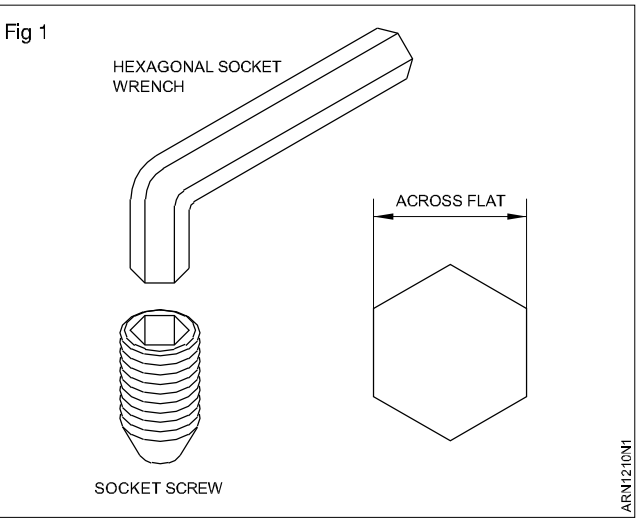
Uses

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

Allen keys, available in different sets in plastic wallets, surprise of a set of 8 (2 to 10mm) 2,3,4,5,6,7,8 and 10mm

Sizes of Allen keys (Fig 1)

Fig 1



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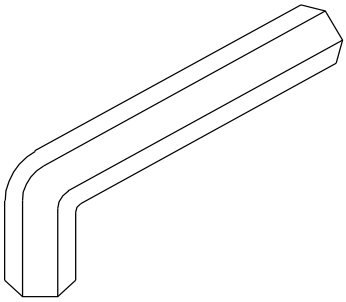
Individual pieces are available as follows 1, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 14, 17, 19, 22, 24, 27, 32 and 36.

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



ARN1210N2

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.**

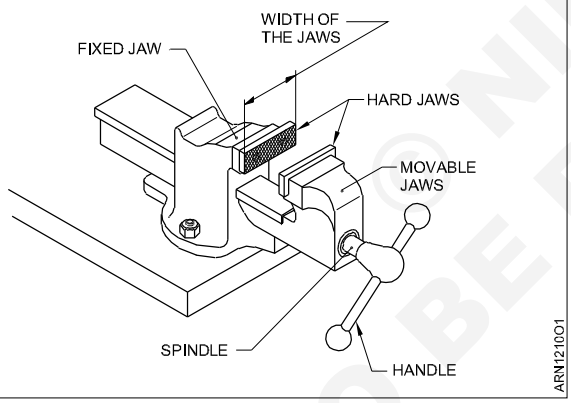
Vices are used for holding workpieces. They are available in different types. The vice used for bench work is called as bench vice or (Engineer's vice)

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)

Fig 1



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The following are the parts of the vice

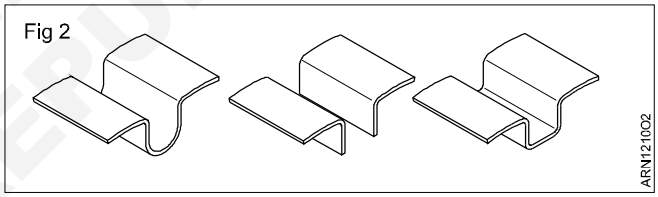
The Vice is generally bolted and secured in a wooden work table, and is useful for operations like filing, chipping, hack sawing, bending sheet metal etc.

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

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

Vice clamps or soft jaws (Fig 2)

Fig 2



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

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

Types of vices

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

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

Quick releasing vice (Fig 1)

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

Pipe vice (Fig 2)

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

Fig 1

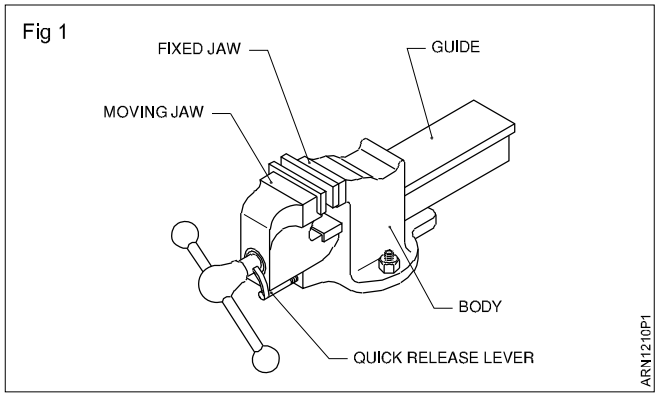

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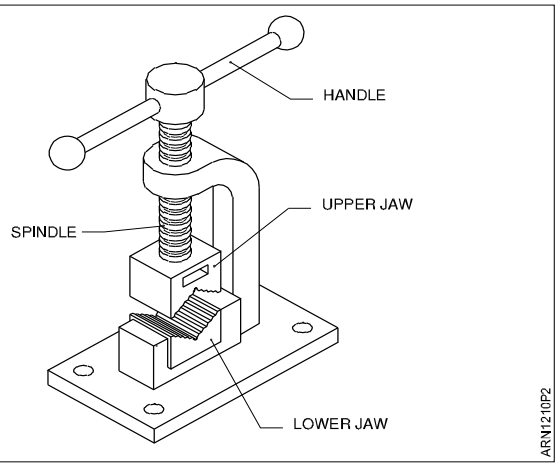
Fig 2

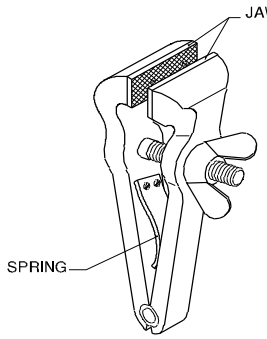


The jaw works vertically. The pipe vice grips the work at four points on its surface.

The parts of a pipe vice are shown in Fig 2.

Hand vice (Fig 3)

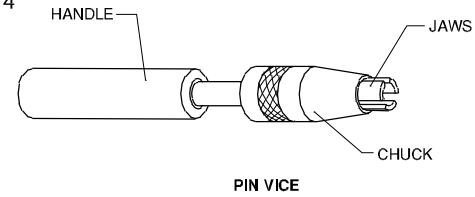
Fig 3



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

Pin vice (Fig 4)

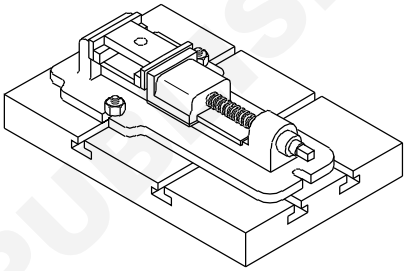
Fig 4



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

Toolmaker's vice (Fig 5)

Fig 5



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

C - Clamps and toolmaker's clamps

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

Purpose of using clamps

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

Requirements of clamping devices

Should be able to manipulate for easy loading.

Should provide the required clamping force.

Should be capable of locking with minimum movement.

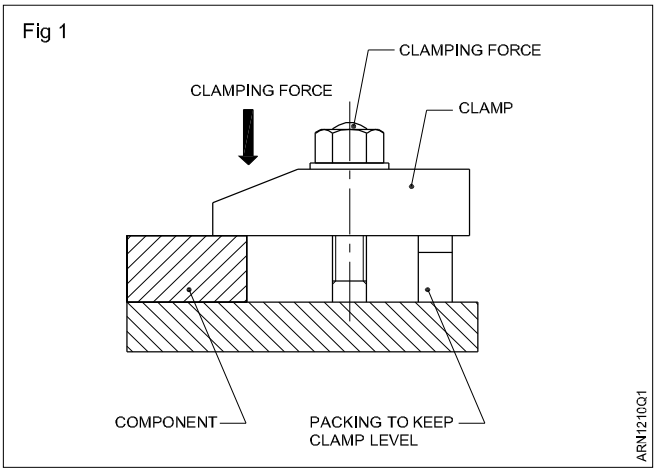
Should accommodate a range of sizes of jobs.

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

'C' Clamps

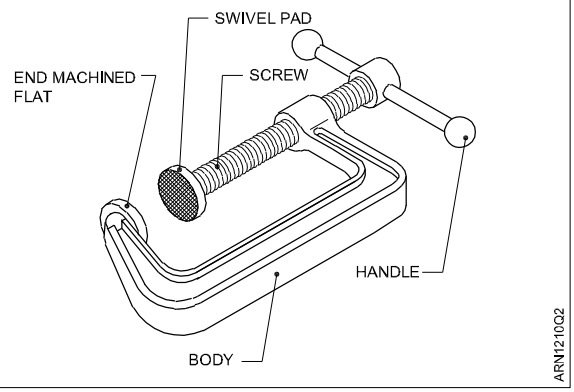
These clamps are in the shape of a 'C'. The 'C' clamp has its body forged or cast. One end of the clamp is machined flat. The other end is drilled and threaded to accommodate a screw-rod which is operated by a handle.

Fig 1



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



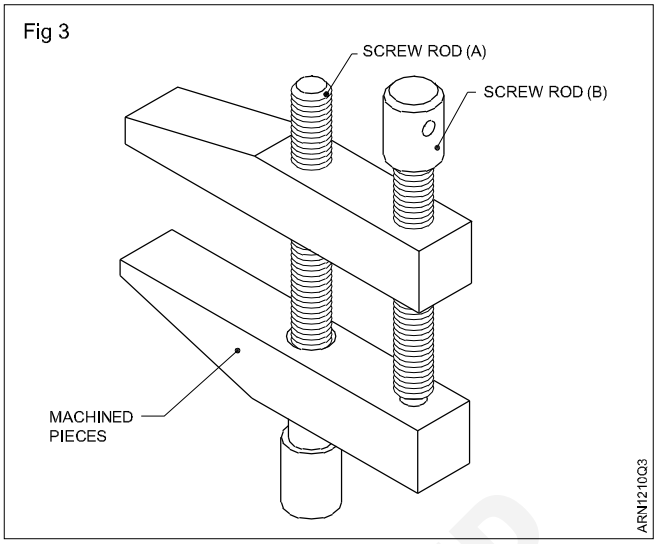
These clamps are used to hold work, on an angle plate or a drill press table, and also, for holding two or more workpieces together.

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.

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.

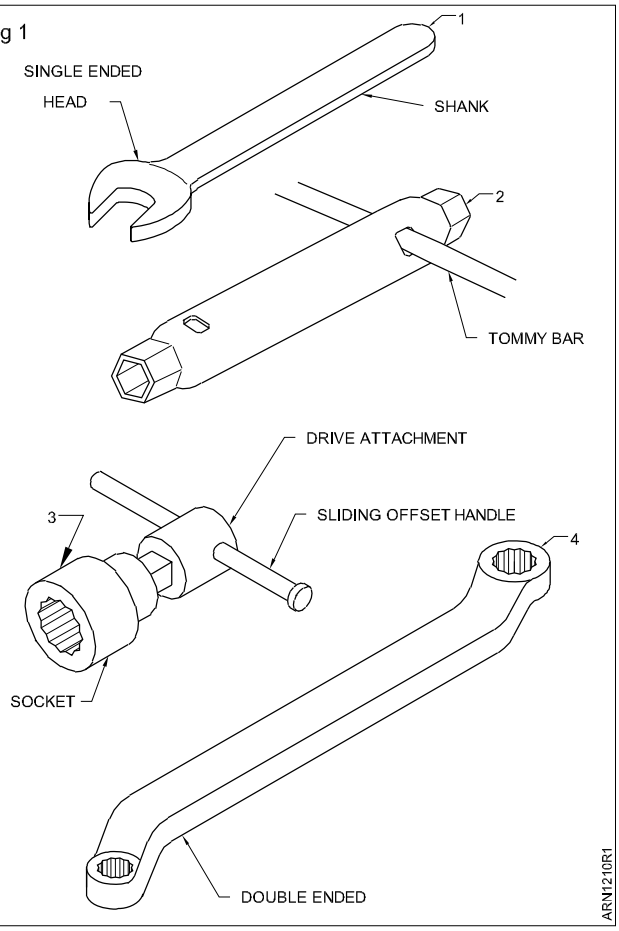
Use both hands for large spanners.

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)

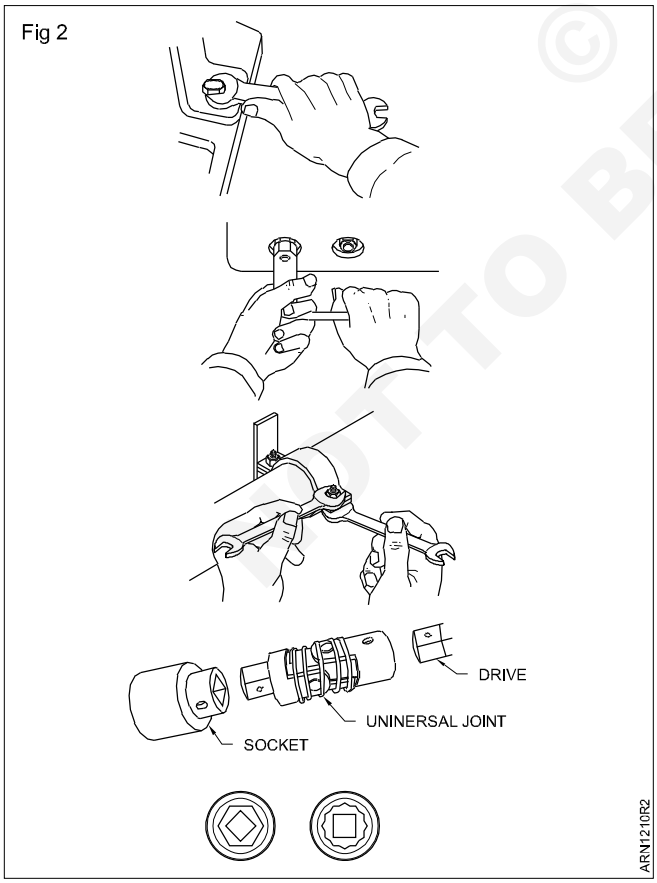
Use two spanners as shown in the figure to stop the head of the bolt rotating as the nut is operated. (Fig 2)

Fig 1



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

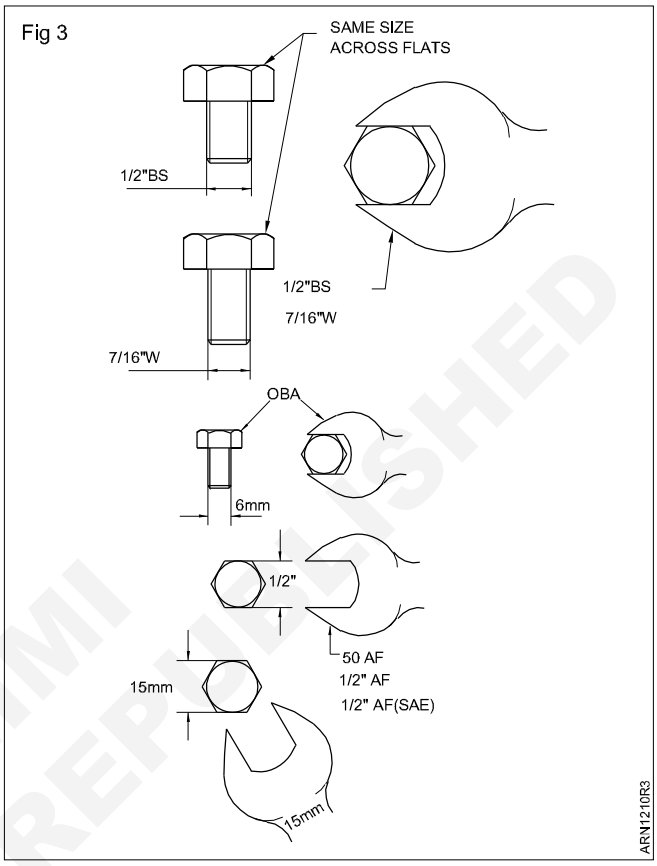
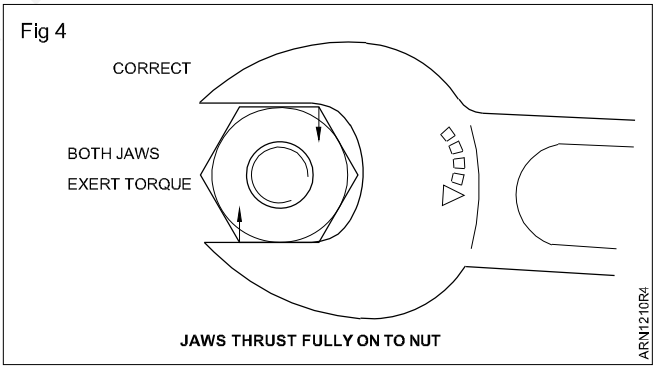


Fig 4



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:

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

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

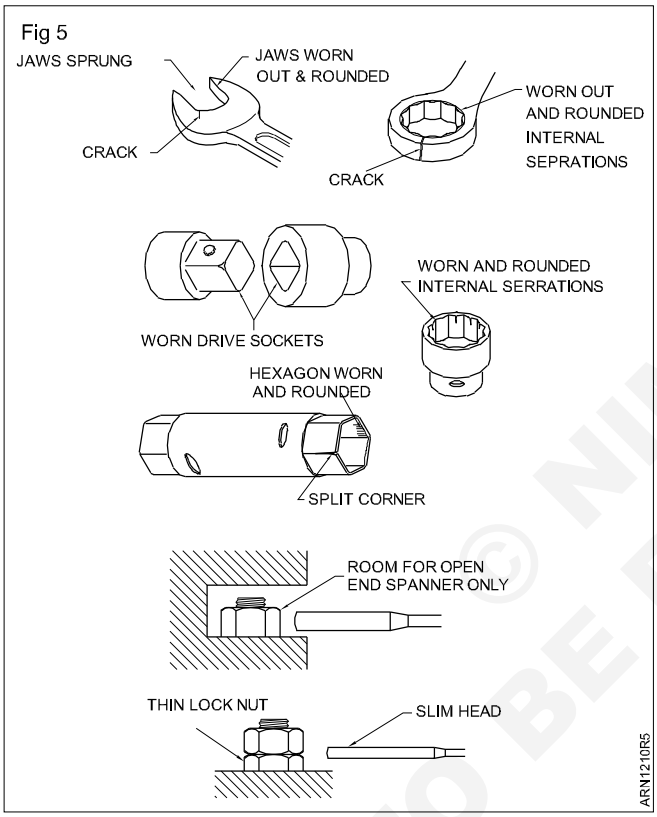
Place the spanner so that its jaws bear fully on the flats of the nut.

Incorrect use damages the spanners & the nuts too.

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

Choose spanners that allow room for use.

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



Length of spanners (Fig 6)

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

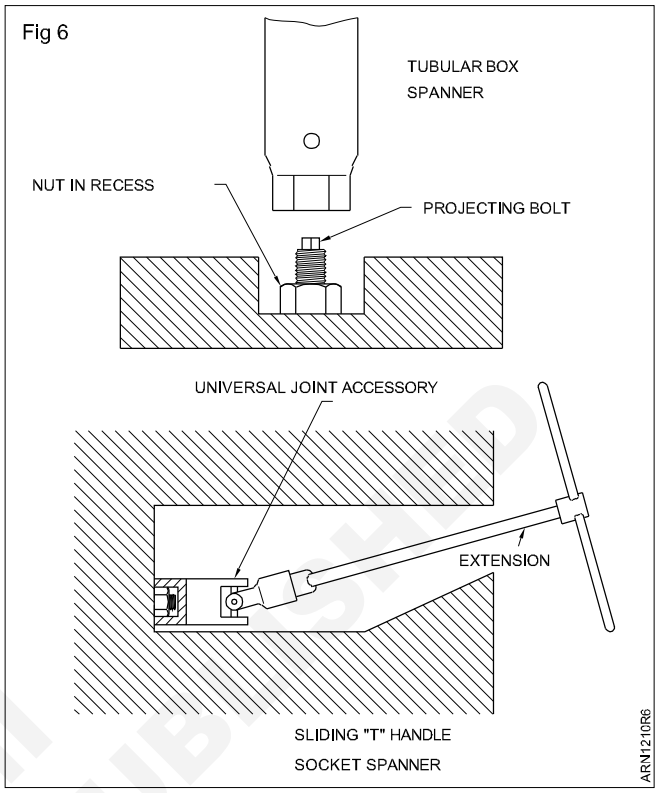
Never exert excessive pull on a spanner, particularly by using a pipe to extend the length of a spanner.

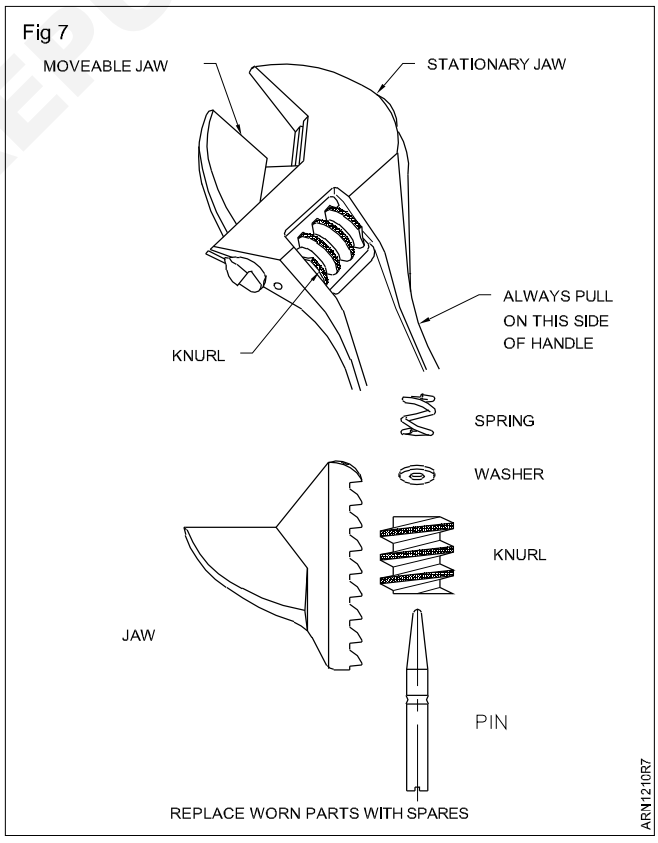
Excess turning effect of the spanner could result in:

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

Adjustable spanners (Figs 7 & 8)

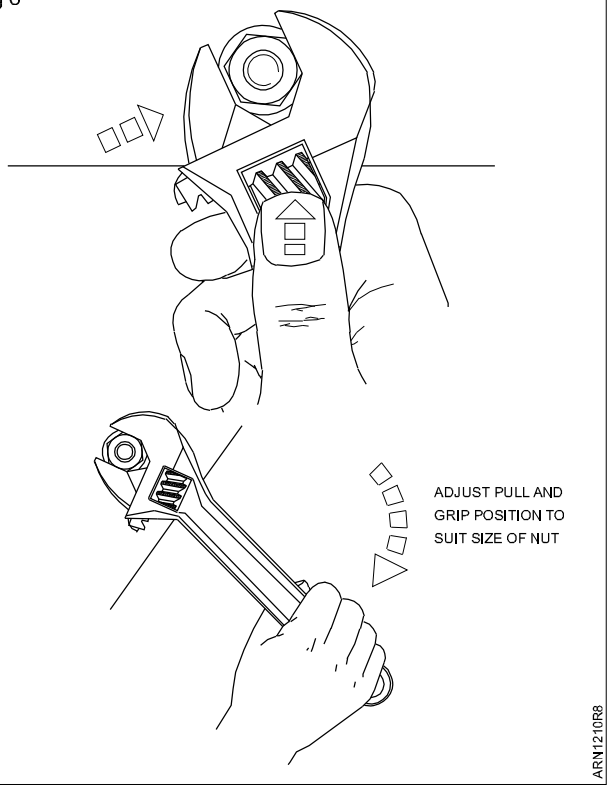
Most common types of adjustable spanners are similar to open and spanners, but they have one movable jaw. The opening between the jaws of a typical 250 mm spanner can be adjusted from zero to 28.5 mm. Adjustable spanners may range in length from 100 mm to 760 mm. the type illustrated has its jaws set an angle of 22 1/2° to the handle.





Adjustable spanners are convenient for use where a full kit of spanners cannot be carried about. They are not intended to replace fixed spanners which are more suitable for heavy service. If the movable jaw or knurled screw is cracked or worn out, replace them with spare ones.

Fig 8



When using the adjustable spanner follow the steps given below.

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

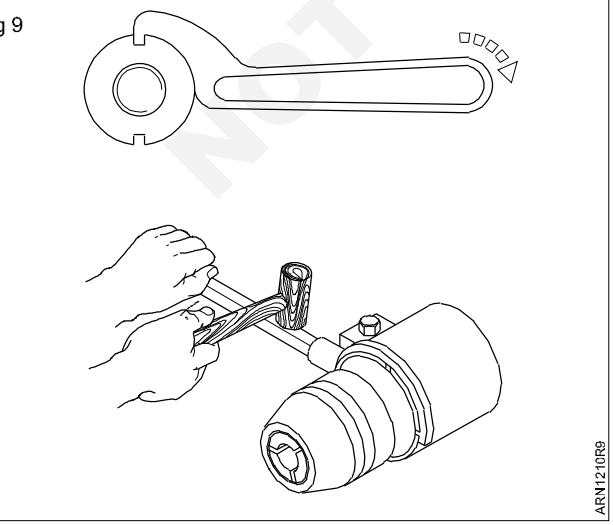
Push the jaws into full contact with the nut.

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

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

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

Fig 9

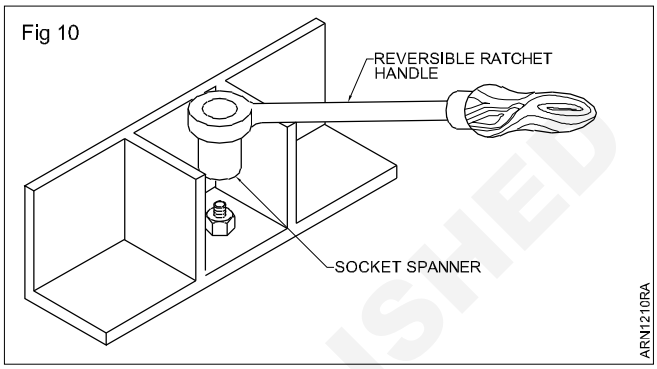


It has a lug that fits in a notch, cut in the outer edge of a round nut. The 'C' section is placed around the nut in the direction in which it is to be turned. In adjustable hook wrenches, part of the 'C' section pivots to fit nuts with a range of diameters. A set of three spanners is needed to cover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

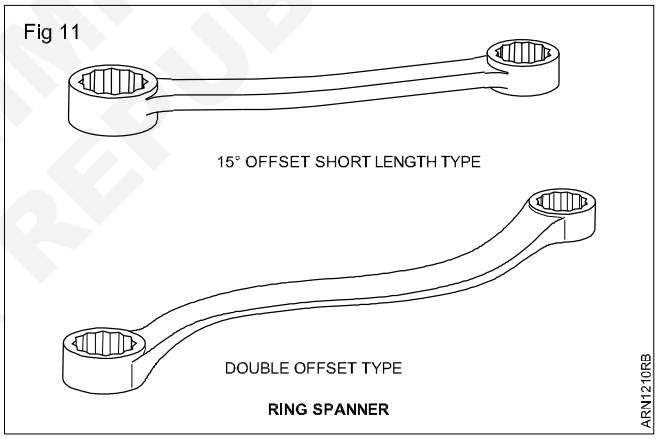
With socket spanners (Fig 10), use the reversible ratchet handle for doing fast work, where turning space is restricted.

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.

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.

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 12

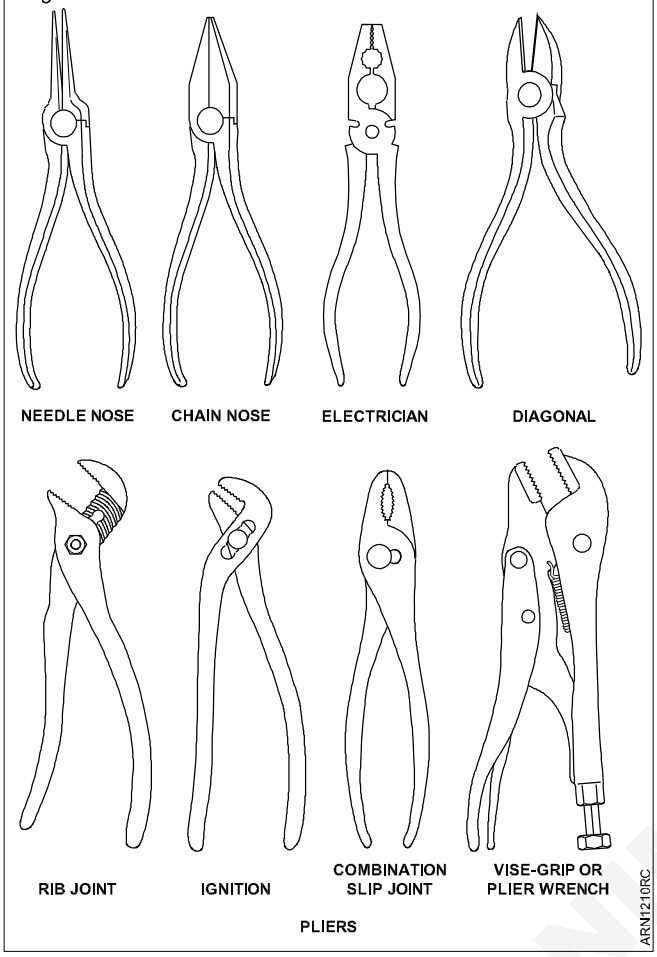


Fig 13

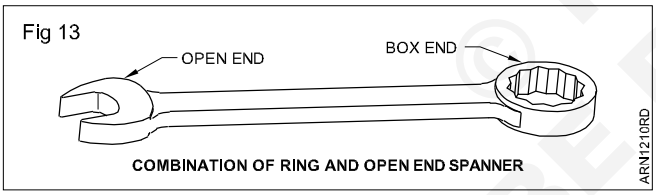
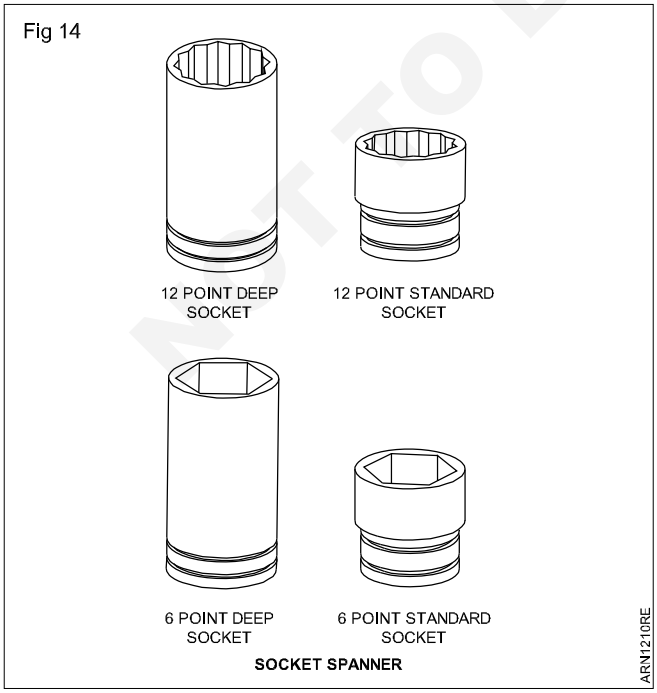


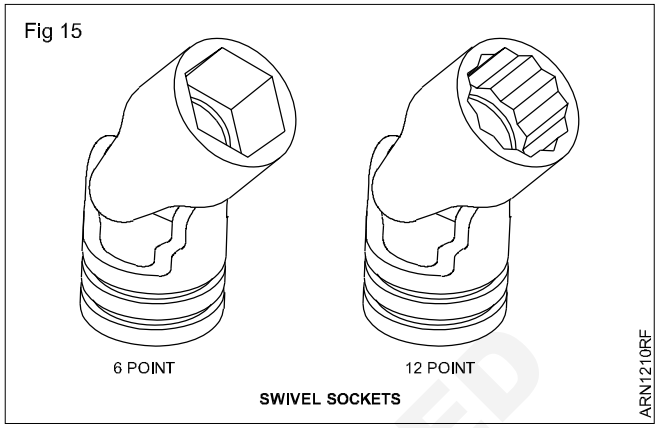
Fig 14



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) is used whenever possible as it can be turned rapidly and socket extension bar (Fig 17) iis used with ratchet handle.

Fig 16

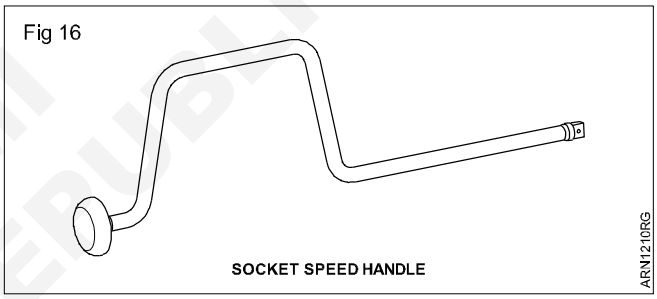
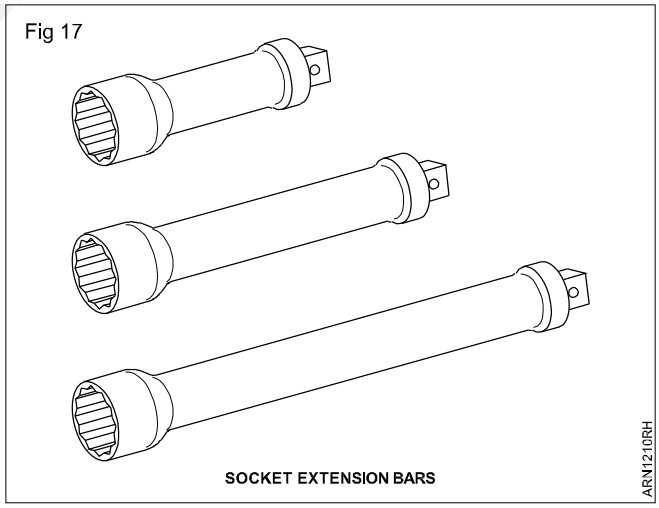


Fig 17



Pliers

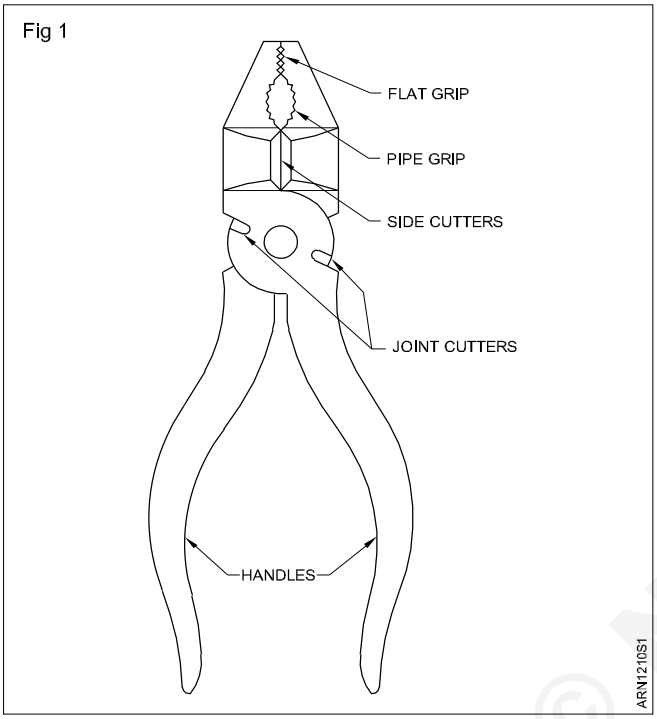
Objectives: At the end of this lesson you shall be able to
- **state the features of pliers**
- **state the uses of pliers.**

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)

Fig 1



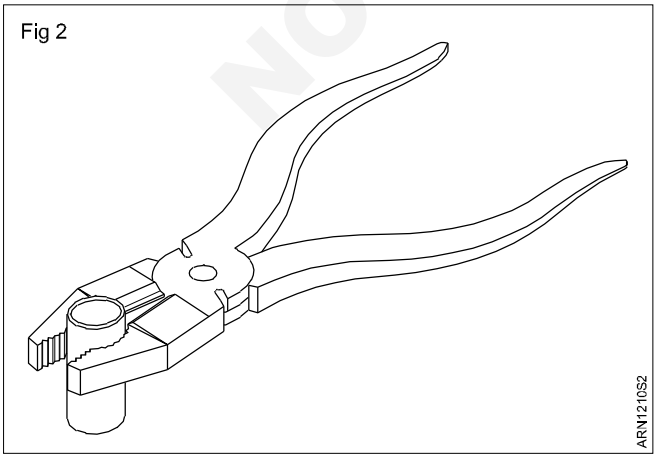
Combination pliers

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

Features

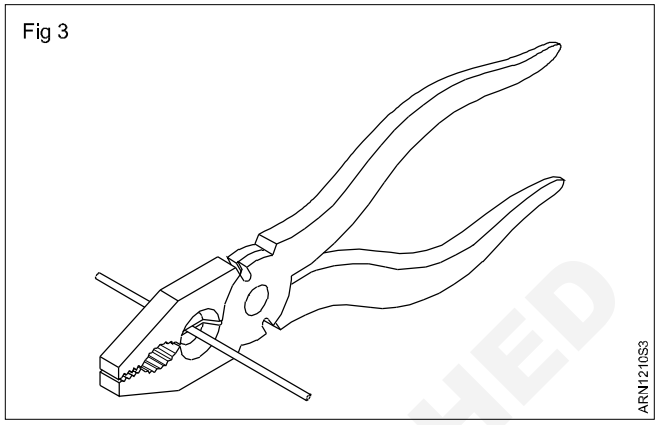
Flat jaw tips are serrated for general gripping. Pipe grip is serrated for gripping cylindrical objects. (Fig 2)

Fig 2



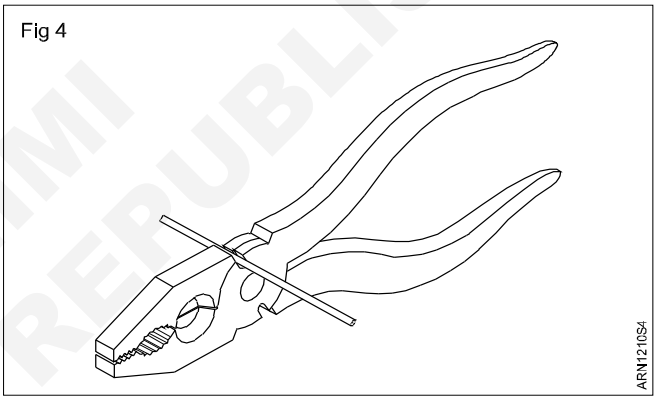
Cutters are provided for cutting off soft wires. (Fig 3)

Fig 3



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

Fig 4



Handles are used for applying pressure by hand.

Pliers are available in sizes from 150 mm to 230 mm.

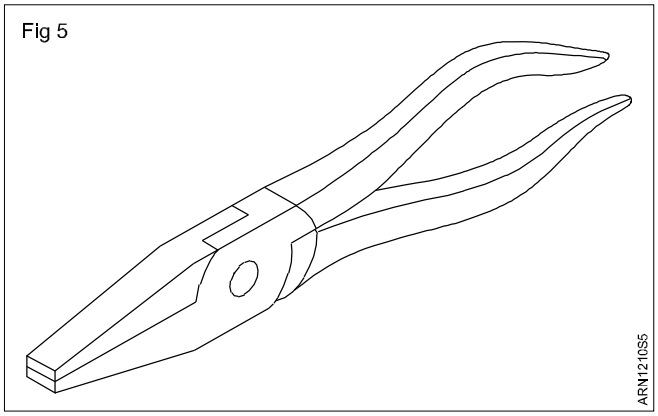
(Size = Overall length)

Other types of pliers

Flat nose pliers

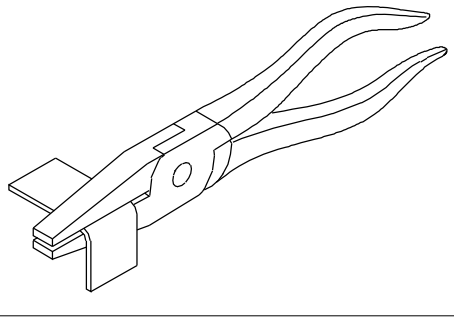
It has tapered wedge jaws with flat gripping surfaces which may be either smooth or serrated. (Fig 5)

Fig 5



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

Fig 6



Round

nose Pliers

This type of pliers is made with tapered round shaped

Fig 7

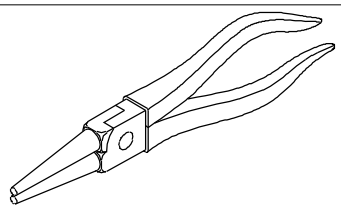
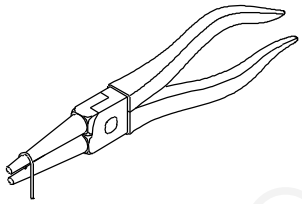


Fig 8

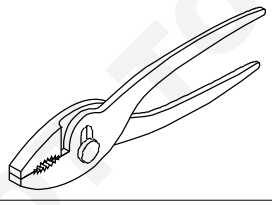


(Fig 7) They are used to shape loops in wires and the form curves in light metal strips (Fig 8)

Slip-joint pliers

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

Fig 9



ranges of jaw opening.

Mainly used for gripping. (Fig 9)

End cutting pliers

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

Circlip pliers

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

Fig 10

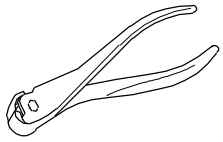
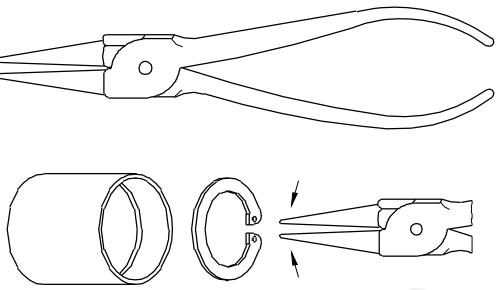


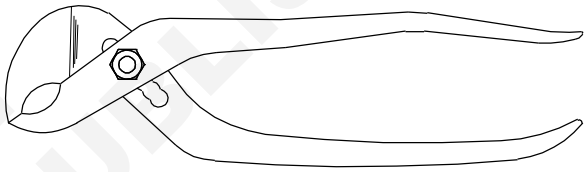
Fig 11



Internal circlip plier

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

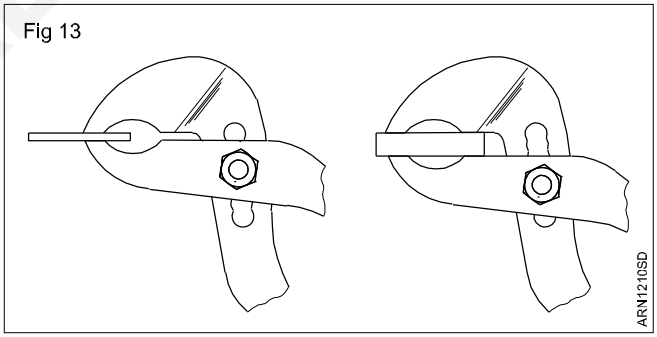
Fig 12



Slip-joint, multi-grip pliers

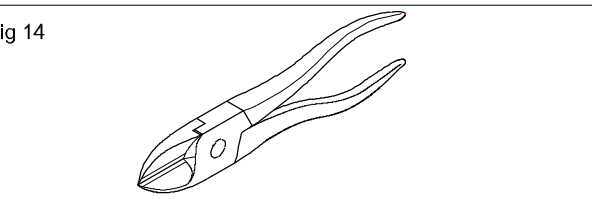
It is similar to the grip pliers but has more openings in the

Fig 13



legs. It gives a range of jaw openings. It allows parallel gripping by the jaws in a number of positions. (Fig 12)

Fig 14



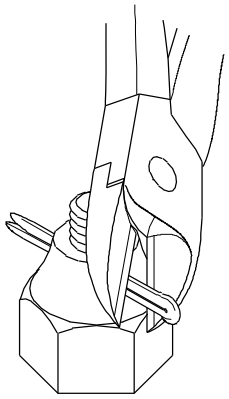
The shape and length of the leg are different from those of the slip-joint pliers. (Fig 13)

Side cutting pliers

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

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

Fig 15



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They are also used for spreading the cotter pin.

External circlip pliers

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

Locking pliers

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

It has high gripping power.

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

SNIPS (Straight & Bent)

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

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

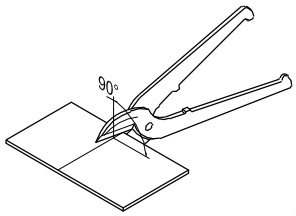
Types of snips (shears)

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

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

Straight snips (Figs 1 & 2)

Fig 1



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

Straight snips have thin blades which are only strong on a vertical planes. They are, therefore, only suitable for straight cuts and external curves when surplus waste has to be removed. While cutting, the blade of the snips should not cover the marking.

Bent snips (Fig 3)

These snips have curved blades for making circular cuts.

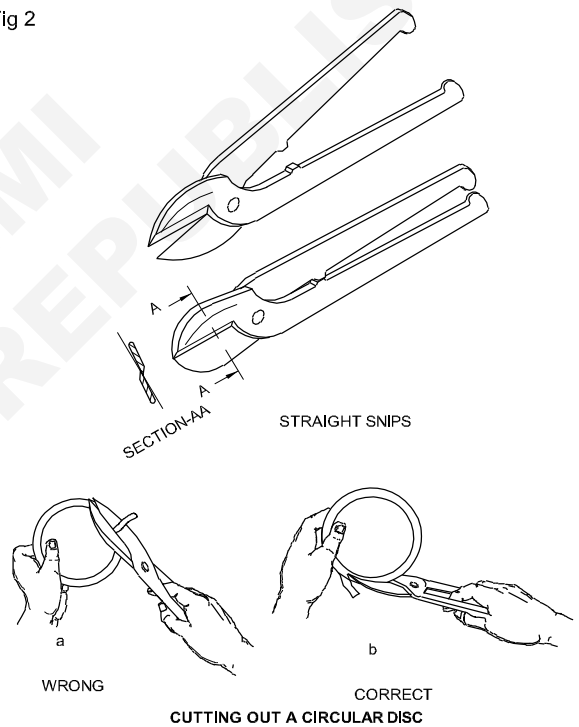
They are also used for trimming cylindrical or conical work in sheet metal.

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

Example

200mm straight snip (Fig 4)

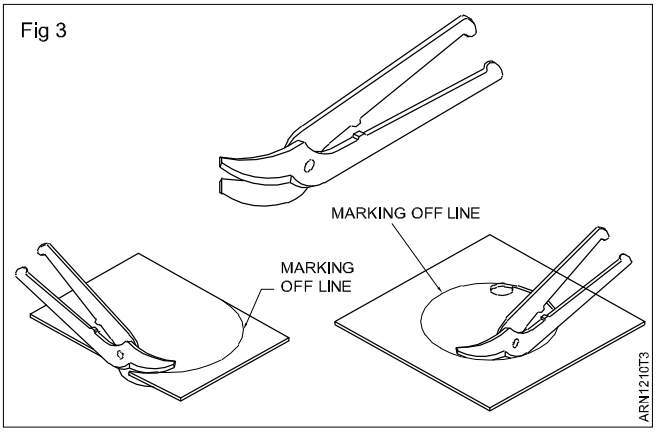
Fig 2



CUTTING OUT A CIRCULAR DISC

ARN1210T2

Fig 3



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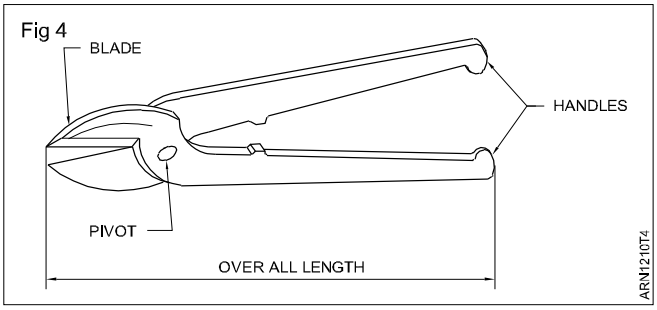


Screw Extractor is a tool for removing broken or seized screws. There are two types one is spiral flute another is straight flute structure. It is made of hard, brittle steel, while applying twisting torque with screw extractor upon the broker screw, enter and bring out.

Nipper is a tool to 'nip' or remove small amount of hard material such as pieces of tiles which need to be fitted around an odd or irregular shape. Nipper is used to in railway line.

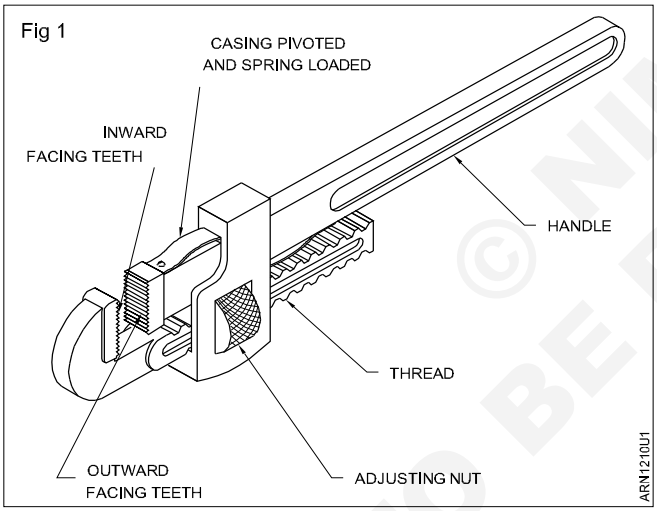
Wrenches

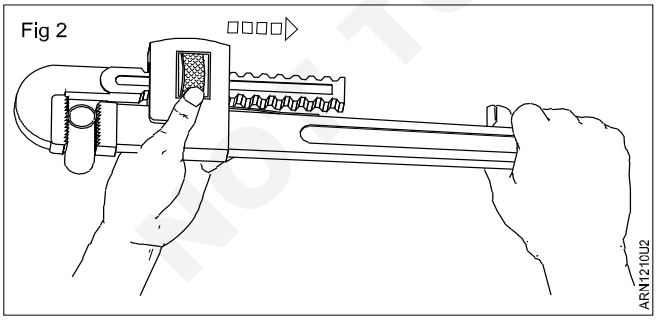
Objectives: At the end of this lesson you shall be able to
- **name the different wrenches used**
- **state the features of each type of wrenches.**

Types of wrenches

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

Stillson pipe wrenches (Fig 1 & 2)





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

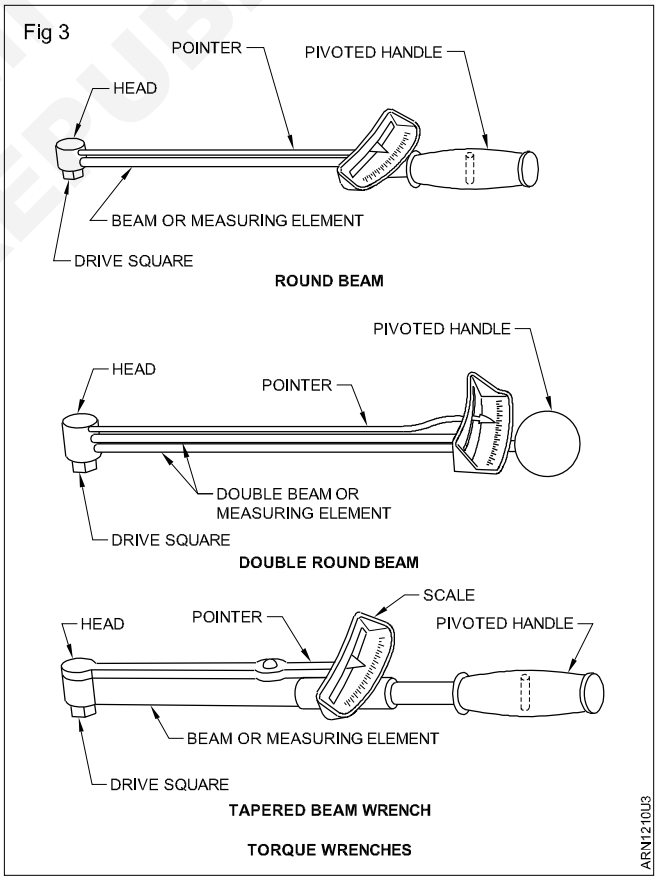
The parts and their names are shown in the

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 tenor/ parts and loose tightening will lead to leakage/breakage during operation. Torque wrenches are available in special shapes and sizes. Selecting the torque wrench of the appropriate size and range is very important. Torque

wrenches are available in pound feed (lb-ft), pound inch (lb-in), kilogram metre (Kg-m) kilogram - centimetre (Kg-cm) and Newton metre (N-m). Newton metre is the preferred metric unit, although others are still used by the manufactures.

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

Dial type

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

Brake over (Micrometer)

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

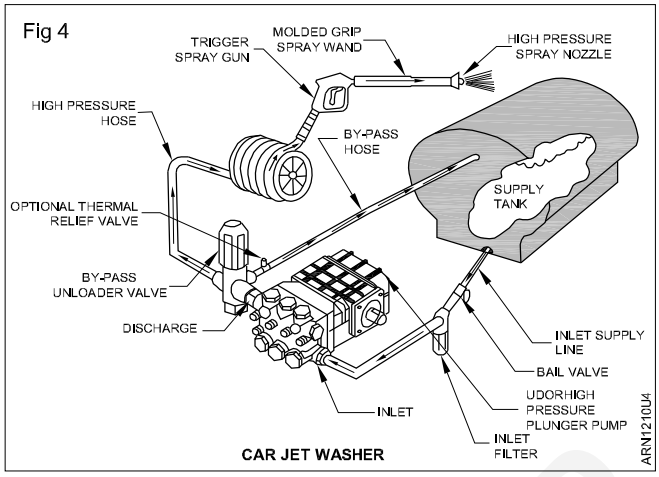
Torsion bar torque wrench

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

Digital read out torque wrenches are also available.

Car jet washer (Fig 4)

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 in car service station for commercial purpose

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 specialized application such as crank shaft bearing removal brake drum, removal pilot bearing removal.

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

Safety: To avoid personal injury during system operation,

Always wear proper PPE gear

Never use a tool to strike a puller

Make sure that items are pulled is well and adequately supported

Do not apply heat to a puller

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

Use puller only with recommended attachment

Do not over load a pulley which may cause to break

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

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

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

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

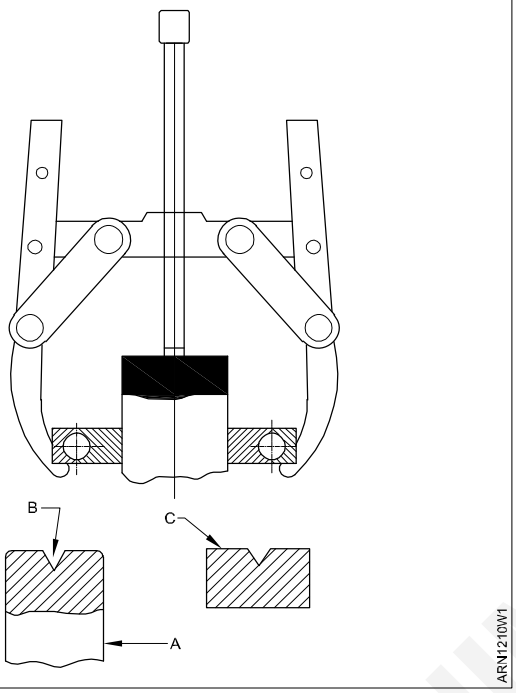
In Automobiles Hydraulic Puller especially used for marine engine liner from the cylinder block during engine Reconditioning Work.

Mechanical Puller Operation (Fig 1)

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

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

Fig 1



3 Tighten strap bolts to hold jaws lightly in place

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

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

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

7 Tighten the strap bolts.

8 Apply pulling force by turning the spindle.

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

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

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

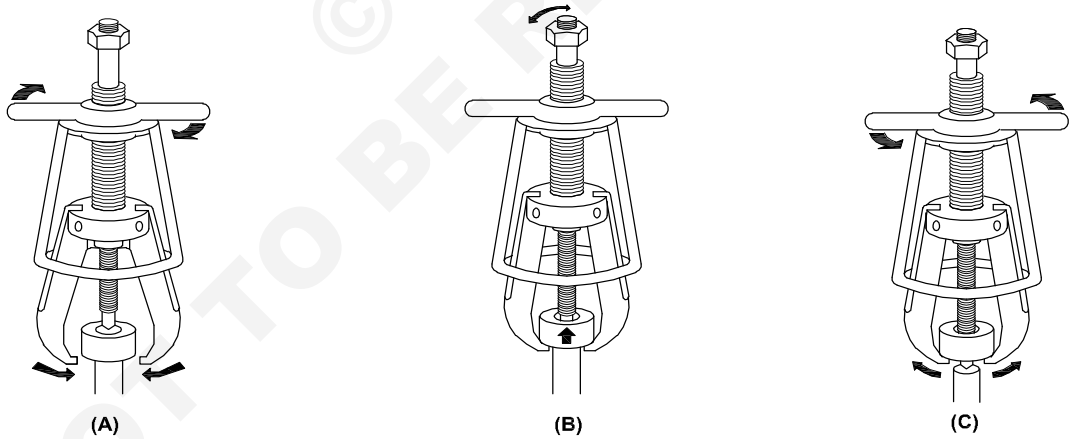
3 To operated the puller, grasp the puller with one hand and turn the T-handle counter-clockwise with the other hand until the jaw opening is big enough to fit over the component to be pulled.

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

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

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

Fig 2



Air impact wrench, air ratchet and other power tools

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**
- **state the features of power tools.**

Air powered wrenches: Air-powere wrenches involved threaded fasteners can be done faster and easer with air powerd wrench. There are two types of wrenches. (1) Impact wrench (2) Air ratchet wrench.

Impact wrenches: An impact wrench is a portable hand held reversible air powered tool for rapid turning of bolts and nuts impact wrench output shaft spins freely over 2000 rpm. The socket snaps over the square drive head and shaft when using an impack wrench, it is important that only impact sockets and adopters be used. Air impact wrenches work regularly well for tightening and loosening. The rotation of wrench is controlled by a switch or two

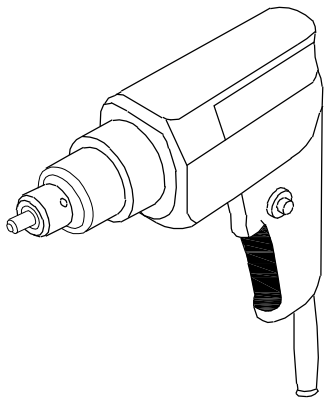
way trigger. Remember not to change the direction of rotation while the trigger switch is ON.

Air impact wrench (Fig 1)

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

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

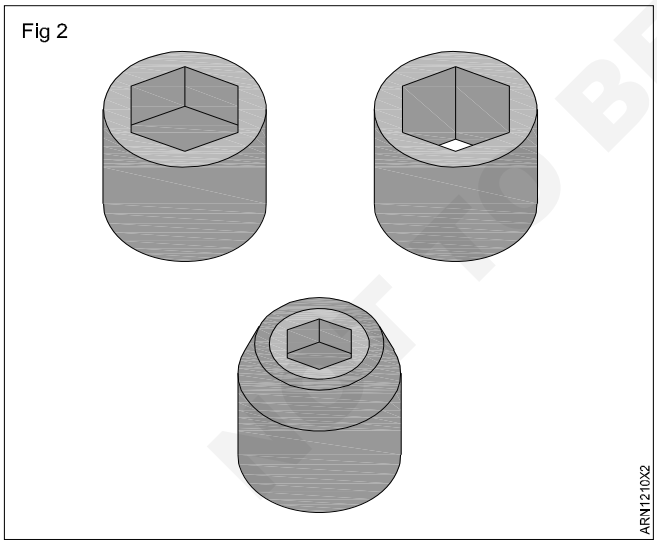
Fig 1



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

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

Fig 2



Air Ratchet

Air ratchet wrenches: It is like the hand ratchet its angle drive reaches in and spins fasteners where other hand or power wrenches just cannot work. The air ratchet looks like and ordinary ratchet but it has a thicker hand grip that contains the air vane motor and drive mechanism.

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.

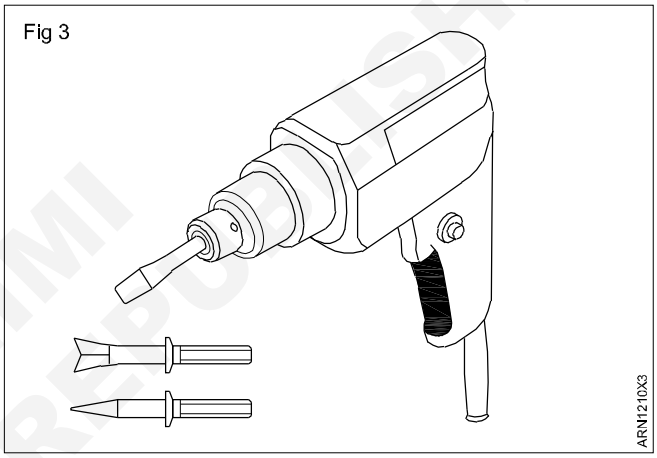
Air Chisel (Fig 3)

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



Maintenance of pneumatic tools: Air tools maintenance is need to up keep the air tools in service.

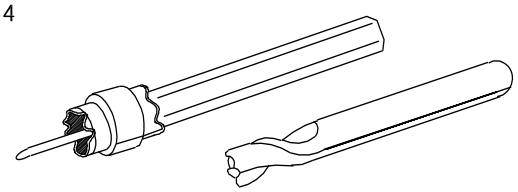
- Lubricate the air tools periodically (Don't use motor oil)
- Squirt a couple of drops of oil into the oil inlet holes on the tool before and after use. This will prevent rapid wear and rusting of the tools.
- Runs the tool after lubricate the oil
- Wipe the excess oil off to the tool to keep it from the body parts.
- Use in-line oiler attachment that will automatically meter the oil into air lines for air tools.
- Don't use the inline oiler's in the paint area.
- Don't use excess lubrication oil on air tools that excess oil could be spoiled the vehicle's surface with oil.

Air drill: Air drill is used an air pressure to spin a drill bit. Air drills are smaller and lighter than electric drills. It is very easier to use for most tasks, especially for drilling operations in auto body repair works.

Spot weld remover air drill (Fig 4): Air drill attachment that are used for cutting out spot welds. When cutting out the spot weld the drill can be fastened to the weld area

with a clamp attachment that makes operation easier. The cutter drill bit will not deviate from the weld center during cutting. These are two types of spot cutters available that can be mounted in an air drill for cutting out spot welds. So work finishing is easy and very smooth as desired.

Fig 4



SPOT WELD CUTTER

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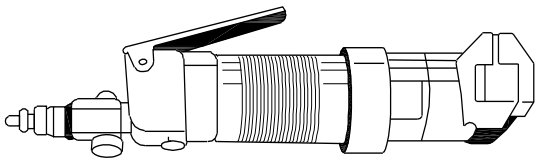
Spot weld cutter drill hole saw type (Fig 5): Air drill hole saw type cutting depth can be adjusted. So that the bottom panel is not damaged. It is necessary to sand off the remaining portion the weld.

Fig 5



AIR BENCH

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Vacuum cleaner: Vacuum cleaner is used for removing dust and debris from the vehicle interior. It is the first tool used when a vehicle comes in for refinishing work. Vacuum cleaner will greatly reduce the chance of dirt getting into the complete refinishing job.

Power washer: Power washer can be used in exterior can preparation engine cleaning, under carriage, shop degreasing and cleaning of the vehicle. Before using a power washer, check the personal and machine safety.

Heat gun: Heat gun have many uses in auto body repair shop. Heat gun is used in almost all vinyl roof repairs as well as well as other plastic repairs. Always allow a heat gun to run in the cool air for position for a minute or two offer use. This will protect the heating element from damage.

Hydraulically powered shop equipment: These type of equipment are used on oil like liquid called hydraulic fluid. These equipments operate by hydraulic oil pressure achieved by manually pumping on a handle or lever to build up the fluid pressure or motor by electrically provides the fluid pressure needed to force the hydraulic fluid to the equipment cylinder. The cylinder then causes the tool to operate when a button or lever is turned ON.

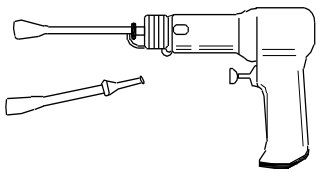
Never work under vehicle supported by hydraulic Jack place the jack stands under the vehicle before working under chassis of the vehicle.

Hand or bottle Jacks: It is tubular shaped and perform a variety of functions and range from 1 1/2 tons of lifting capacity. They are useful when a service jack is too much.

Service jacks: It is a four wheeled jack with a pump handle are by far the most commonly used jack in the body shop. Its lifting capacity is 1 ½ ton to 5ton these jacks are easily dollied around the shop. This jack is intermediate, compact to use.

Air chisel (Fig 6): Air chisel is used for various driving and cutting operations of auto body repair. Different types of chisels or blade can be installed in the air chisel body to complete various auto body repair tasks.

Fig 6



AIR CHISEL

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When you are using the air chisel, position the tool by starting slowly, then increasing power. Avoid running into hardware frames and so forth, with sheet metal cutting tools. Check the chisel shanks periodically and keep the cutting sharp when you are using a air chisel wear thick gloves, a face mask/shield and hearing protection during power cutting metal.

Transmission jacks (Fig 7): It is used to remove the transmission, engine or drive train from the unibody before servicing a repair. This jacks lifting capacity ranges from ¼ to 1 ton.

Frame jacks: Power portable frame jack is a hydraulic hand pump and ram the minor body and frame straightening operations. These jacks are used to perform the many different straightening operations involving pushing pulling or holding a panel to align metal, a large assortment, of attachments can be obtained.

The basic hydraulic jack unit consists of a manual, electrical or air pump, a hydraulic hose, and a ram. Rams are available in various lengths. Included under rams are two wedge - type or spreader rams used for getting into light location. There are two basic types of frame jacks as below.

1 Portable frame rack

2 Stationary frame rack

Frame rack: Frame rack is a large electro/hydraulic machine for holding a vehicle while pulling out major structural damage. It is rack is a thick steel frame work that supports and holds the vehicle secure while pulling cut the damage park of the vehicle.

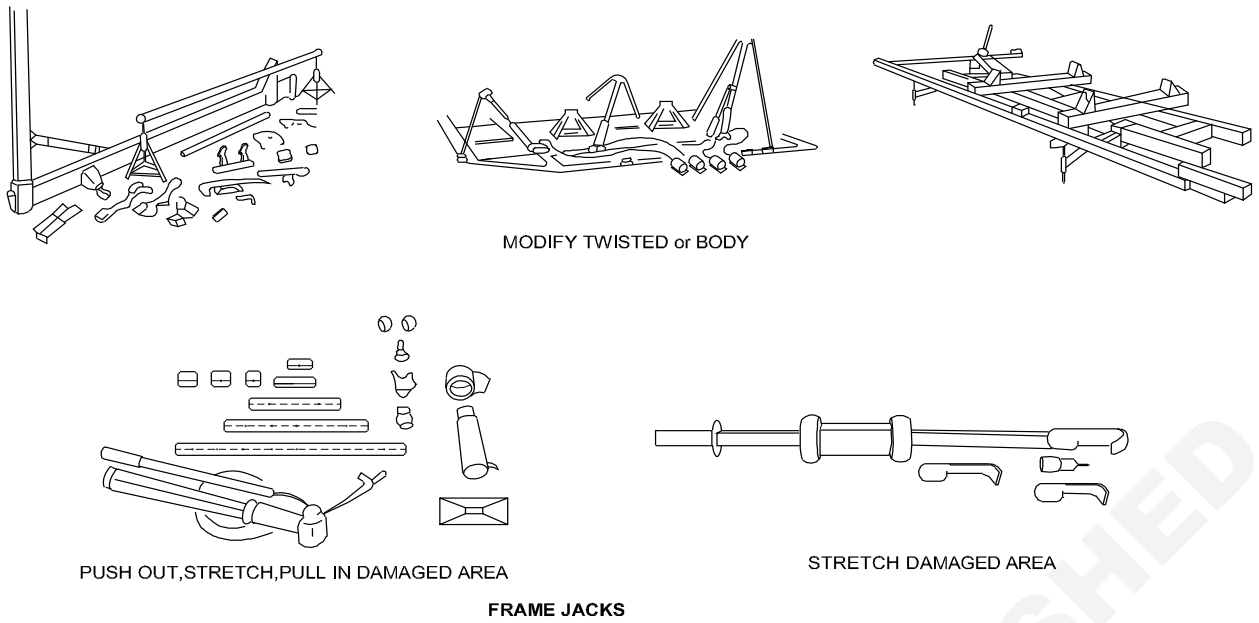
Pulling towers contains hydraulic rams and pulling charms that attach to the damaged area of the vehicle.

Hydraulic rams mounted on the pulling towers attach and pull on the chain attached in the vehicle.

Hydraulic tool maintenance: Hydraulic tools preventive maintenance. Avoid failure at a critical moment.

- Hydraulic tools should be lubricate properly.
- Use the SAE 30 - lubricate oil the moving parts include the moving mechanism, pump roller, universal joint, handle socket, pivot pins, wheels and bearings.

Fig 7



FRAME JACKS

- Be sure to grease the fittings and sliding points used in pumping.
- Avoid over filling a hydraulic oil in a tool.
- Make sure the system and ram are fully retracted so oil pressure has been released.
- Remove air spongy effect in hydraulic system.
- Maintain the correct level of fluid in hydraulic tools circuit.
- Arrest the leaks under fluid pressure and air pressure in the circuit.
- Check and ensure the proper function of valves provided in the air and hydraulic circuit.
- Ensure the proper function of hydraulic tool operating system.

Hydraulic lifts: It is used to raise the whole vehicle in the air for easier working. The traditional stationary in the ground unit is used in car service station, dealers, repair shops and auto body repair shop. Hydraulic lifts are used lift off the vehicle from ground to estimate and repair the vehicle easier.

There are several ways to get a vehicle off the ground by four post and two post hoists. The using of lifts is a much less physical and mental task on the body of technicians. The quality of lifts provides the number of safety devices on each model, makes them safe to operate.

Maintenance on above ground lifts is minimal, but important depending on the lift, pulling, pivoting lift, links and wheels should be greased. Bearings, pins, and other moving parts should be oiled, and cables and chains should be checked for worn or frayed areas following the manufactures directions.

General maintenance on lifts includes inspecting the lift pods and bumbor cushions regularly and replacing them if of necessary.

Engine crane: An engine crane uses hydraulic power to raise heavy power trains from a vehicle during major repairs. The engine and transmission may have to come out to replace frame rails or other structural panels. The engine crane has a large lift arm that can be raised by pumping the handle on the hydraulic cylinder. The ram will then extent to lift the aim and any assembly attached to engine.

Power tools: Air powered tools: Air power tools are driven by compressed air supplied by an air compressor. Pneumatic tools can also be driven by compressed carbon dioxide (Co_2) stored in small cylinders allowing for potability.

Advantages of air powered tools: Pneumatic tools have many benefits, which have contributed to their rise in popularity. The advantage and disadvantages of using compressed air to power tools are

Advantages	Disadvantages
Inexpensive	Air power tools required larges up front cast
Safe to use	Air tools themselves are usually less expensive than their counter parts
Easy to operate	Air compressors are an expensive and unavoidable up front cost for pneumatic tools
Portable	Pneumatic tools are lighter and stranges
Low theft rate Low maintenance cost	

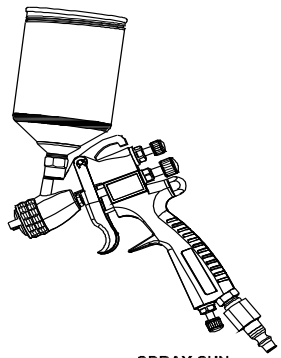
Electrical power tools: Electrical power tools are driven by electrical energy which supplied by power grid or power

generators. This type of power tools have more risk to operate. While because

- Electric shock risk
- Low or high power damage the power tools
- Power is not available in all place
- High theft rate
- High maintenance cost
- Initial cost also higher than air power tools that performs the same task.
- Electric require less (expensive) investment
- Electric tools were more versatile

Air spray gun (Fig 8): The spray guns are used to apply sealer primer, paint and other liquid finishing materials to a vehicle. The air spray gun flows liquid on to the vehicle body surface smoothly and evenly. The paint spray gun atomizes a liquid by breaking it into a mist of droplets. This requires sufficient air pressure and volume at the gun, which can be powered by pneumatic energy, although air spray gun is used to do most of the refinishing work. Air spray guns are also one of the most efficient of all pneumatic tools.

Fig 8



SPRAY SUN

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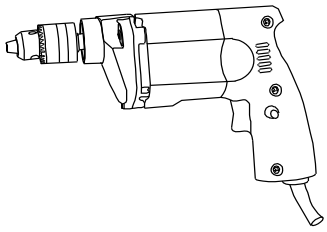
A conventional atmoizing as spray gun is a precision tool using compressed air to atomize sprayable material. Replacing the conventional system is many body shops is the high volume, low pressure gun. Air and paint enter both types of guns through separate passages and are mixed and ejected at the air nozzle to provide a controlled spray pattern.

Air drill (Fig 9): Air drills are used the shop air pressure to spin a drill bit. They can be adjusted to any speed and are more commonly used than electric drills. They are usualy available in many sizes. Air drills are smaller and lighter than electric drills. Their compactness makes them a great deal easier to used for most tasks, especially for drilling operations in auto body work. Drill bits of different sizes for into the chuck on drills for making holes in parts drill bits comes in various sizes. The drill size is usually stamped on the upper part or shank of each drill bit.

A key is used to tighten the chuck. The chuck has movable jaws that close down and hold the bit. The key has a small gear that turns a gear on the chuck. Never leave a key in a drill when not tightening. Always unhook the air hose when installing a bit to prevent injury.

Fig 9



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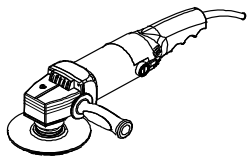
Air screw driver: Air screw driver is a portable, hand held, reversible air powered tool for effective rapid turning of screws and nuts. When triggered the output shaft spins freely over high rpm. When using an air screw driver it is important that only suitable screw driver be used make certain air screw drivers are clearly marked or labeled for use with air screw drivers. An adjustable air regulator is part of most penumatic impact screw driver. Turning the air control knob allows to adjust the tools speed and torque. To remove conventional threaded fasteners set the switch for left hand counter clock wise rotation place a screw driver over the fastener screw head. Exert forward pressure on the screw driver, while deprassing the trigger switch. As soon as the fastener screw becomes loosened, relax the forward pressure on the wrench to let it spin the fastener screw free, do not use and air impact screw driver for final torque fasteners. When important fluid torque should be done by hand. This will prevent broken fasteners. Air screw driver run cool will not burn out even under constant use. They are designed to perform will in wide variety of applications.

- machine screws in tapped holes
- soft tapping screw in plastic
- sheet metal screws
- self drilling screw and thread forming screw in blend die-cast holes

Air sanders -disk type (Fig 10): An air sander uses an abresive action to smooth and shape body surface different coarseness sand papers can be attacahed to the pad on the sander. Coarse sand paper remarks materials more quickly. Fire sand papers produces a smoother surface finish. Air sanders are one of the most commonly used air tools in auto body repair most rough sanding done in automotive work done with a disc sander.

Fig 10



DISC SANDER

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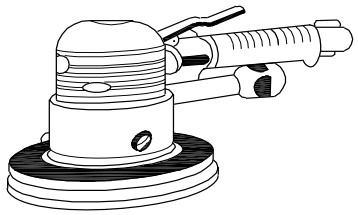
Dual-action sander (Fig 11): The dual action orbital sander oscillates while it is rotating and creates a buffing pattern rather than the swirls and scratches often caused by the disc sander it is designed for fire finish sanding it is possible to use a wider variety of abrasives with finish sanders. The sander pad is a soft mounting surface for the sand paper. Disc adhesive self-stick paper, or hook and latch paper holds the sand paper onto the pad. Disc adhesive is special non hardening glue that comes in a

tube it can be placed on the pad to adhere the paper to the sander self-stick paper already has a non hardening glue on it hook and latch paper's advantage is that can take hook and latch paper off the tool without damage and reuse it.

Fig 11



DOUBLE ACTION SANDER

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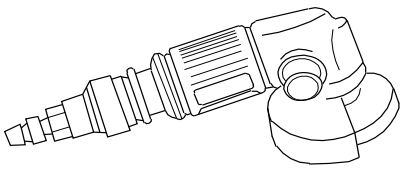
Air grinders (Fig 12): Air grinders are used for fast removal of material. They are often used to smooth metal joints after welding and to remove paint and primer. The most commonly used portable air grinder in collision repair and refinishing shops is the dise type grinder. It is operated like the single action disc sander. Air grinder should be used carefully. It can quickly thin down and cut through body panels cause for major problems. 5 inch dual-action is good for most featheredging tasks and small diameter sander will work well in confined spaces or a small parts.

Fig 12



DISC GRINDER

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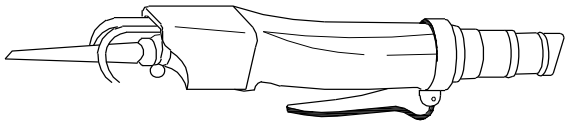
There are several other grinders are used in the body shop. They are as follows.

- A horizontal grinder is used for heavy-duty grinding
- The vertical grinder is a larger version on the disc grinder with a sanding pad, this grinder can be converted into a disc sander most vertical grinders can be used with both straight wheels and cup wheels.
- An angle grinder is used primarily for smoothing deburring and blending welds.
- A small wheel grinder is used with abrasive wheels and wire brushes.
- The die grinder is used with mounted points and carbide burrs for a variety of applications.
- A cut off grinder is used to cut through muffler clamps and hangers with ease.

Air saw (Fig 13): An air saw uses a reciprocating action and hacksaw type blade used to quickly cut through metal. An air saw is handily, when using an air saw, do not apply to much pressure to the blade. Otherwise it will heat the saw teeth and dull the black.

Air scraper: Air scraper produce a reciprocating action on a hardened steel scraper blade. The sharp air scraper blade quickly peels off sound deadening sealer and material. This scraper is used for removing the damaged body panels of a vehicle.

Fig 13



AIR SAW

ARN1210XD

Air sealer: It is ideally used for crimp the seal on an package with a round or small surface area of vehicle panel by superior tensioning force. It is best performer when striping bars, bundles, pipes and coils.

Air Nibblers: Air nibbler is a rapid cutting motion to nibble or cut small bits of metal. The air tool drives the die up and down, so that small bit of sheet metal are ribbed away air nibbler will make a very clean cut and ideal for cutting relatively flat sheet of metal.

Air chuck: Air chuck is used to fill tires with compressed air. The chuck has a small valve that is opened when forced over the valve stem on a tire.

Air shears: Air shear tool is used to move sharp sheet metal cutting blade back and forth. The shears can be moved to cut irregular shapes in sheet metal.

Air polishers/buffers: This tool is used to smooth and shine painted surfaces by spinning a soft buffing pad. This removes minor paint imperfections to increase paint gloss. The polishing pad is a thick cotton, synthetic cloth, lamb's wool or foam covers that fits over the polisher's rubber backing plate.

Media blaster: Media blasting is called sand blasting it is the most effective way to remove all finishes from any vehicle Media blasting operations are usually done at 60-100 PSI pressure.

Plastic media blasting: It has replaced the sand blasting. The process is very similar in principle to sand blasting instead of using hard slice sand, much softer reusable plastic particles are used at low blasting pressures of 20 to 60 psi. This plastic media plasting removes paint coatings with damaging the under laying substrates, plastic can be used in standard and captive sand blasters.

Soda balster: Soda blaster is used to stripping paint either wet or dry under air pressure to strip away the old finish in this system can be safely used on almost any subtract.

Spray gun: Spray guns are used to apply sealer. primer, paint and other liquid finishing materials to a vehicle. Spray guns atomize the liquid, often paint. Spray gun required sufficient air pressure and volume at the gun to fire the liquid.

The spray guns air control valve or spreader valve controls how much air flows out of the air cap side jets. It has a air that can be slid back and forth to open or close the air valve. The spray gun trigger can be pulled to open both the fluid and air valves it uses lever action to pull back on the needle valve. The spray gun air cap works with the air valve to control the spray pattern of the paints.

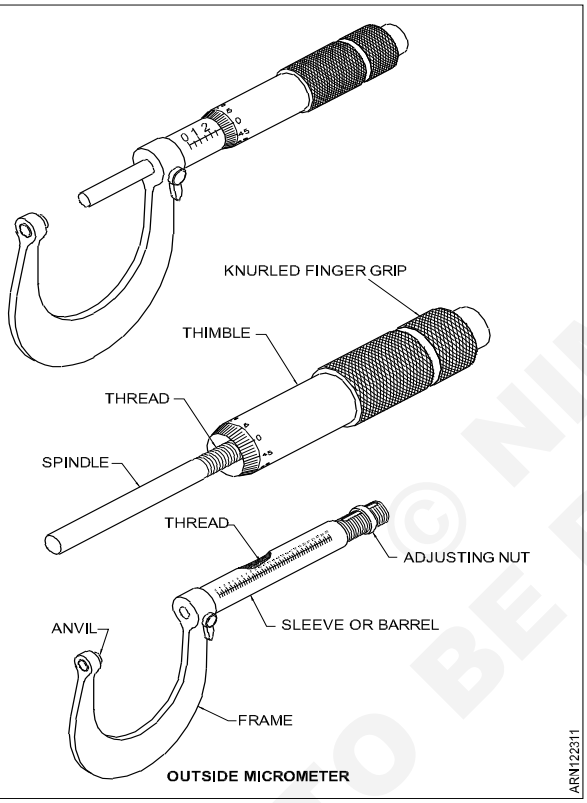
Air blow gun: Air blow gun is used for serve the efficient air pressure for cleaning and drying and blowing off of automotive used and dry parts or work area.

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)

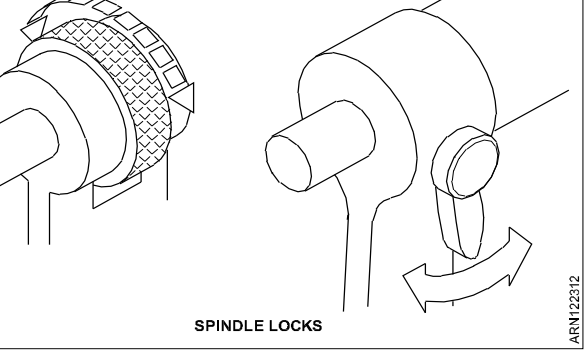
Fig 1



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.

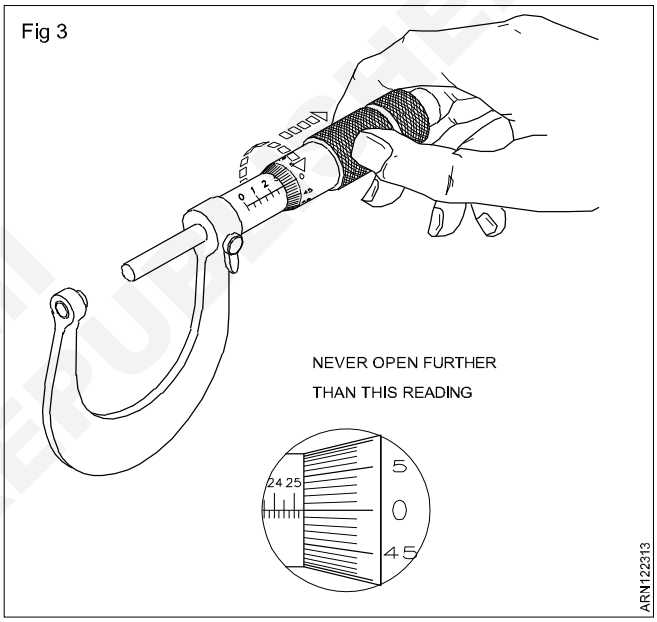
Fig 2



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.

Fig 3



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.

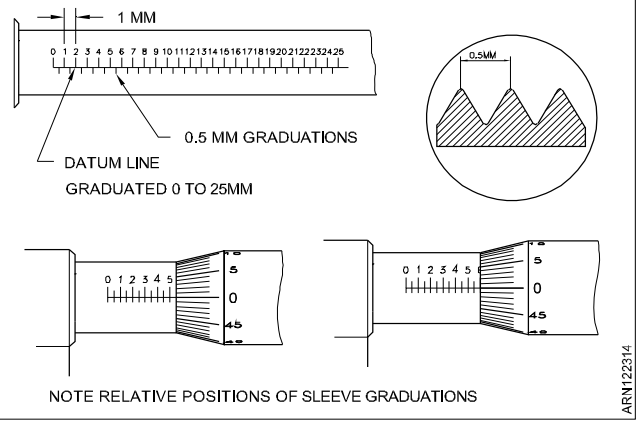
The range of micrometers are 0-5 mm, 25-50 mm, 50-75, 75-100 mm etc. The spindle can be easily screwed down in the barrel. In order to have the reference point for reading the micrometer, the datum or index line is marked on the sleeve.

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

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

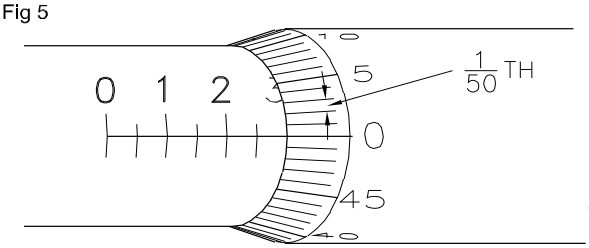
Deriving the least count of a metric micrometer: The main scale is graduated in ½ mm. Every 5th mm is shown with the reading. The pitch of the screw thread is accurately maintained to ½ mm. (Fig 4)

Fig 4



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

Fig 5



Determining the reading of a metric micrometer

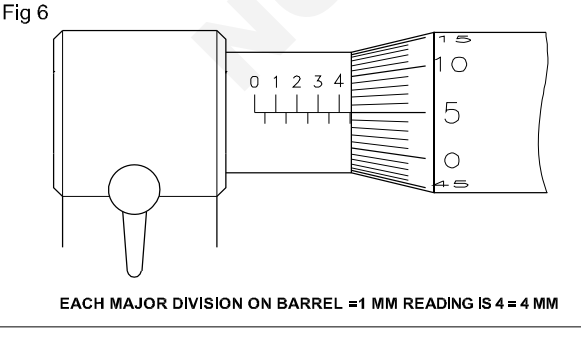
Before using the micrometer for measurement, it is necessary to ascertain that there is no error in the micrometer.

The faces of the anvil spindle must be free from dust. While reading the micrometer, the spindle must be locked with the reading.

Method of reading

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

Fig 6

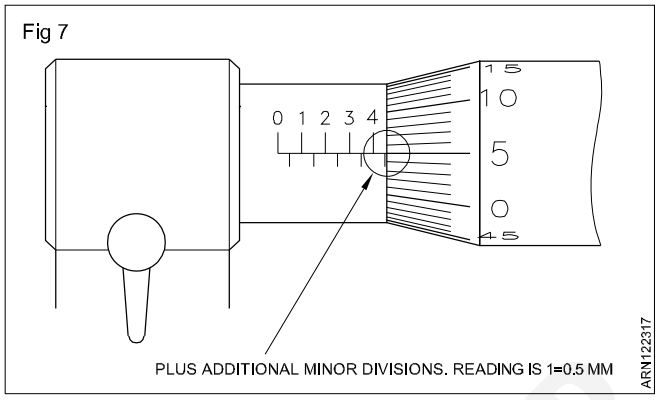


Add to this any half millimeters that are completely visible from the bevel edge of the thimble.

The figure reads ½ = 0.5 mm (Fig 7)

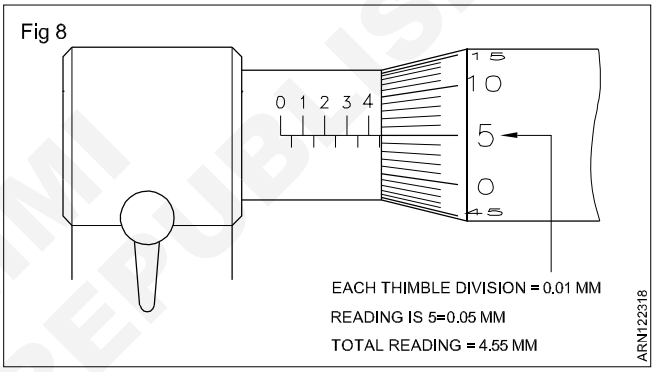
Add the thimble reading to the two earlier readings. (Fig 7)

Fig 7



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

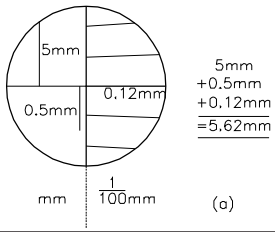
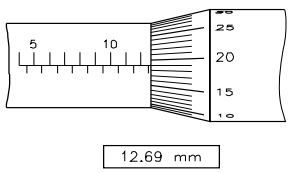
Fig 8

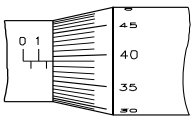
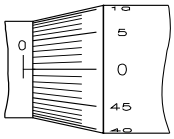
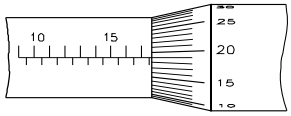
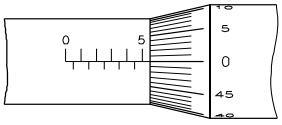
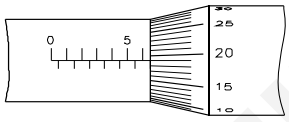


a	4.00 mm
b	0.50 mm
c	0.05 mm
Total reading	4.55 mm

A 0- 25 mm capacity outside micrometer can read a maximum Some examples of metric micrometer readings and their

Solution: (Fig 9)

i	5.00 mm	
	0.50 mm	
	0.12 mm	
Total	5.62 mm	
ii	12.00 mm	
	0.50 mm	
	0.19 mm	
Total	12.69 mm	

iii		01.00 mm	
		0.50 mm	
		0.39 mm	
	Total	1.89 mm	1.89 mm (c)
iv		0.00 mm	
		0.49 mm	
	Total	0.49 mm	0.49 mm (d)
v		17.00 mm	
		0.50 mm	
		0.19 mm	
	Total	17.69 mm	17.69 mm (e)
vi		5.00 mm	
		0.50 mm	
		0.00 mm	
	Total	5.50 mm	5.50 mm (f)
vii		6.00 mm	
		0.50 mm	
		0.19 mm	
	Total	6.69 mm	6.69 mm (g)

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 10)

Method of reading the micrometer 0-25 range (Fig 11)

Look at the reading which has been taken from the work-place.

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

Add any half millimeters that are completely visible from the bevel edge of the thimble. Figure 'b' shows 1 division = 0.5 mm.

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

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

Fig 10

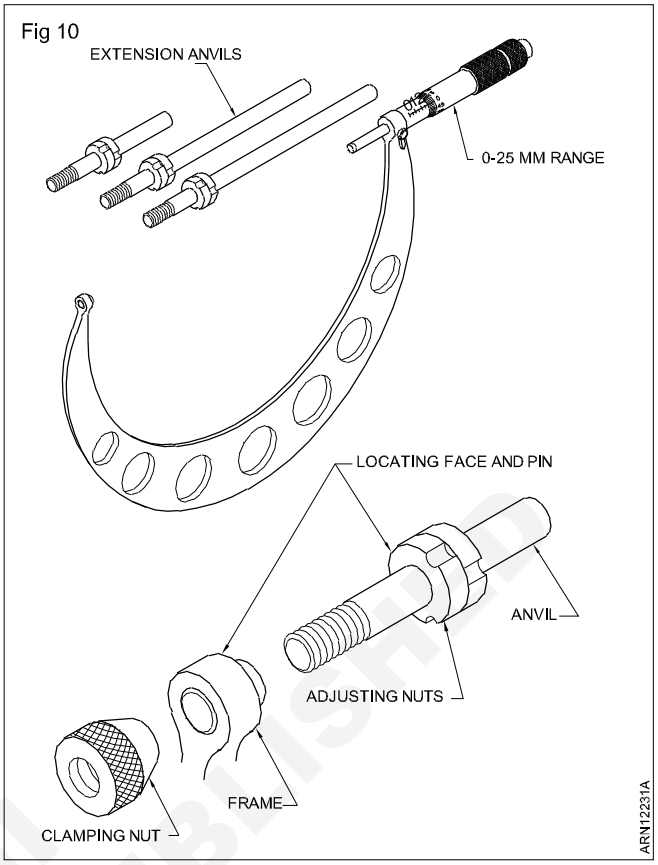
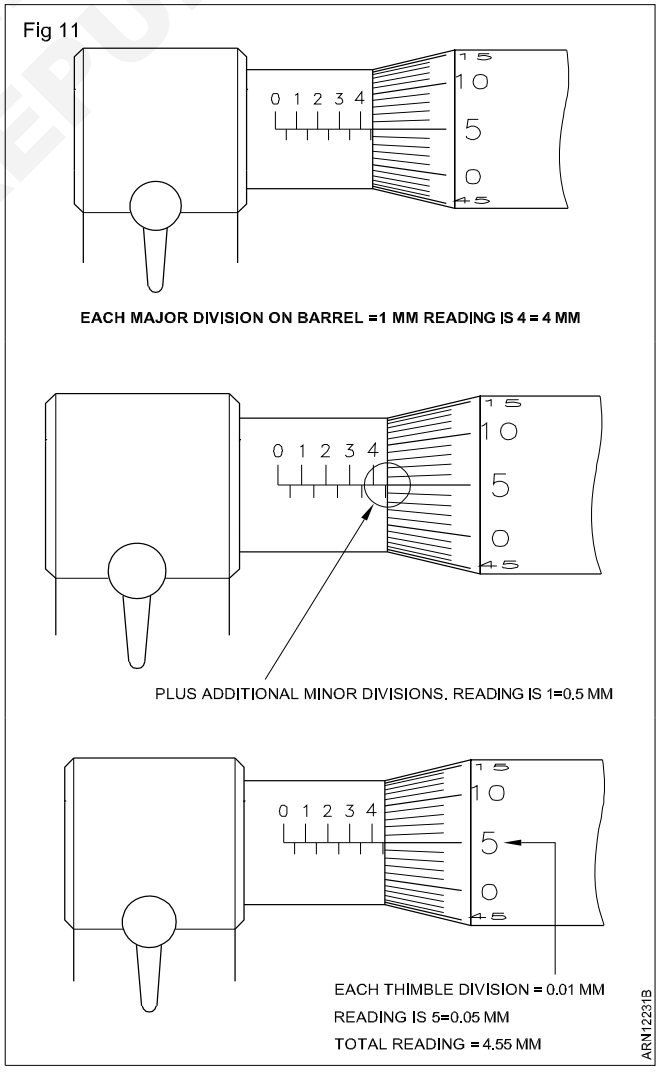


Fig 11

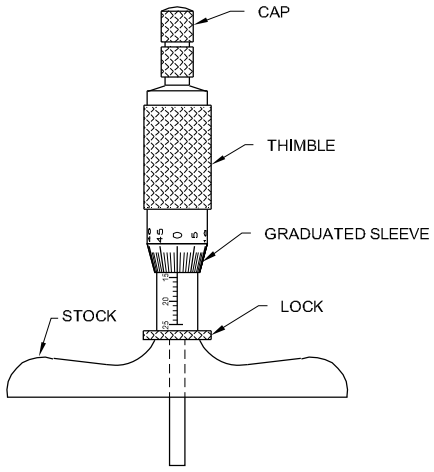


Depth micrometer

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.

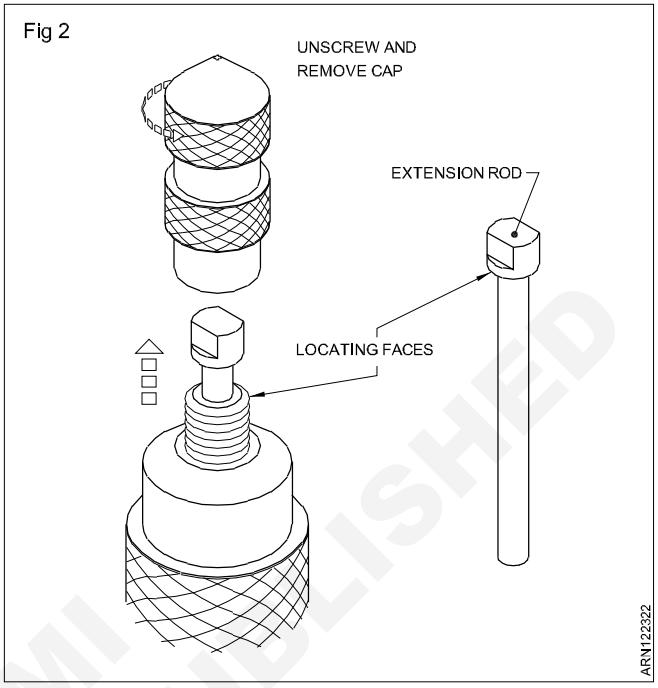
The extension rods may be removed and replaced according to the size to be measured.

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)

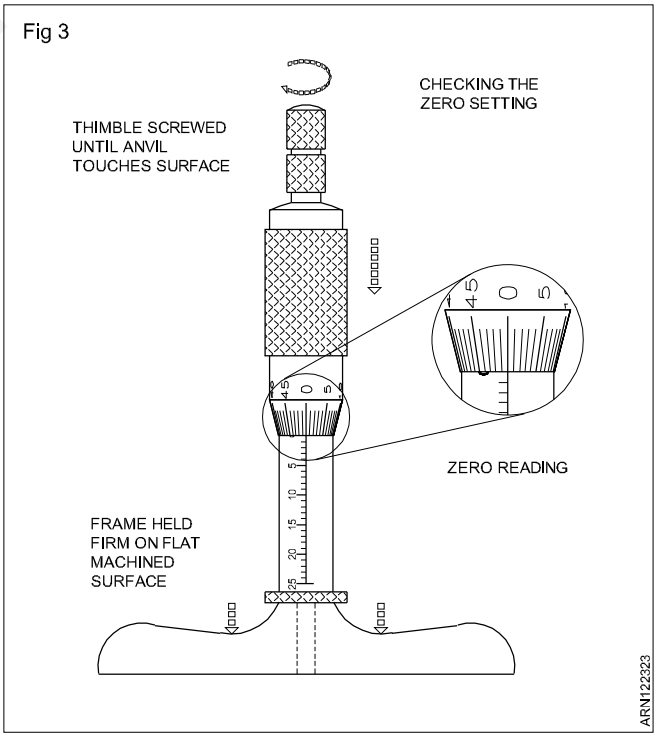
The graduations numbered are in the reverse direction to that marked on an outside micrometer.

Fig 2



The zero graduation of the sleeve is one the top and the 25 mm graduation is near the stock. The bevel edge of the thimble is also graduated. The circumference is divided into 50 equal parts and every 5th division line is drawn longer and numbered. The numbering is in the reverse direction and increases from 0 to 5, 10, 15, 25, 30, 35, 40, 45 and 50 (0). (Fig 3)

Fig 3



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

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

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

Uses of a depth micrometer

Depth micrometers are special micrometers used to measure:

- Depth of holes
- Depth of grooves and recesses
- Heights of shoulders and projections.

The Universal Vernier Caliper and its application

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

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

A universal vernier caliper consists of a

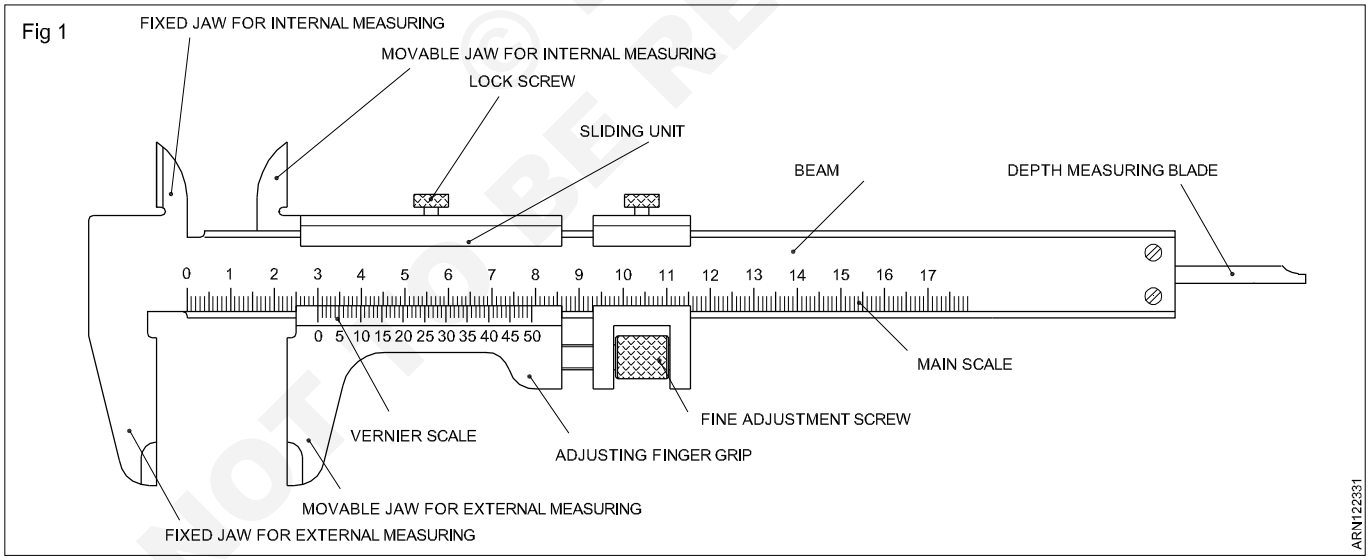
- Beam
- Fixed jaw for external measurements
- Movable jaw for external measurements
- Movable jaw for internal measurements
- Blade for depth measurement
- Main scale
- Vernier scale
- Fine adjustment screw
- Set of locking screws.

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

Constructional features (Fig 1)

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

Fig 1



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

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

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

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

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

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

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

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

Least count

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

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

The difference of the two main scale divisions and 1 vernier scale division gives the least count and it is equal to 2 X 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

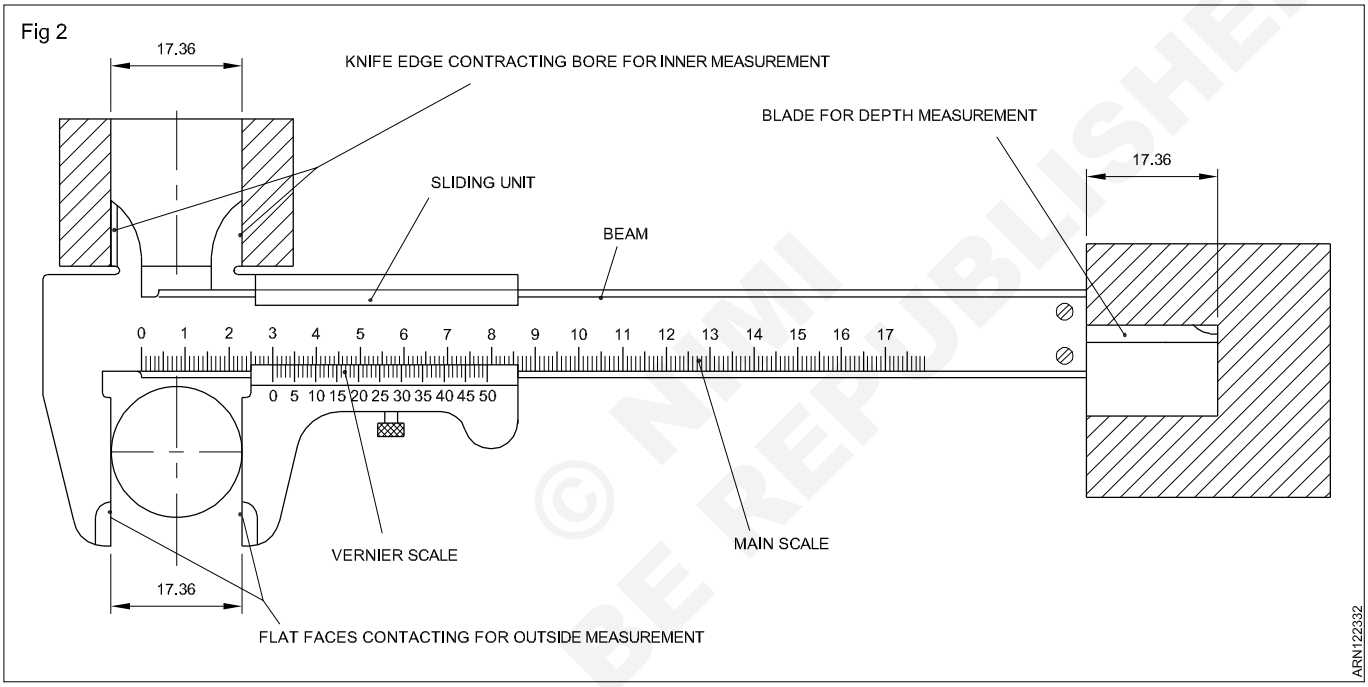
$$\frac{49}{50} = 0.98\text{mm}$$

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)

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.

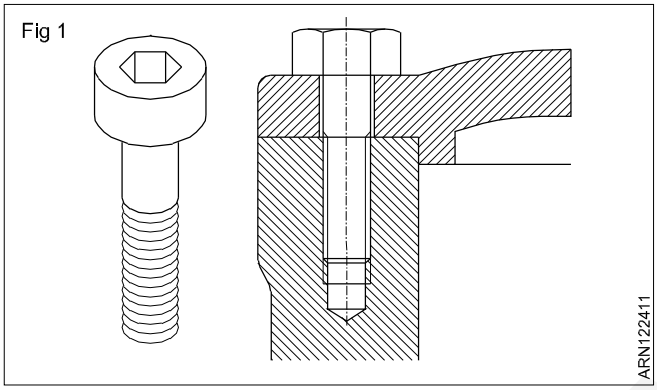
Add the multiplied value to the main scale reading.

Different types of screws, nuts, studs and bolts

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

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

Fig 1



Types of machine screws (Heavy duty)

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

These are heavy duty screws.

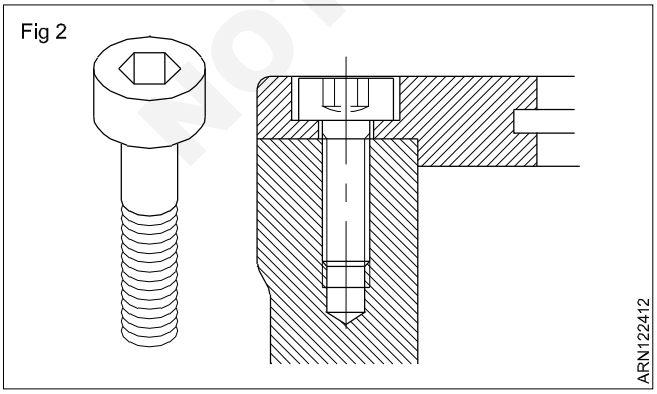
Hexagon head screws

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

Hexagon socket head cap screws

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

Fig 2



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

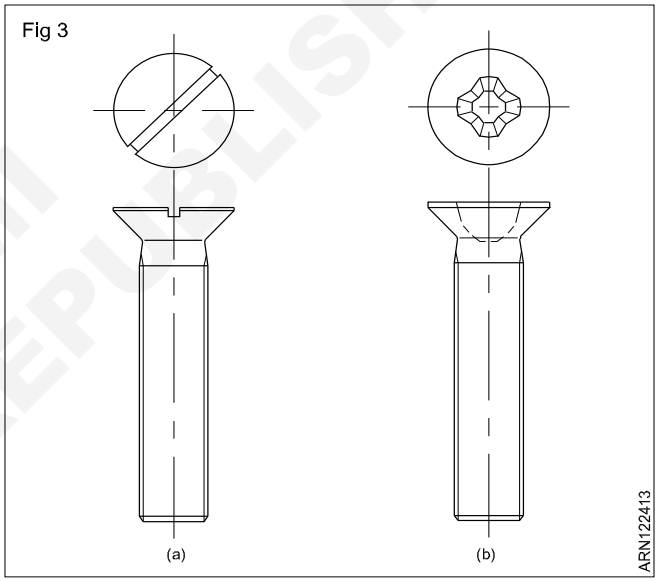
Countersink head screws

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

They are:

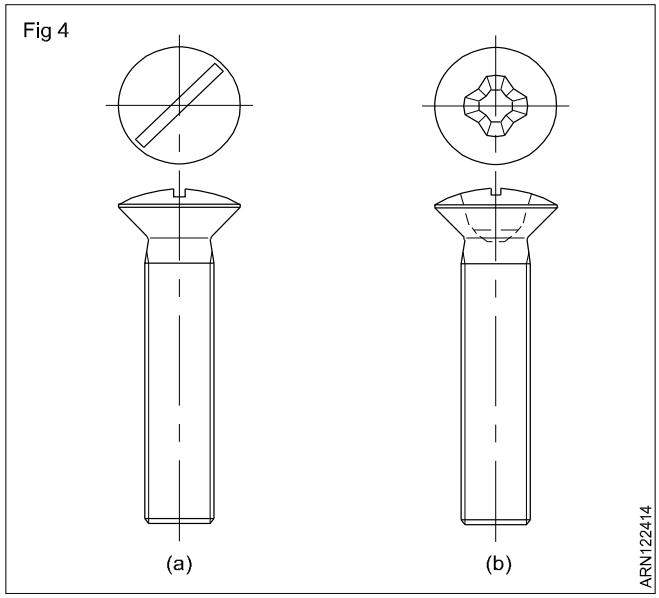
- Slotted countersink head screws (Fig 3a)
- Cross-recessed countersink head screws. (Fig 3b)

Fig 3



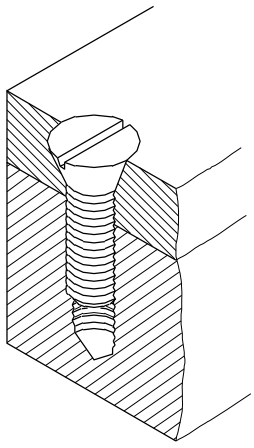
- Slotted raised countersink head screws (Fig 4a)
- Cross recessed, raised countersink head screws. (Fig 4b)

Fig 4



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

Fig 5



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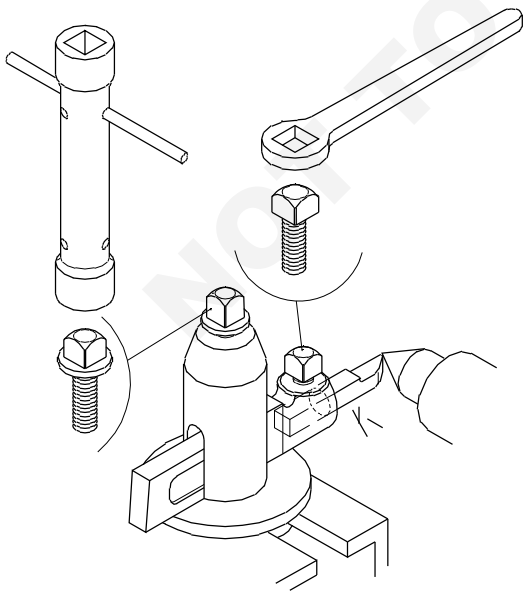
The projection of the screw head above the assembly is also avoided. B.I.S. specification covers the following ranges of countersink head screw sizes in different types.

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

Square head screws (Fig 6)

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

Fig 6



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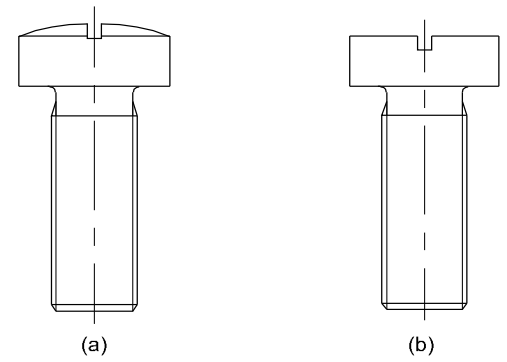
Other types of machine screws used in light assembly work are:

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

Fig 7



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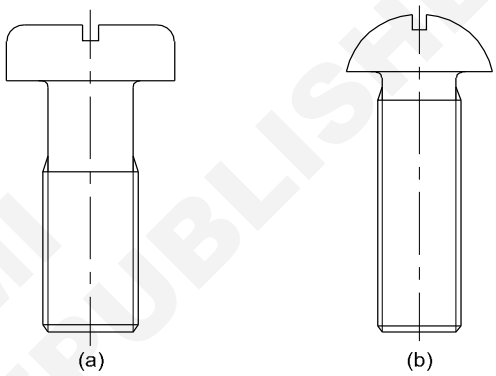
- Raised cheese head (Fig 8a)
- Round head (Fig 8b)

Fig 8



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

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

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

Set screws and grub screws Hexagonal socket set screws (Fig 9&10)

These are headless socket screws available with different points for various functional requirements.

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

Fig 9

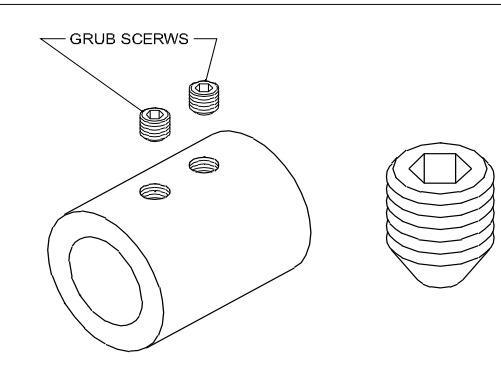

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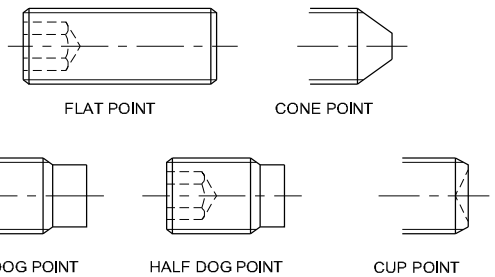
Fig 10



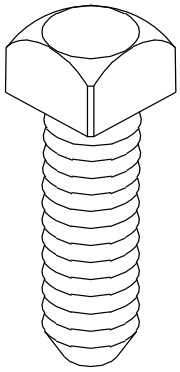
SET SCREW POINTS

Square set screws (Fig 11)

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

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

Fig 11



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

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

Fig 12

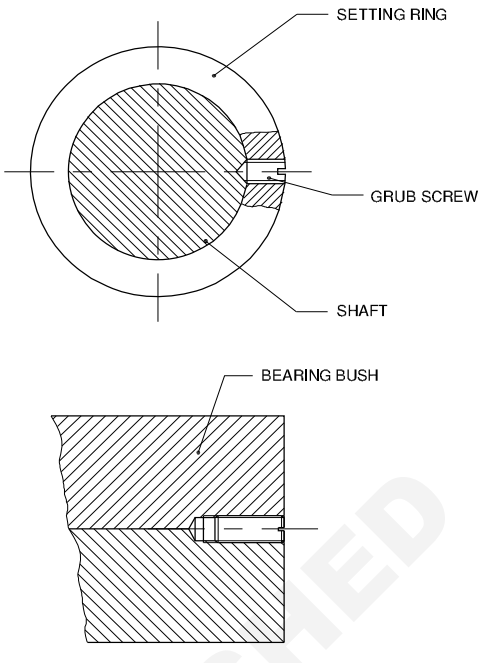
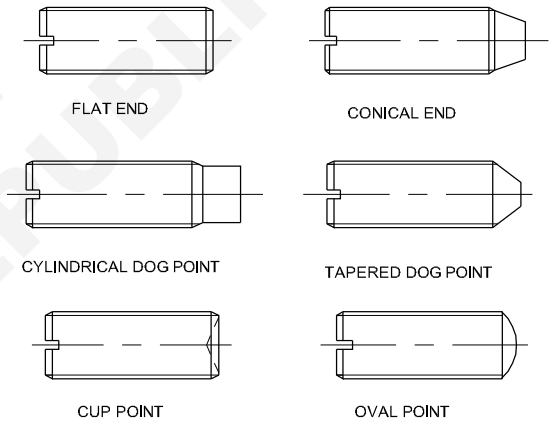


Fig 13



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.

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.

Studs (Fig 3)

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

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/mm^2 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.

Fig 1

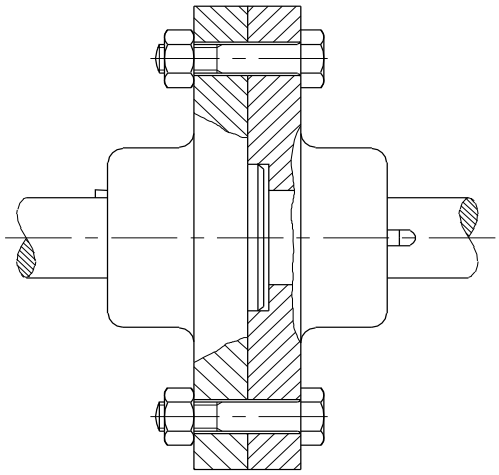


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Fig 2

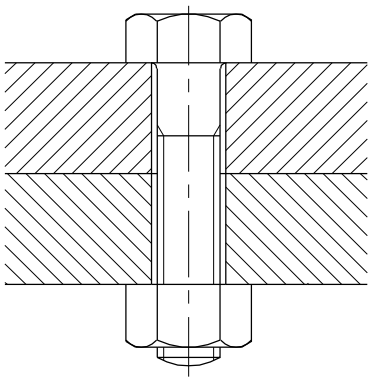

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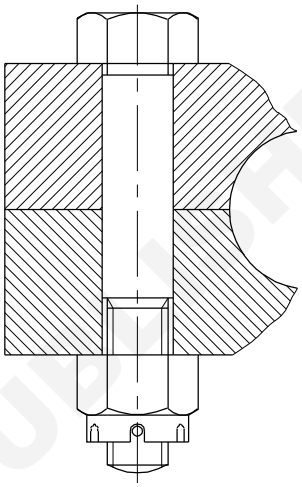
Fig 3



BODY FIT BOLT

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Locking devices

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

- **state what is a locking device**
- **name the effect, if proper locking devices are not employed**
- **name the various types of locking devices**
- **state the uses of the commonly used locking devices.**

Locking devices

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

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

Classification of lock-nuts

Lock-nuts are classified into two categories.

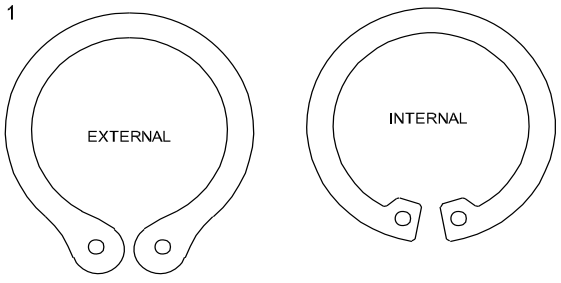
- Positive locking device
- Frictional locking device

These nuts have special provision in the form of slots for fixing split pins for locking the nuts. Slotted nuts are hexagonal shaped throughout. In the case of castle nuts, the top part of the nut is cylindrical in shape.

Circlip (Fig 1)

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

Fig 1



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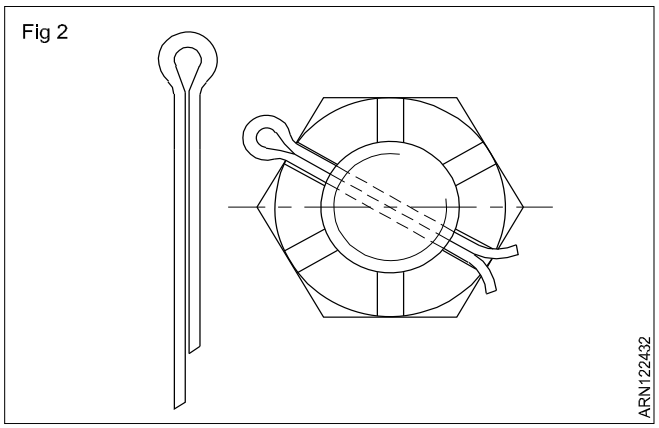
Split pin (Fig 2)

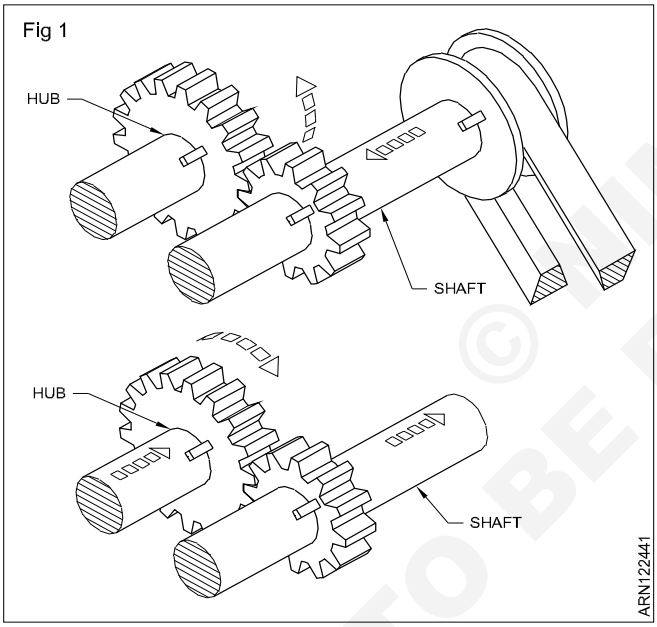
A split pin is made from a steel wire of semicircular cross section, bent as shown in the figure. It is inserted in a hole drilled in the bolt so that it exerts pressure on the top face of the nut to prevent it from turning.



Keys

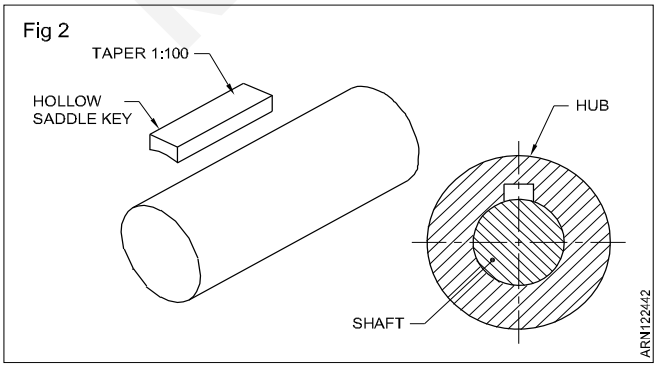
Objectives: At the end of this lesson you shall be able to
- **name the different types of keys used in transmission**
- **state the features of each type of keys.**

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



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

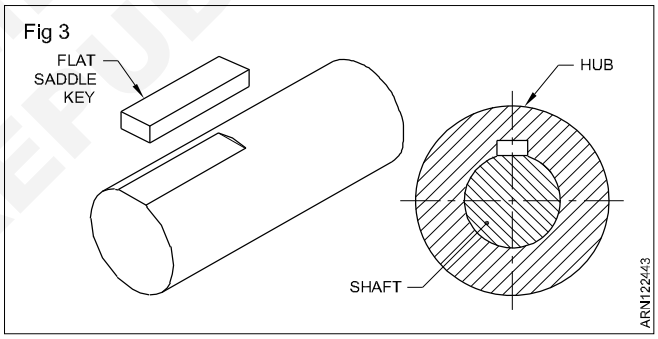
Hollow saddle key: One face of this key has a curvature to match with that of the shaft surface. It has a taper of 1 in 100 and is driven in through the keyway. (Fig 2)



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

Flat saddle key

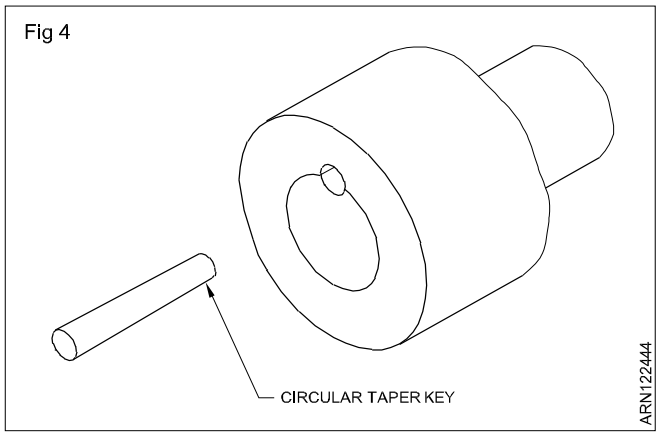
This key has a rectangular cross-section. For fitting this key in the assembly a flat surface is machined on the shaft. (Fig 3).



The key is placed between the flat surface of the shaft and the keyway on the hub. This is considered to be stronger than the hollow saddle key. This is not suitable for heavy duty transmission.

Circular taper key

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 & 6)

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

Fig 5

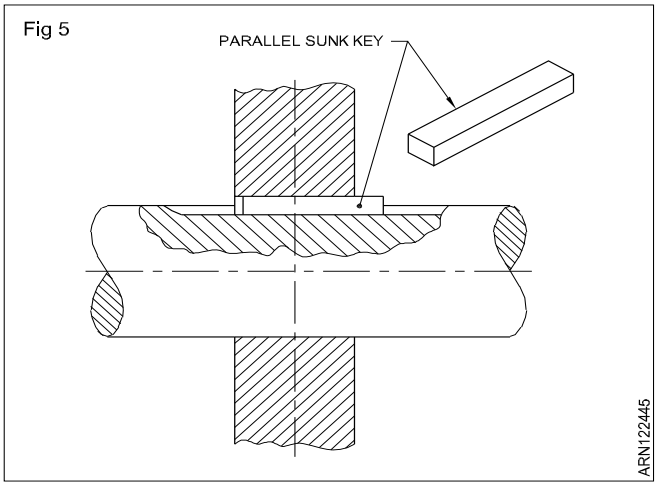
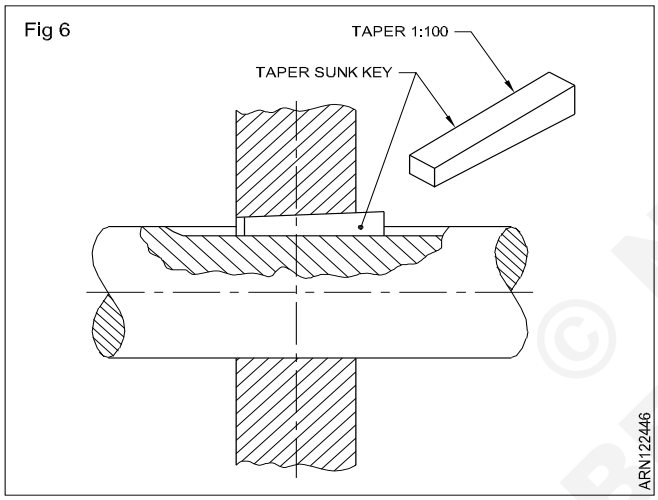


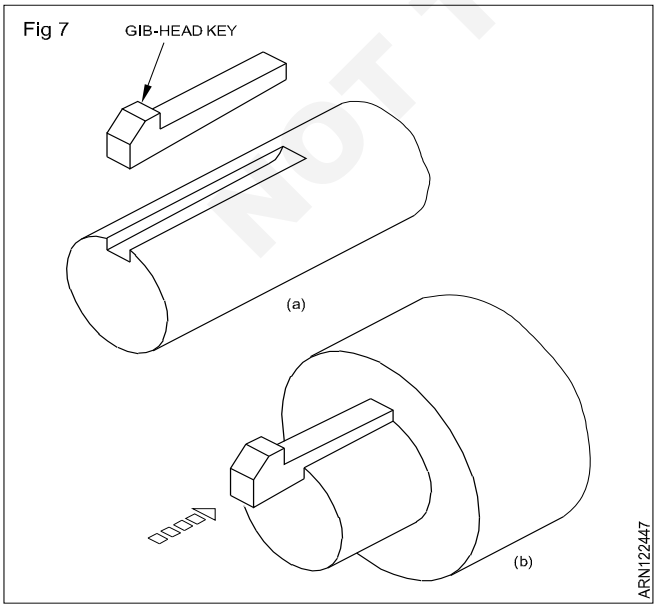
Fig 6



Gib-head key (Fig 7)

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

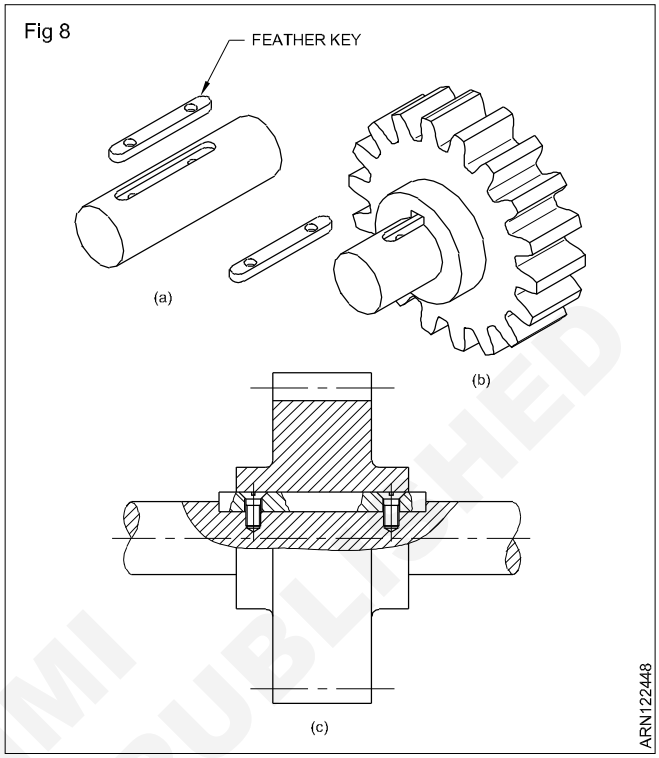
Fig 7



Feather key (Fig 8)

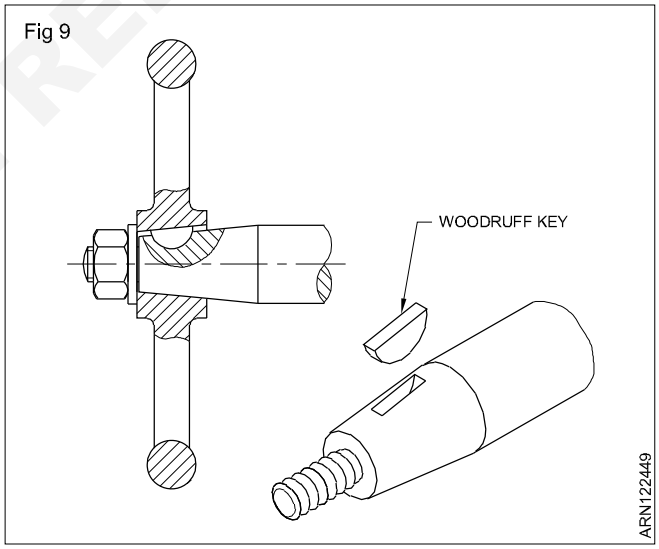
This is a parallel key with rounded ends. This is useful when the hub/pulley has to slide axially on the shaft to some distance. (Figs 8a,b and c) This key may be either tightly fitted in the keyway or screwed in.

Fig 8



Woodruff key (Fig 9)

Fig 9



This is semicircular key and it fits on to the shaft on which matching recesses are cut. The top portion of the key projects out and fits in the keyway cut on the hub. (Fig 9) This key is particularly useful on tapered fittings of shafts Splined shaft & serrated shaft Splinded shafts along with splined hubs are used particularly in the motor industry. The splined hub can also slide along the shaft, wherever necessary. (Figs 10a and b) In certain assemblies, serrated shafts are also used for transmission. (Figs 11a and b)

Fig 10

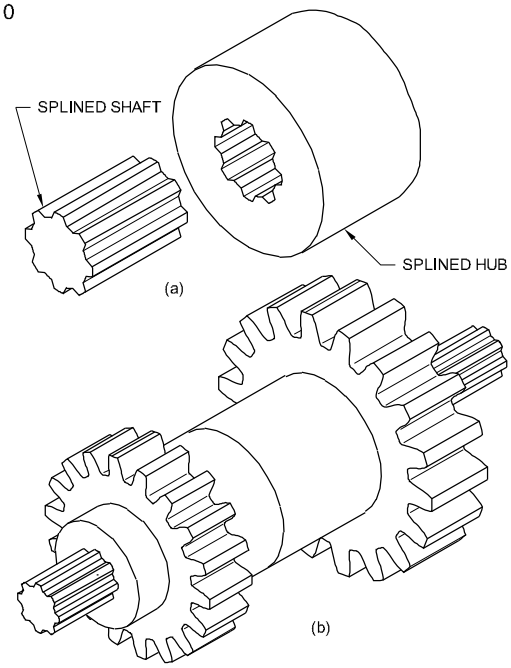
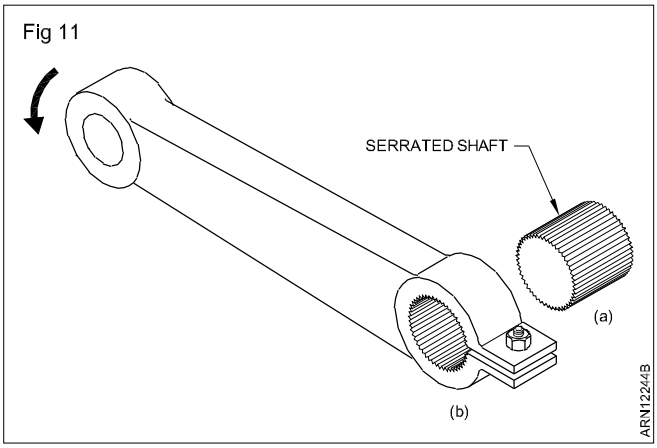


Fig 11



Circlips

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

- **state the functions of circlips**
- **state the different types of circlips**
- **state the advantages of circlips over other fastening devices**
- **state the materials 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 materials having good spring properties so that the fastener may be deformed elastically to a considerable degree and still spring back to its original shape. This permits the circlips to spring back into a groove or other recess in a part or they may be seated on a part in a deformed conditional so that they grip the part by functional means. Circlips are manufactured from spring steel with high tensile and yield strength.

Fig 2

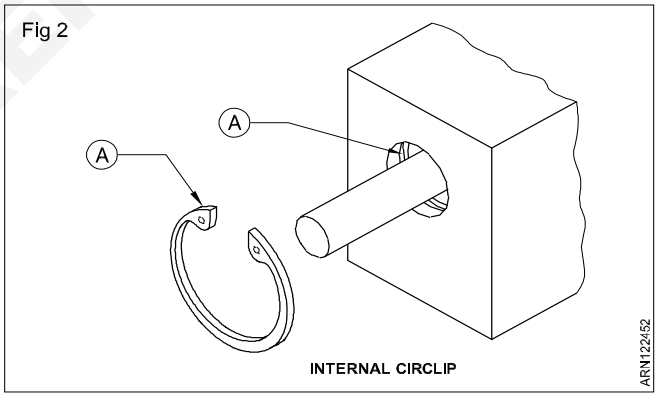


Fig 1

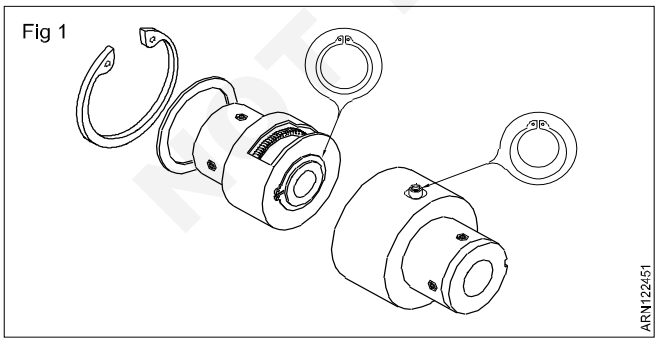
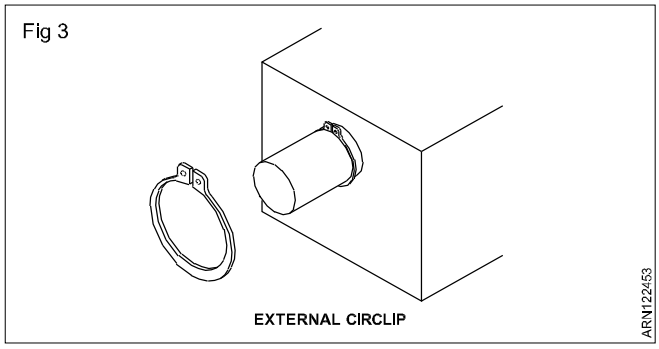


Fig 3



Types

There are two types. Internal circlips (Fig 2) This type of rings are assembled in holes, bores or housing.

External circlip (Fig 3) This type of rings are installed on shafts, pins, studs and similar parts. Both types offer a number of advantages over other types of fasteners.

- Their cost is relatively low when compared with other types of fasteners.
- Their use often results in savings in raw material and simplified machining operations for other parts in the assembly.

- One circlip often can replace two or more parts.
- Assembly toolings developed for circlips usually permit very rapid assembly of the fasteners, even by unskilled workers.

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

Washers - types and uses

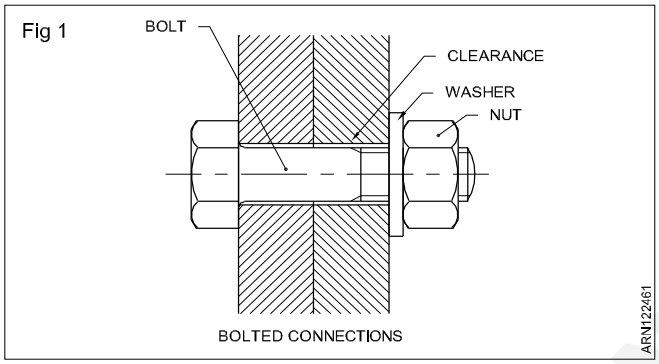
Objectives: At the end of this lesson you shall be able to
- **state the purpose of washers**
- **name the types of washers**
- **state the uses of each type of washers**
- **specify the washers as per B.I.S.**

Purpose

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

Washers help to (Fig 1)

Fig 1



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

Types of washers

There are different types of washers available. They are

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

Plain or flat washers (Fig 2)

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

Plain washers are available as machined or punched washers.

Machined washers (Fig 3)

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

Fig 2

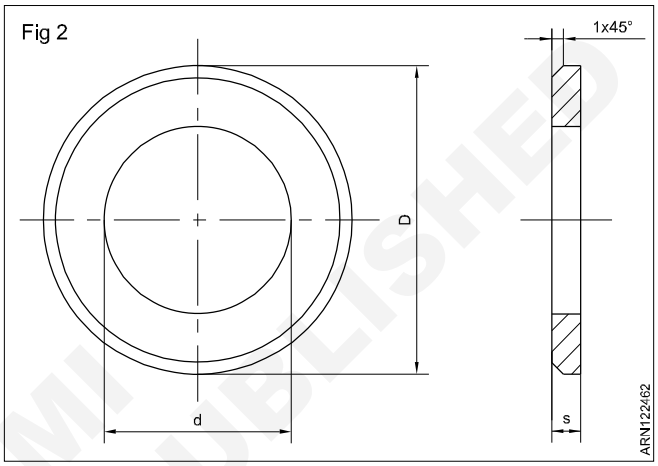
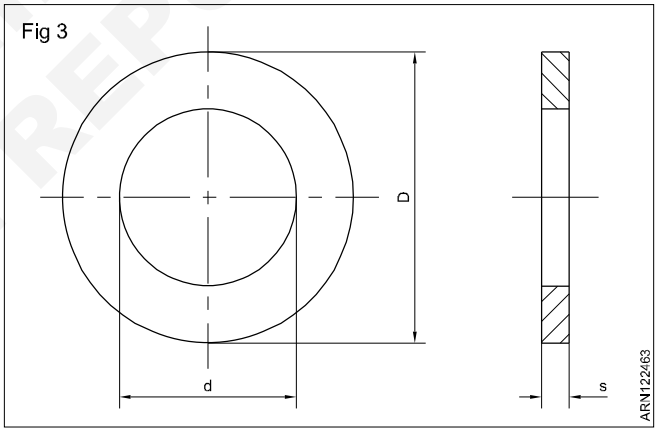


Fig 3



Punched washers

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

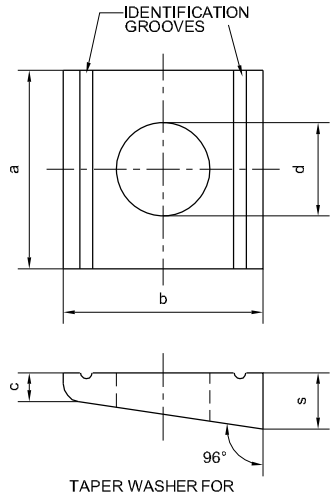
Tapered washers (Figs 4 & 5)

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.

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 4



TAPER WASHER FOR CHANNELS (SMC)

ARN122464

Fig 5

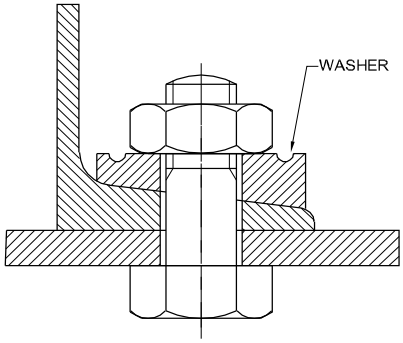


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Fig 6

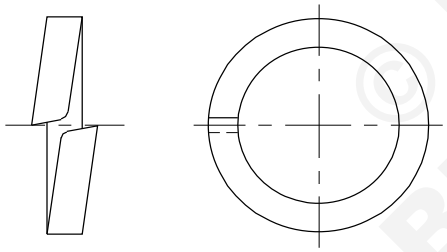

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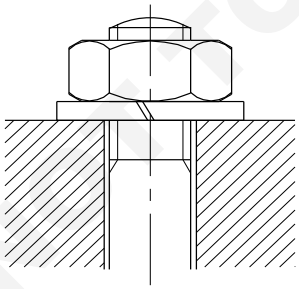
Fig 7



SPRING LOCK WASHER

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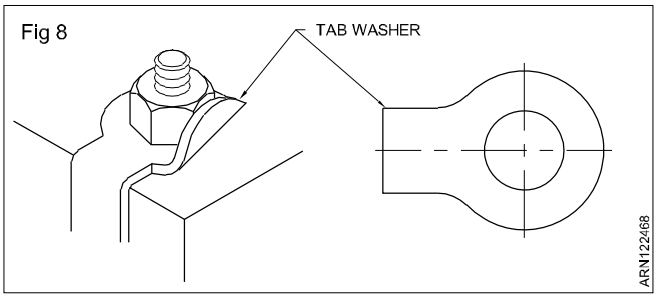
Tab washers (Fig 8)

These washers are used for locking the nuts.

Fig 8



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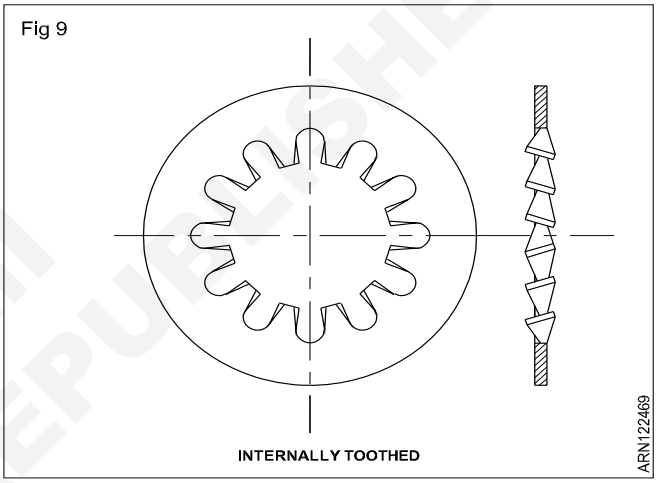
Toothed lock washers (Fig 9)

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

Fig 9



INTERNALLY TOOTHED

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Specifications

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

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

Note

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

Taper washer - IS: 5374 and IS: 5372

Tab washer - IS: 8068

Toothed lock washer - IS: 5371

Plain washer - IS: 2016

Tools for hand riveting

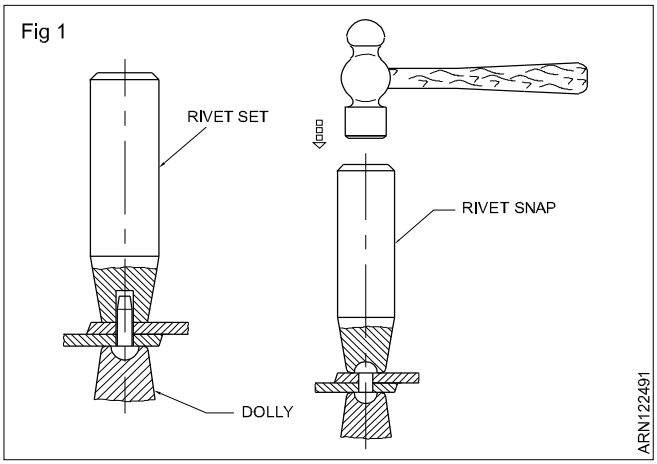
Objectives: At the end of this lesson you shall be able to
- **name the different types of tools used for hand riveting**
- **state the uses of different hand riveting tools.**

The following tools are used for making efficient riveted joints.

Rivet set (Fig 1)

A rivet set is used for bringing the plates closely together after inserting the rivet in the hole. This is required while riveting thin plates or sheets with small rivets.

Fig 1



Dolly

This is used to support the head of the rivet which is already formed and also to prevent damage to the shape of the rivet head.

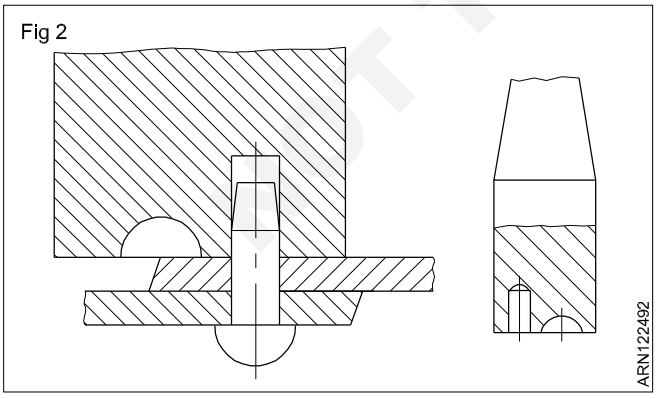
Snap

The rivet snap is used to form the final shape of the rivet during riveting. Snaps are available to match the different shapes of rivet heads.

Combined rivet set (Fig 2)

This is a tool which can be used for setting and forming the head.

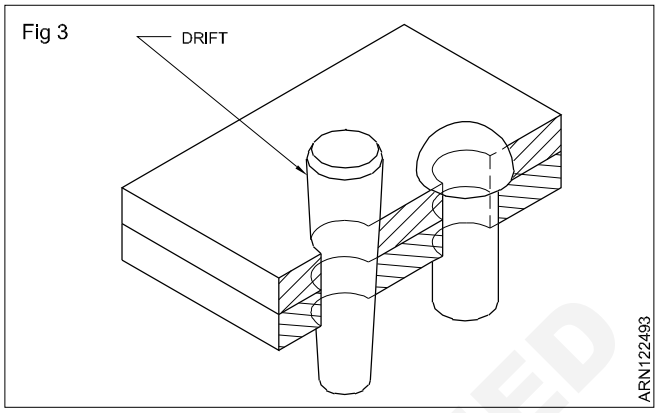
Fig 2



Drift (Fig 3)

This is used to align the holes to be riveted.

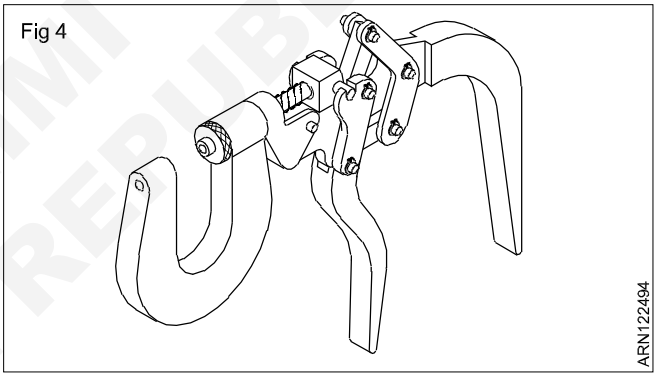
Fig 3



Hand riveter (Fig 4)

This has a lever mechanism which exerts pressure between the jaws when the handle is pressed. This is useful for riveting copper or aluminium rivets, interchangeable anvils can be provided.

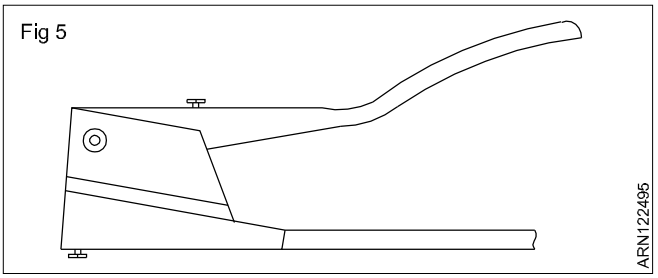
Fig 4



Pop riveter (Fig 5)

This is used for riveting pop rivets by hand. The trigger mechanism squeezes the rivet and separates the mandrel of the rivet. In this method, as the mandrel is being separated from the rivet, the head is formed on the other end.

Fig 5



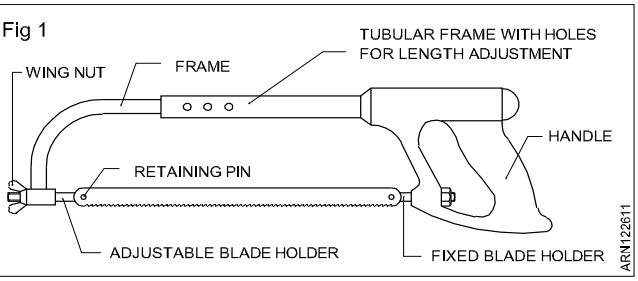
Hacksaw frame and blade

Objectives: At the end of this lesson you shall be able to
- **name the parts of the hacksaw frame**
- **specify hacksaw frame**
- **state the different types of hacksaw frame and their uses.**

Hacksaw frame

The hand hacksaw is used along with a blade to cut metals of different sections. It is also used to cut slots and contours. The parts are identified in the (Fig 1).

Fig 1



Types of hacksaw frames

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

Solid frame

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

Adjustable frame (Flat type)

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

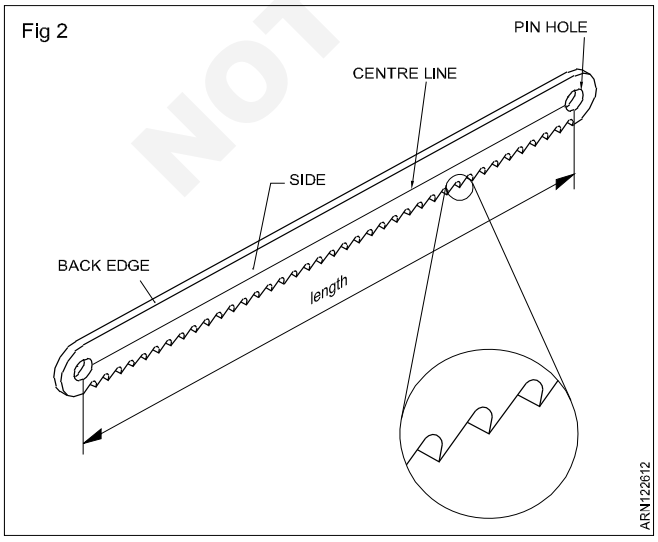
Adjustable frame (Tubular type)

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

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

Hacksaw blades (Fig 2)

Fig 2



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

Types of hacksaw blades

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

All hard blades

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

Flexible blades

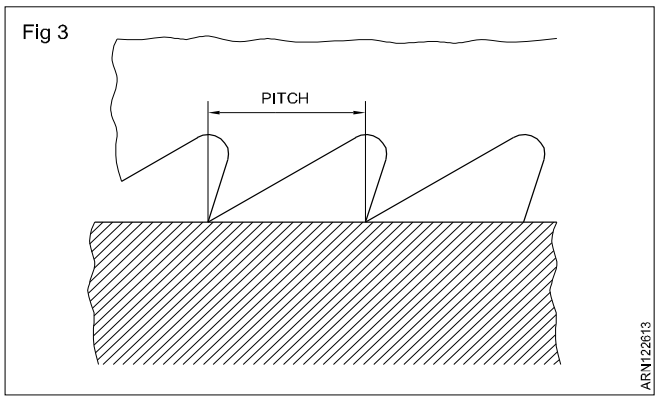
For these types of blades. Only the teeth are hardened. Because of their flexibility, these blades are useful for cutting along curved lines.

Pitch of the blade (Fig 3)

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.

Fig 3



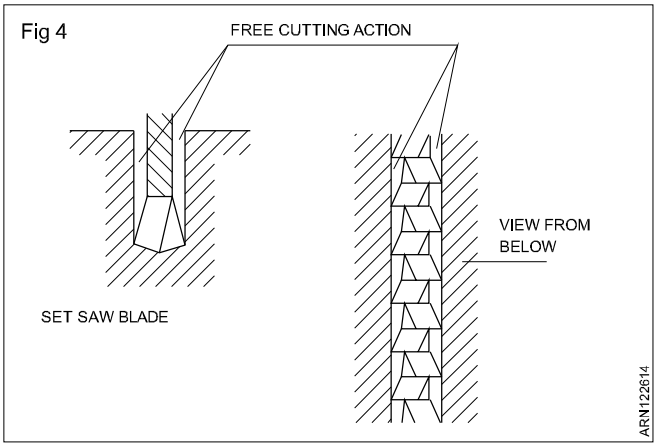
Staggered set (Fig 4)

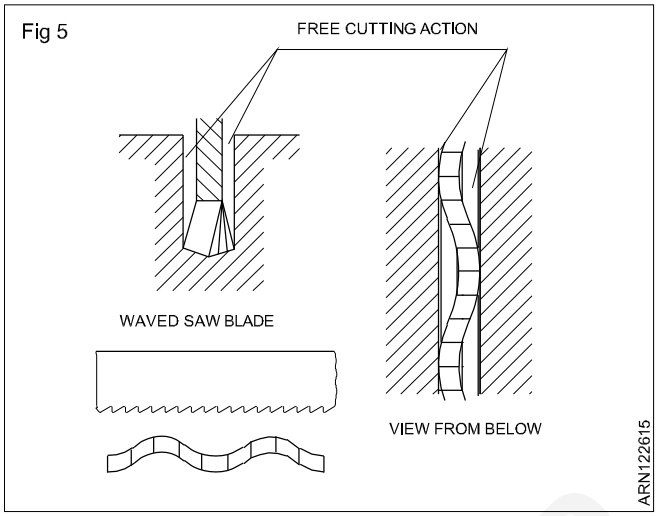
Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting and provides for good chip clearance.

Wave set (Fig 5)

In this, the teeth of the blade are arranged in a wave form. Sets of blades can be classified as follows

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





Pitch Type of Set 0.8 mm Wave -set 1.0 mm Wave or staggered Over 1.0 mm Staggered

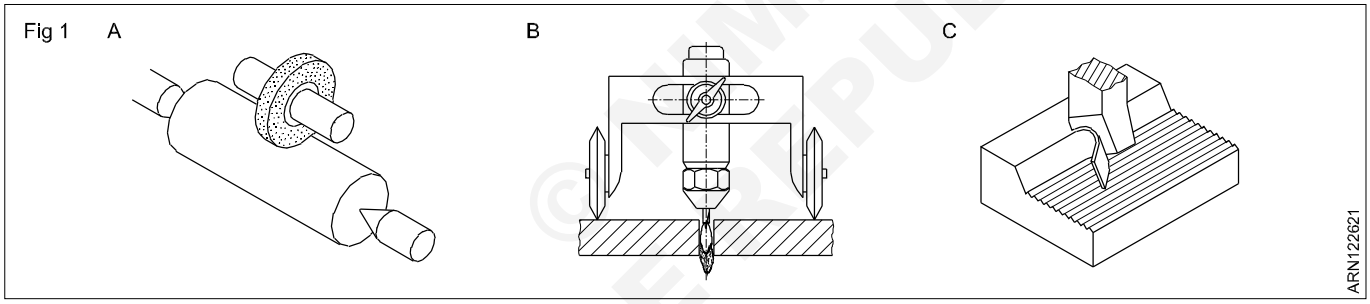
For the best results, the blade with the right pitch should be selected and fitted correctly.

Elements of a file

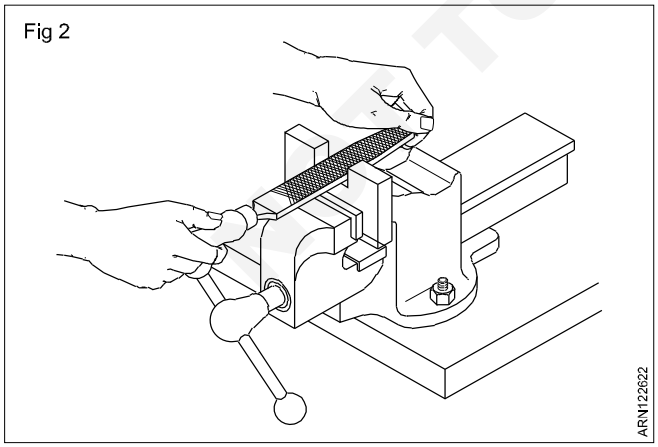
Objectives: At the end of this lesson you shall be able to
• name the parts of a file.

The three methods of metal cutting are

- Abrasion (Fig 1A).
- Fusion (Fig 1B) and
- Incision (Fig 1C)



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



Parts of a file (Fig 3)

The parts of a file as can be seen in figure 3, are

Tip or Point

The end opposite to tang

Face or side

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

Edge

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

Heel

The portion of the broad part without teeth.

Tang

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

Handle

The part fitted to the tang for holding the file

Parts of a file (Fig 3)

Ferrule

A protective metal ring to prevent cracking of the handle.

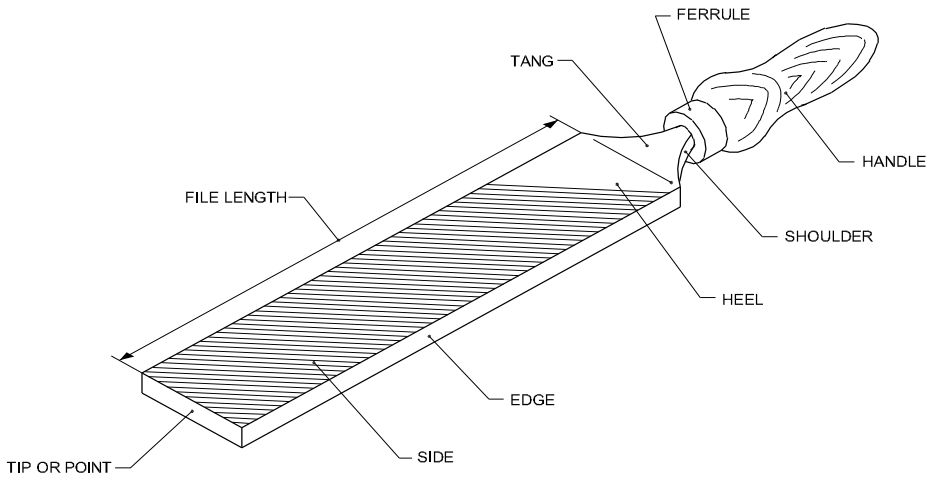
Materials

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

Shoulder

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

Fig 3



Cut of files

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

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

Types of cuts

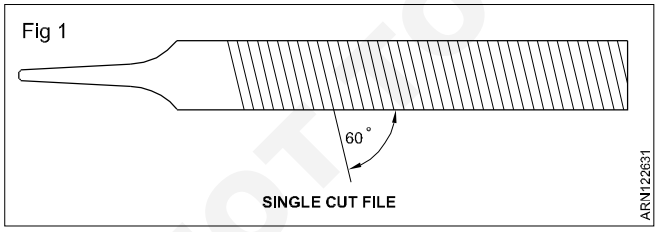
Basically there are four types.

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

Single cut file (Fig 1)

A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60o to the centre line. It can chips as wide as the cut of the file. Files with this cut are useful for filing soft metals like brass, aluminium, bronze and copper. Single cut files do not remove stock as fast as double cut files, but the surface finish obtained is much smoother.

Fig 1



Double cut file (Fig 2 & 3)

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

Fig 2

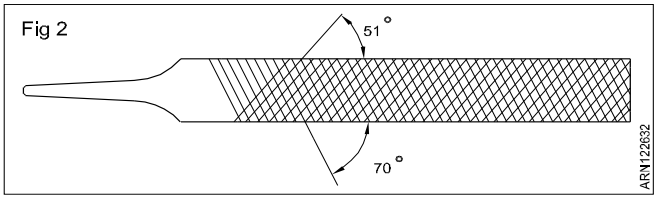
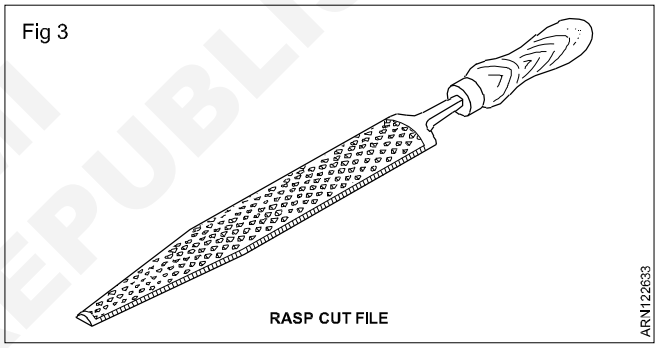


Fig 3

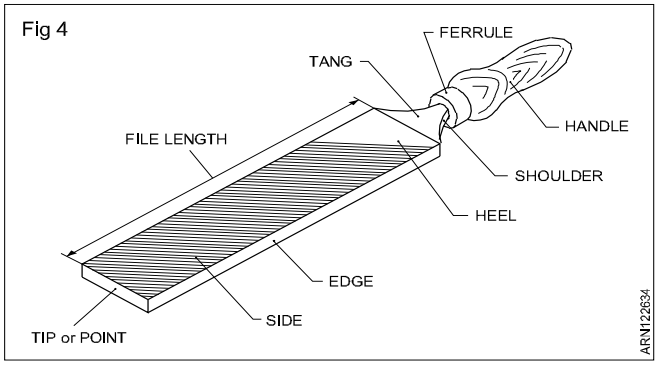


The rasp cut has individual sharp pointed teeth in a line and is useful for filing wood, leather and other soft materials. These files are available only in half round shape.

Curved cut file (Fig 4)

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

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 fies for example, those used for sharpening saws are also of single cut.

File specifications and grades

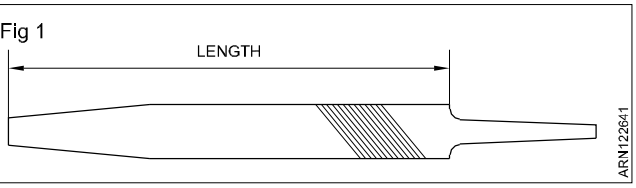
Objectives: At the end of this lesson you shall be able to
- **state how files are specified**
- **name the different types of grades**
- **state the application of each grade of file.**

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)

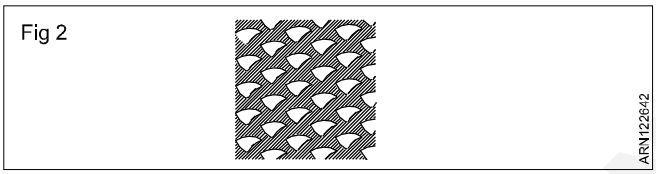
Fig 1



File grades are determined by the spacing of the teeth.

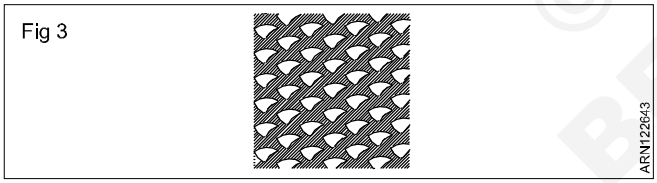
A round file (Fig 2) is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.

Fig 2



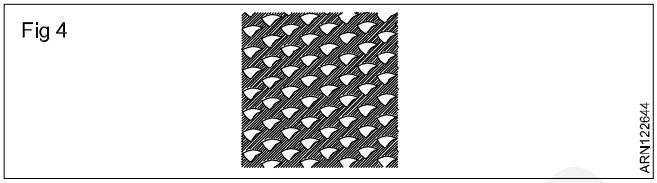
A bastard file (Fig 3) is used in cases where there is a heavy reduction of material.

Fig 3



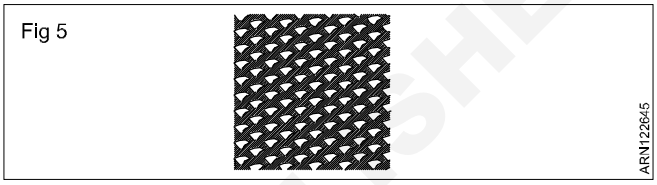
A second cut file (Fig 4) is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.

Fig 4



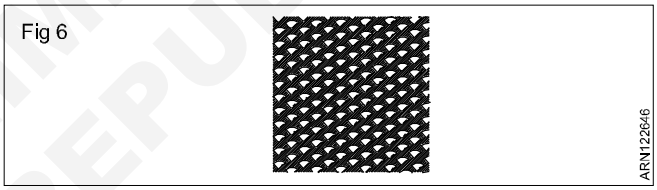
A smooth file (Fig 5) is used to remove small quantity of material and to give a good finish.

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.

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.

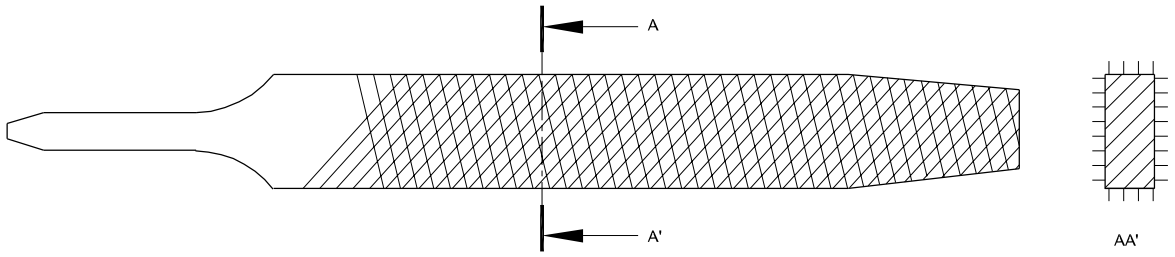
Flat files

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 squre, 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

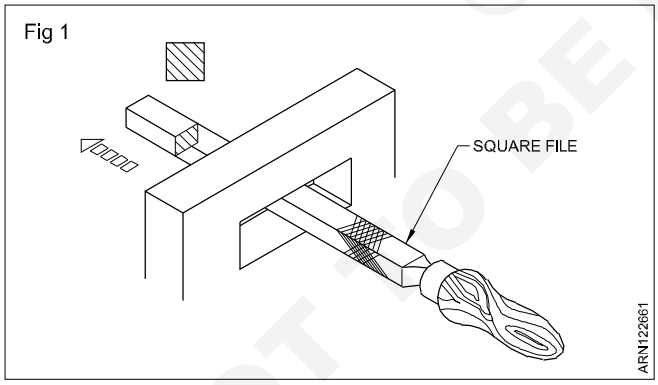
Flat file, Hand file, Square file, Round file Half found file, Triangular file and Knife-edge file.

(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 600. (Fig 4)

Fig 2

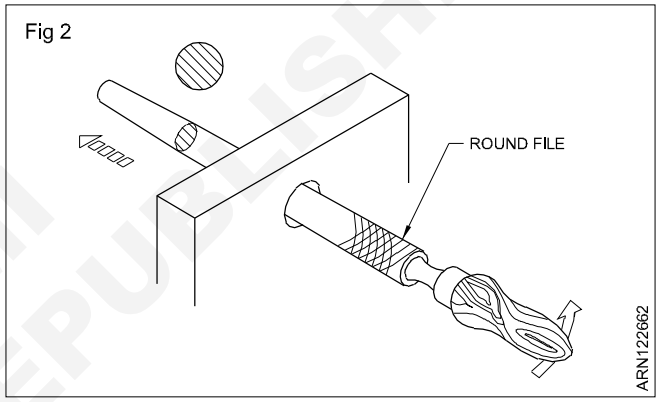


Fig 3

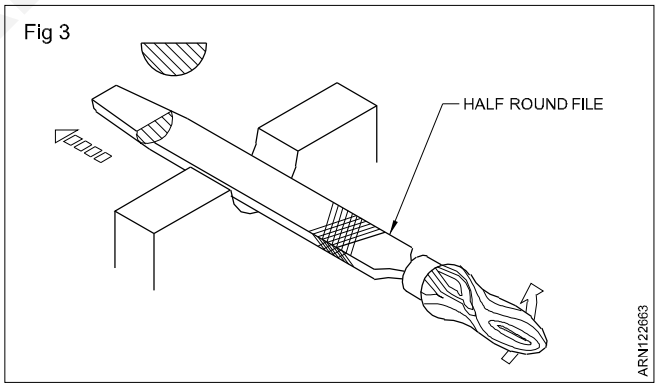
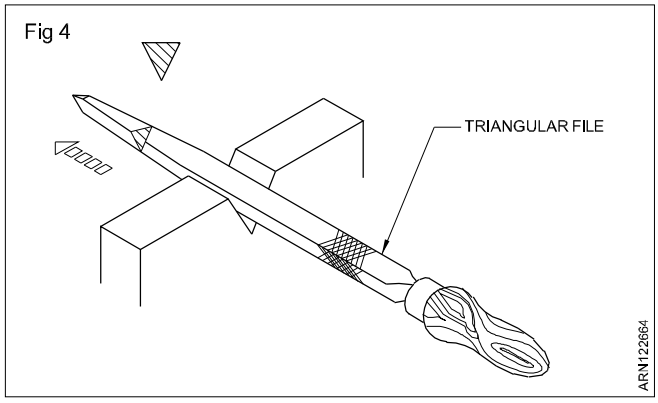


Fig 4

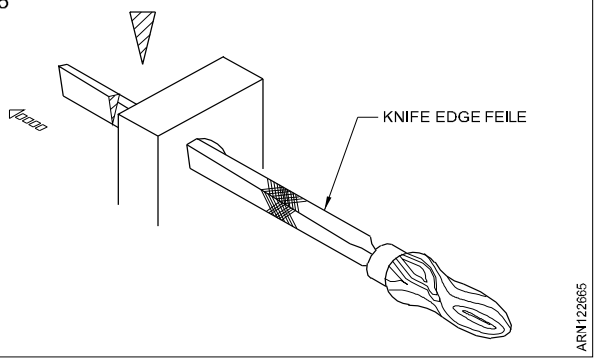


Knife-edge File : A knife-edge file has the cross section of a sharp triangle. It is used for filing narrow grooves and angles above 100. (Fig 5)

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

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

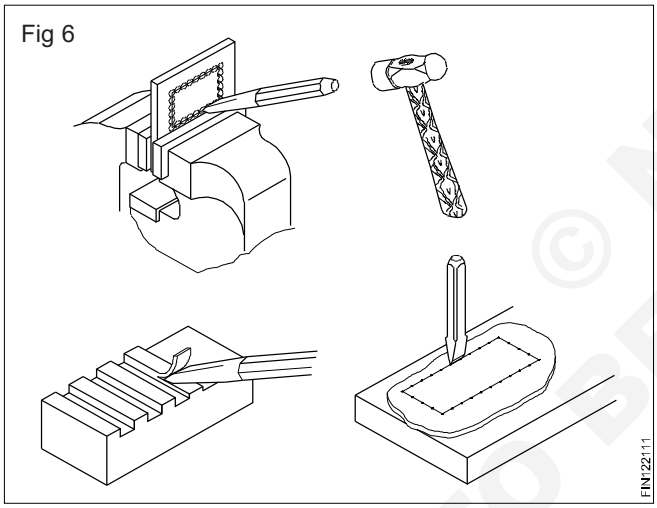
Fig 5



Cold chisel

The cold chisel is a hand cutting tool used by fitters for chipping and cutting off operations. (Fig 6)

Fig 6

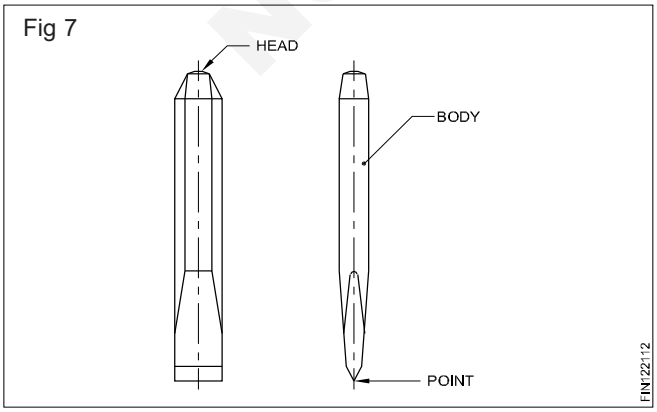


Chipping is an operation of removing excess metal with the help of a chisel and hammer. Chipped surfaces being rough, they should be finished by filing.

Parts of a Chisel (Fig 7)**:** A chisel has the following parts.

Head, body, point or cutting edge.

Fig 7



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.

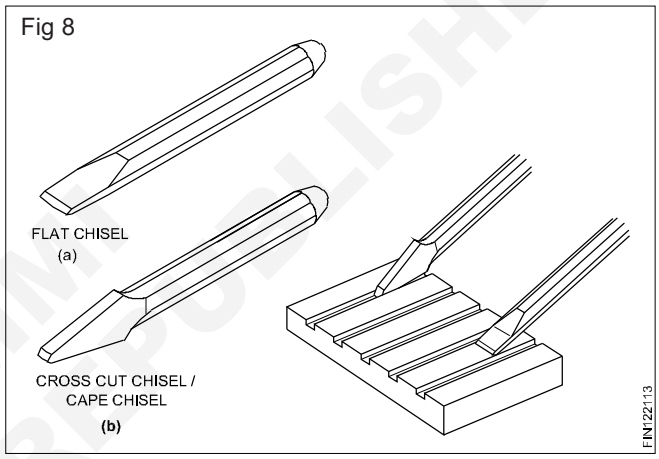
Common types of chisels: There are five common types of chisels.

- Flat chisel
- Cross-cut chisel
- Half-round nose chisel
- Diamond point chisel
- Web chisel

Flat chisels (Fig 8a)**:** They are used to remove metal from large flat surfaces and chip-off excess metal of welded joints and castings.

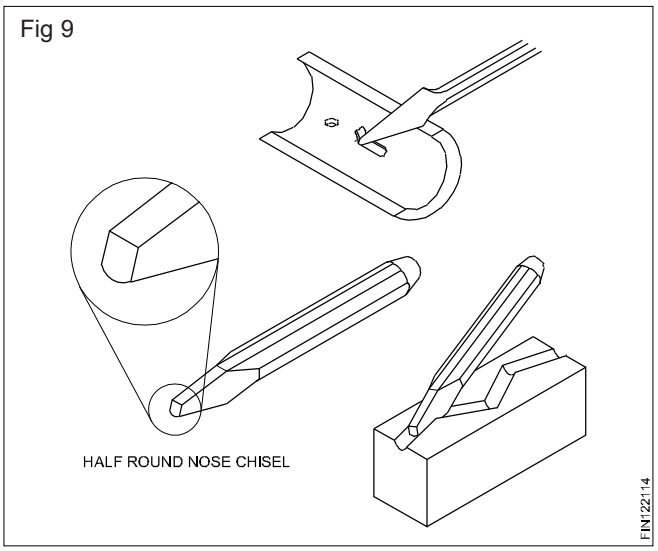
Cross-cut or cape chisels (Fig.8b)**:** These are used for cutting key ways, grooves and slots.

Fig 8



Half-round nose chisels (Fig 9)**:** They are used for cutting curved grooves (oil grooves).

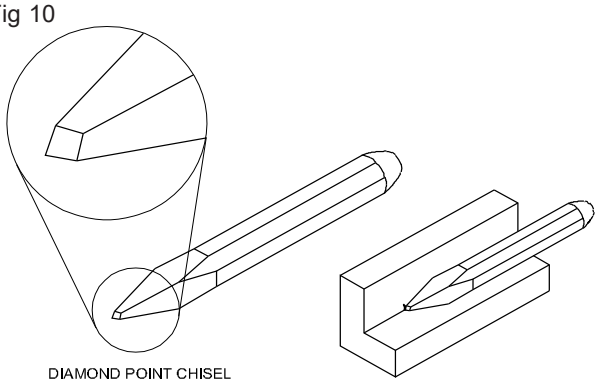
Fig 9



Diamond point chisels (Fig 10)**:** These are used for squaring materials at the corners, joints.

Web chisels/ punching chisels (Fig 11)**:** These chisels are used for separating metals after chain drilling.

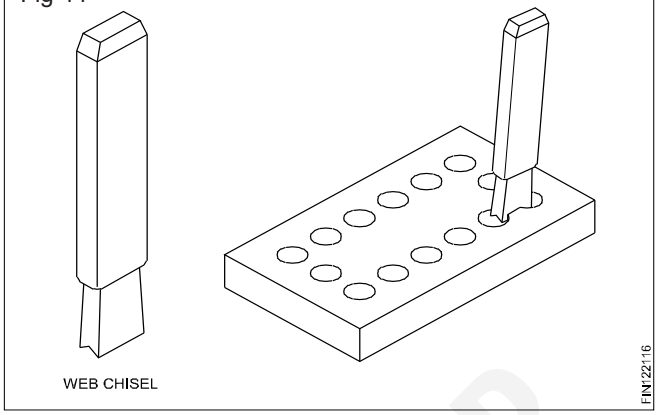
Fig 10



Chisels are specified according to their

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

Fig 11



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

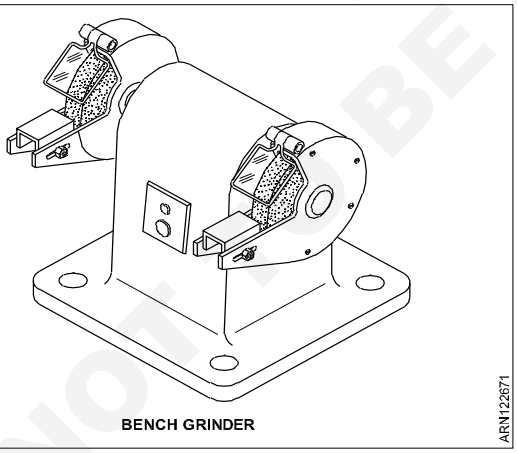
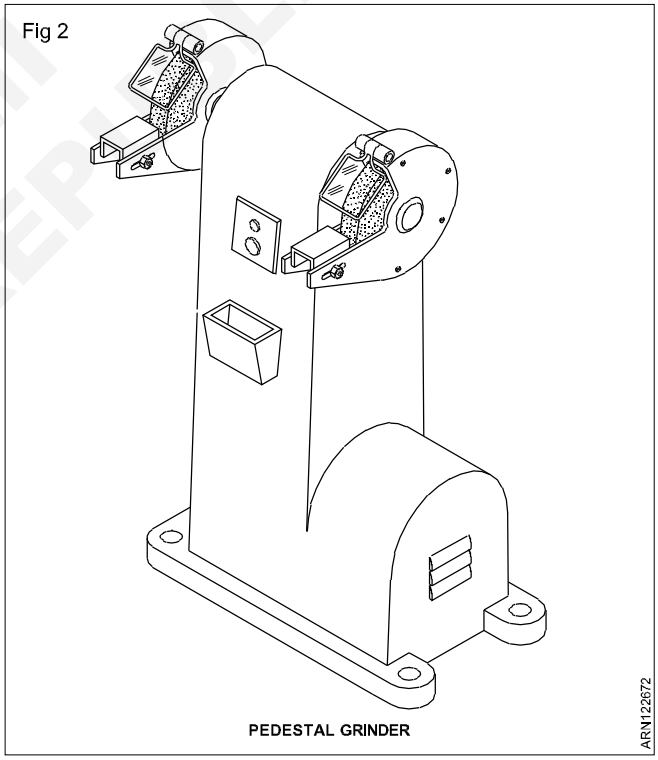


Fig 2



Bench grinders

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

Pedestal grinders

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

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)

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 3

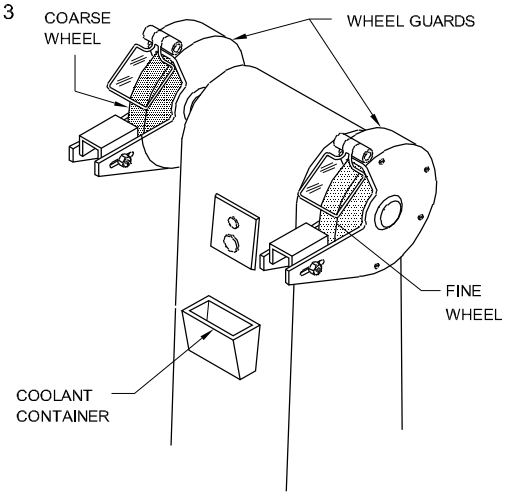
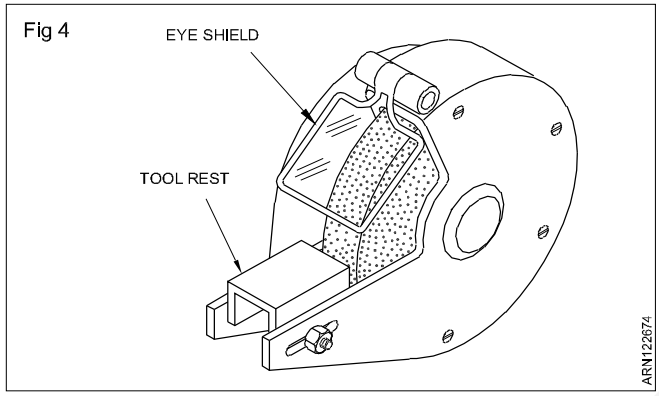


Fig 4



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

Never hold jobs with cotton waste or similar materials. Use gloves for your hands while grinding heavy jobs. Do not grind on the side of the grinding wheels. (Fig 6)

Fig 5

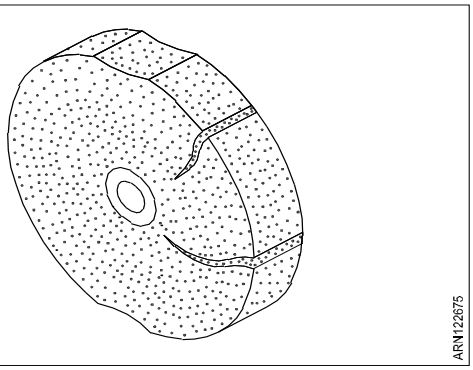
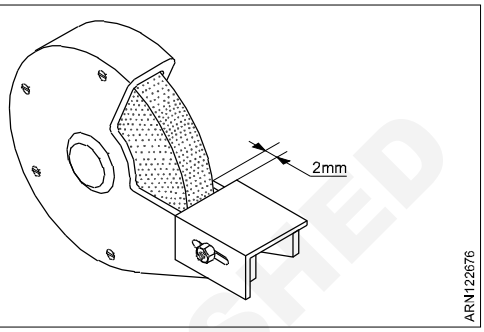
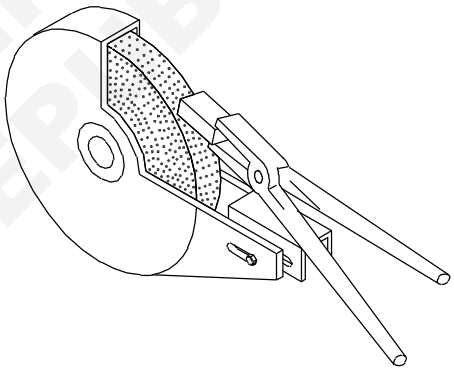


Fig 6



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

Fig 7



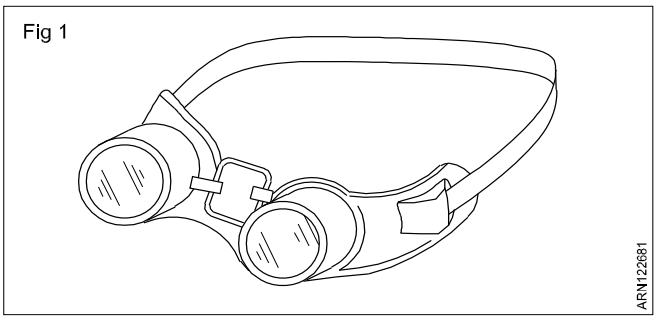
Safe working on off - hand grinders

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

How to work on an off-hand grinder? While working on off-hand grinders, it is important to observe the following safety measures.

Before starting: Make sure the grinding wheel guards are in place. Wear safety goggles while grinding. (Fig 1)

Fig 1

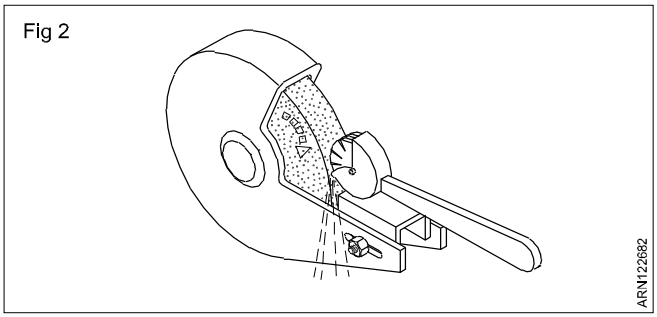


Do not work on grinding wheels which are loaded or glazed. Dress and true wheels whenever necessary. (Fig 2)

If any abnormal sound is noticed, stop the machine. Cracked or improperly balanced wheels are dangerous.

Stand on one side of the machine while starting.

Fig 2



Drilling machines (bench and pillar type)

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

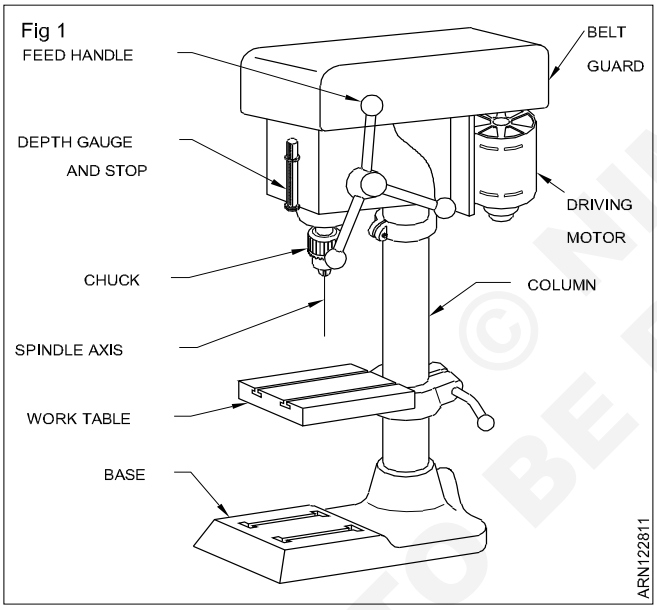
The principal types of drilling machines are :

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

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

The sensitive bench drilling machine (Fig 1)

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

Fig 2

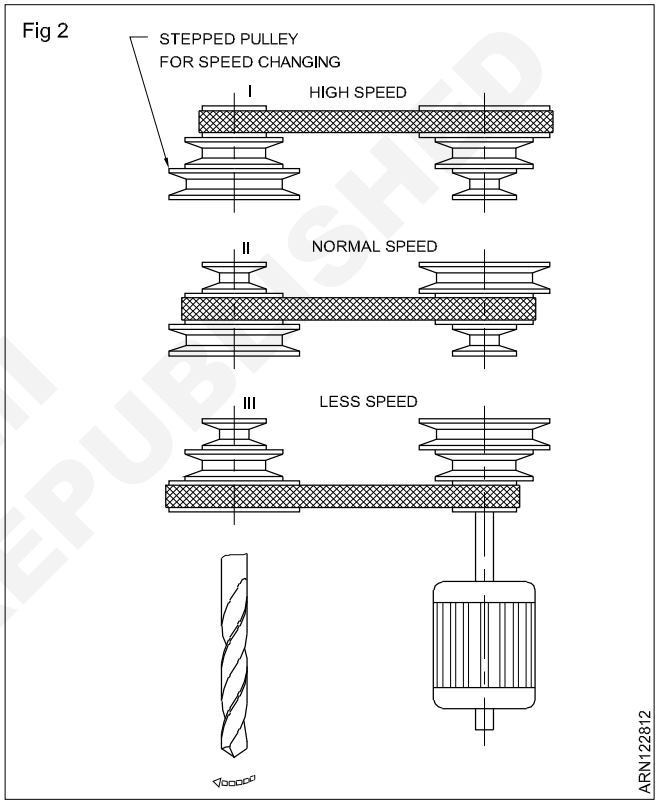
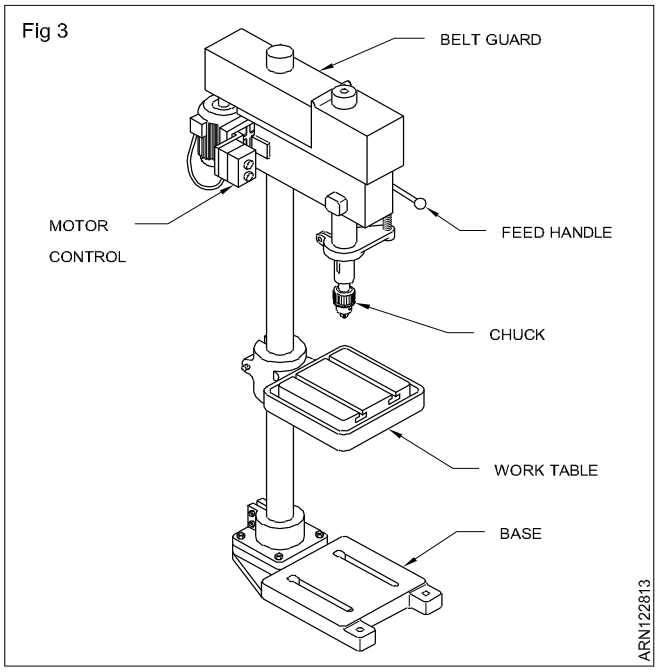
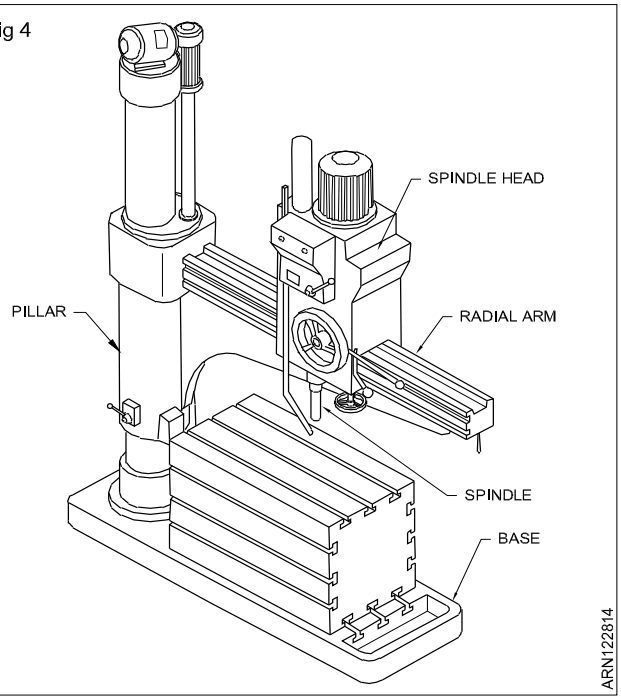


Fig 3



Radial drilling machines (Fig 4)

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.

Drilling machines (portable type)

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

Necessity

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

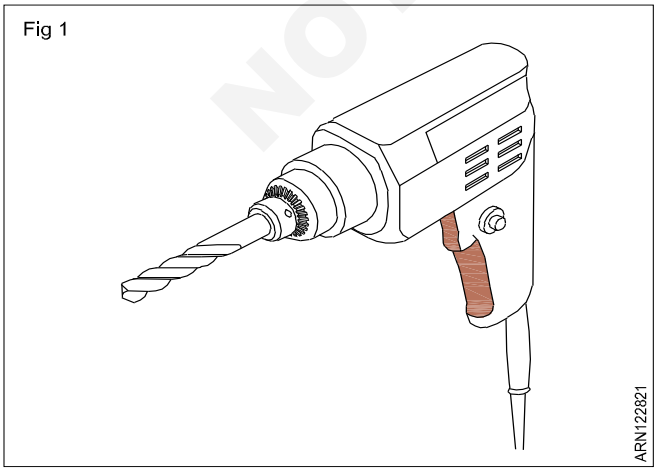
Types: There are two types of portable drilling machines, power operated and hand operated.

Power Operated drilling machines

Electric hand drill (light duty) (Fig 1)

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

Fig 1



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

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

Fig 2

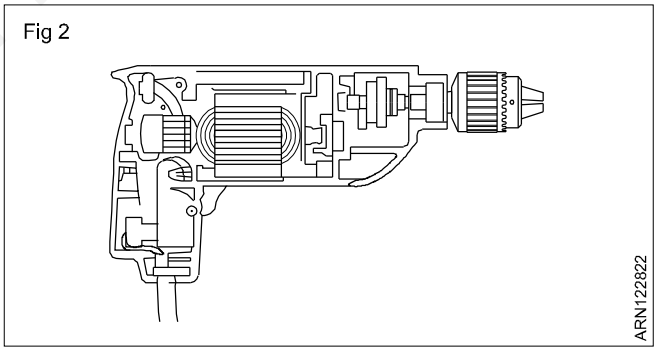
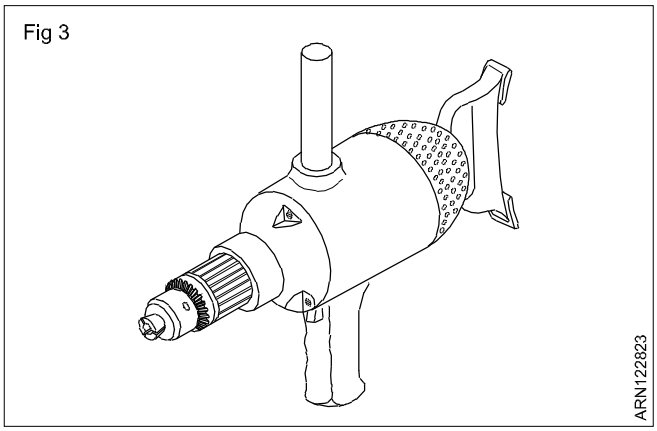


Fig 3

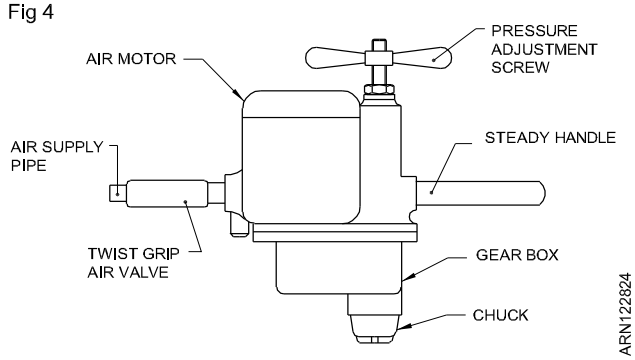


Pneumatic hand drill (Fig 4)

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

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

Fig 4



Hand operated drilling machines

Different types of hand operated drilling machines are shown below. They are used in structural fabrication, sheet metal and carpentry, particularly where electricity or pneumatic supply is not available. The ratchet drilling machine (Fig 5) is commonly used in structural fabrication. Square head, taper shank drills are used on these machines. The bevel gear type drilling machine (Fig 6) is used for drilling small diameter holes up to 6mm. The breast drilling machine (Fig 7) is used for drilling holes of larger diameter as more pressure can be exerted. Drills between 6 mm to 12 mm can be used on these machines.

Fig 5

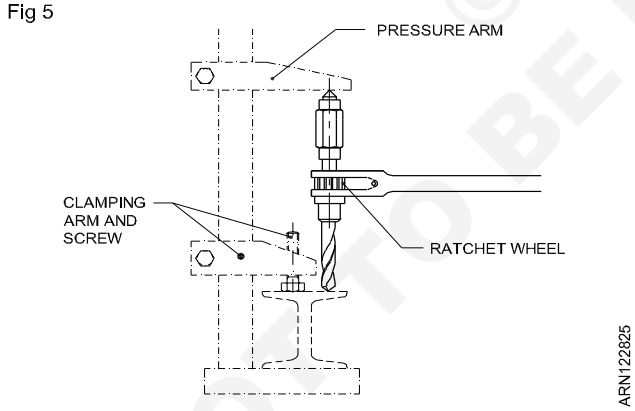


Fig 6

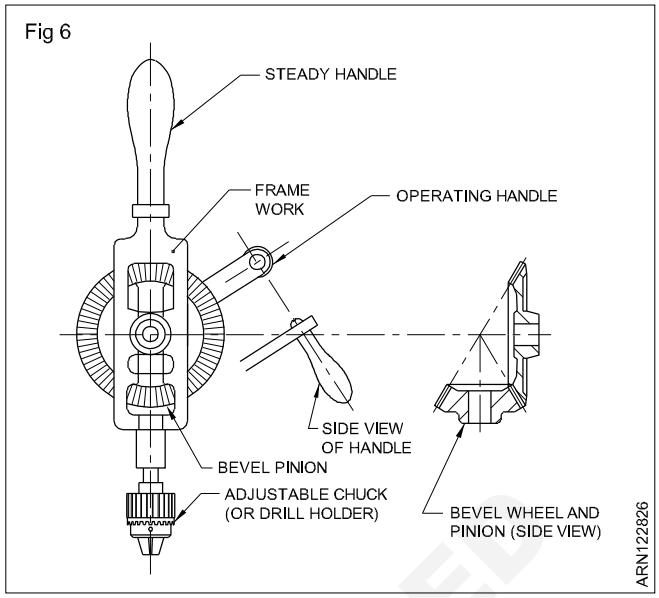
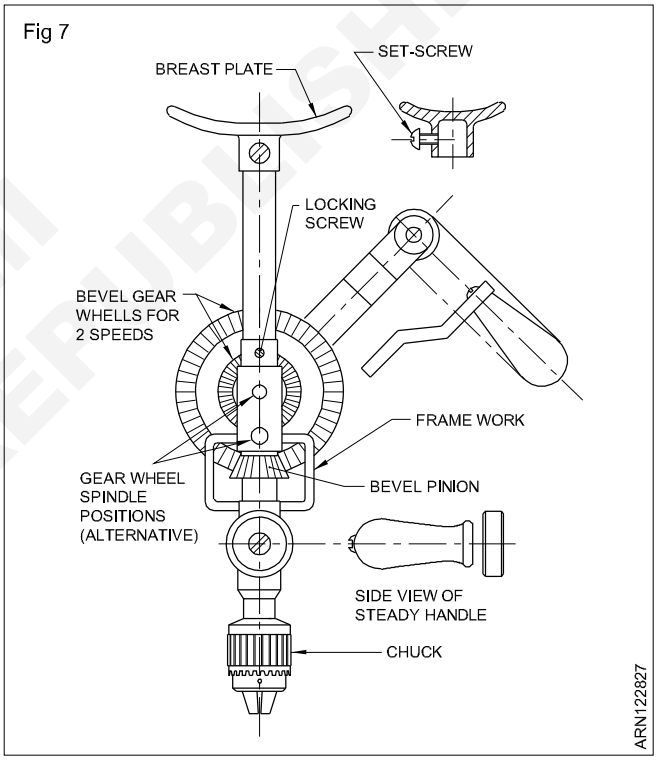


Fig 7



Work holding devices

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

- **state the purpose of work holding devices**
- **name the device used for holding work**
- **state the precautions to be observed while using.**

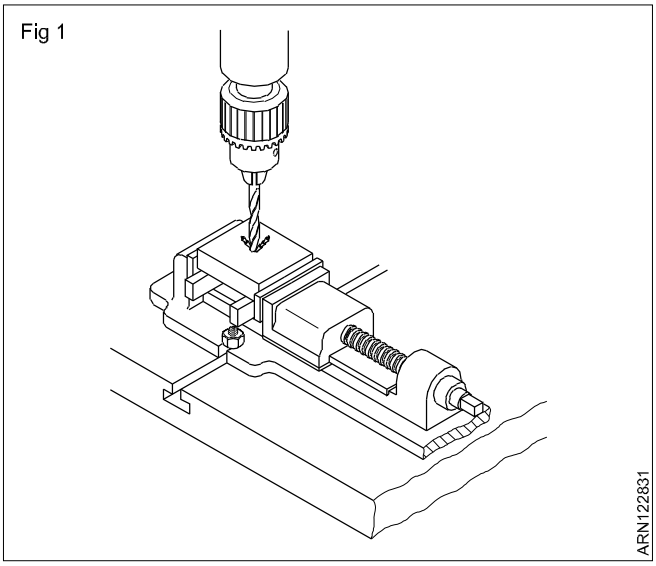
Workpieces to be drilled should be properly held or clamped to prevent them from rotating along with the drill. Improperly secured work is not only a danger to the operator but can also cause inaccurate work, and breakage to the drill. Various devices are used to ensure proper holding.

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.

Fig 2

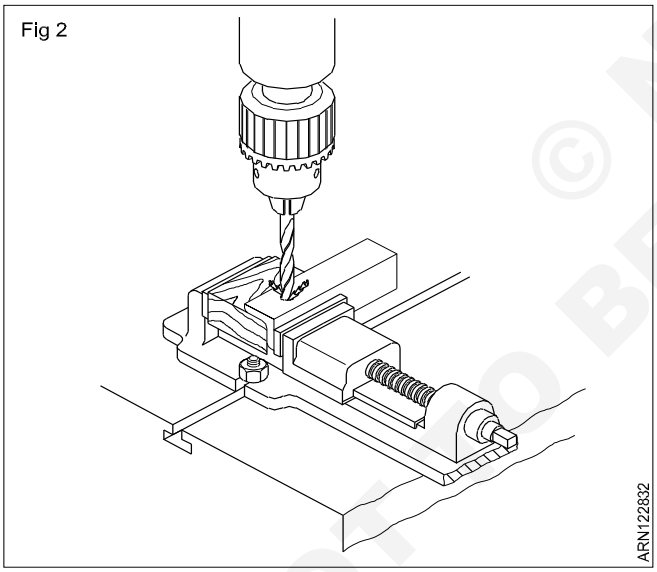


Fig 3

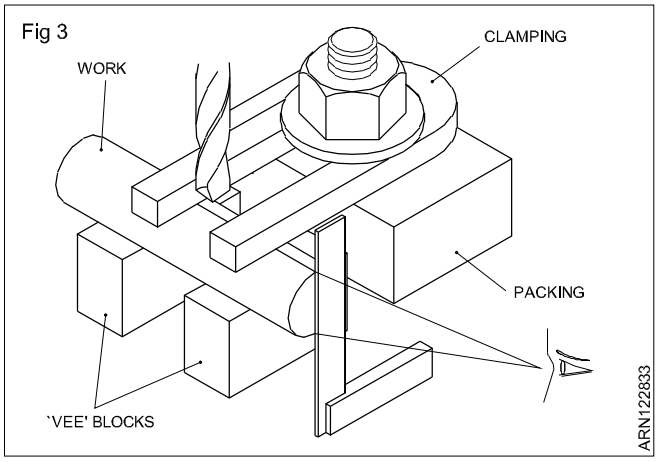


Fig 4

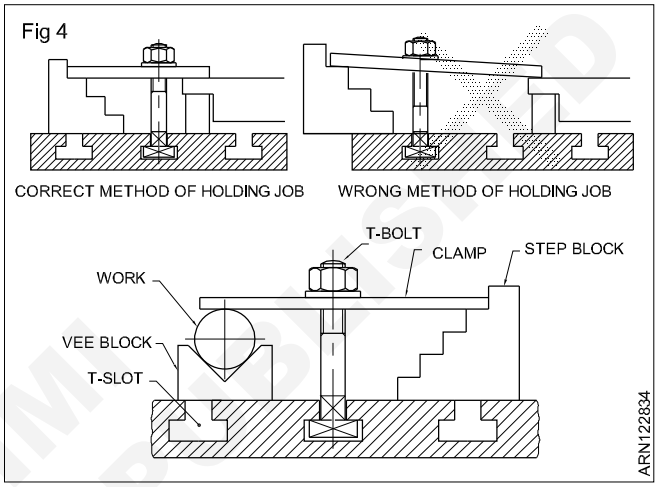
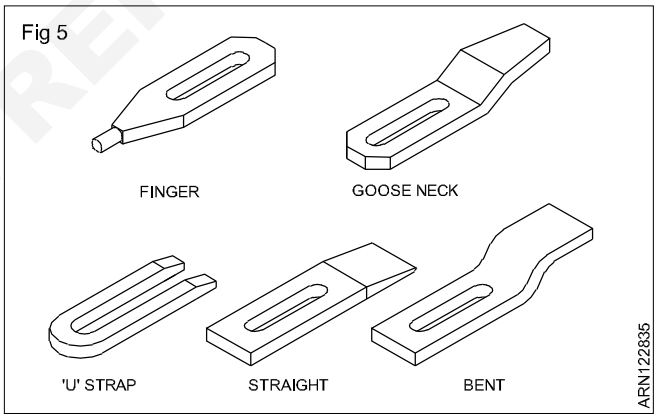


Fig 5



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

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

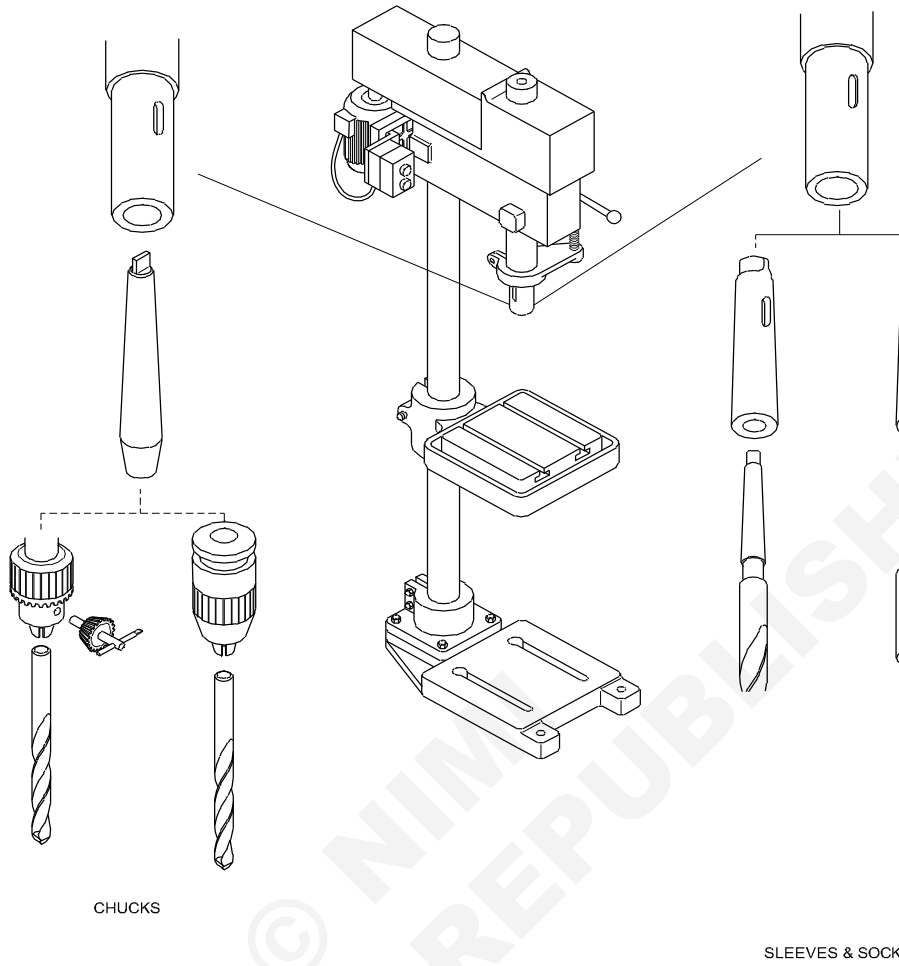
Straight shank drills are held in drill chucks. For fixing and removing drills, the chucks are provided either with a pinion and key or a knurled ring.

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.

Fig 1



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 2

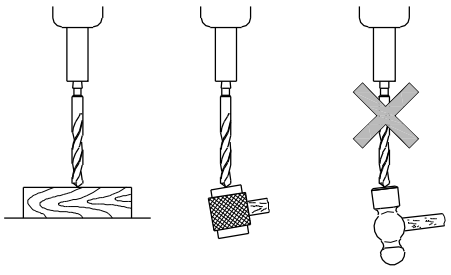


Fig 3

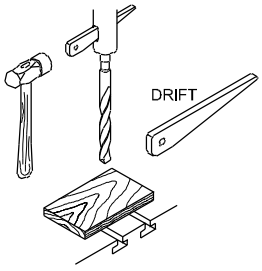
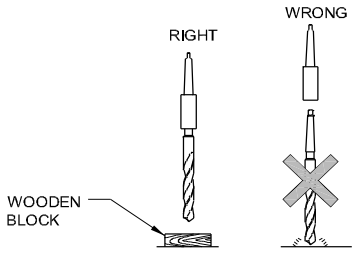


Fig 4



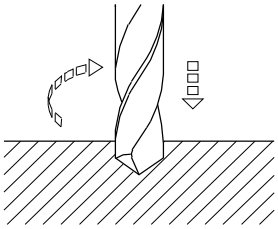
REMOVING A TAPER SHANK DRILL

Drill Bits

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

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

Fig 1



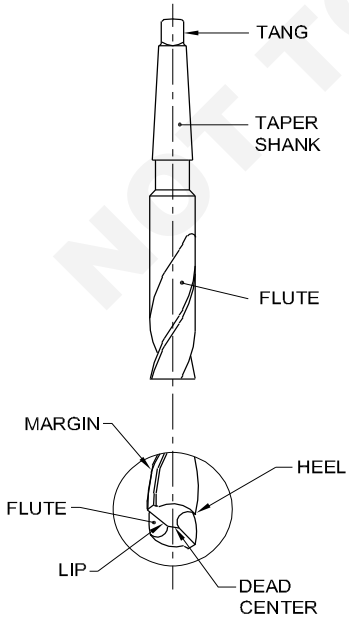
Parts of a Drill (Fig 2)

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

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.

Fig 2



Shank

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

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

Tang

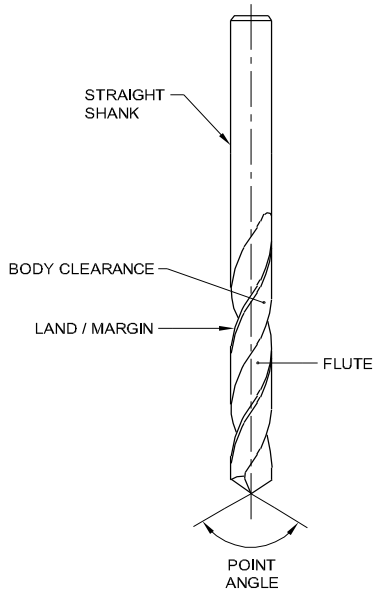
This is a part of the taper shank drill which fits into the slot of the drilling machine spindle.

Body (Fig 3)

The portion between the point and the shank is called the body of a drill.

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

Fig 3



Flutes

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

- to form the cutting edges

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

Land/Margin

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

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

Body Clearance

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

Web

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

Hand taps and dies

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

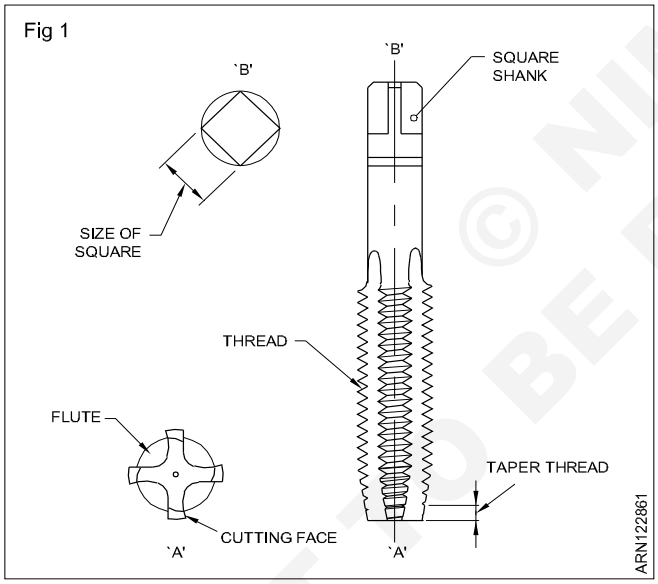
Use of Hand Taps

Hand taps are used for internal threading of components.

Features (Fig 1)

They are made from high carbon steel of high speed steel hardened and ground threads are cut on the surface and are accurately finished.

Fig 1



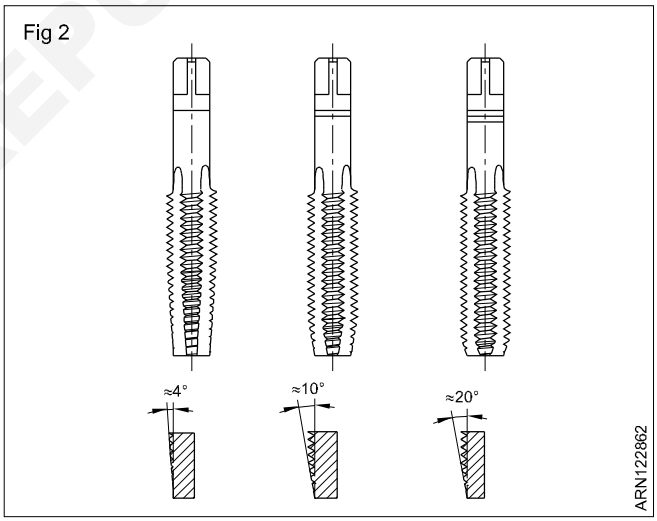
To form the cutting edges, the flutes are cut across the thread. For holding and turning the taps while cutting threads the ends of the shanks are squared. The ends of the taps are chamfered (taper lead) for assisting aligning and starting of the thread. The size of the taps and the type of the thread are usually marked on the shank. In certain cases the pitch of the thread will also be marked. Markings are also made to indicate the type of tap i.e first, second final or plug tap.

Types of Taps in a set

Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2) These are first tap or taper tap second tap or intermediate tap.

Plug or bottoming tap These taps are identical in all features except in the taper lead. The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep. The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth. for identifying the type of taps quickly - the taps are either numbered as 1,2 and 3 or rings are marked on the shank. The taper tap has one ring the intermediate tap has two rings and the bottoming tap has three rings (Fig 2)

Fig 2



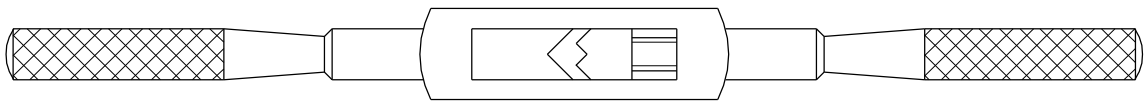
Tap Wrenches

Tap Wrenches are used to align and drive the hand taps correctly into the hole to be threaded. Tap Wrenches are of different types. Double ended adjustable wrench, 'T' handle tap wrench and solid type tap wrench.

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

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

Fig 3



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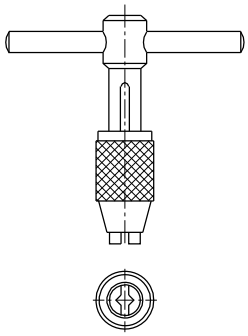
T- Handle Tap Wrench (Fig 4)

These are small adjustable chucks with two jaws and a handle to turn the wrench. This tap wrench is useful to work in restricted places and is turned with one hand only.

Fig 4



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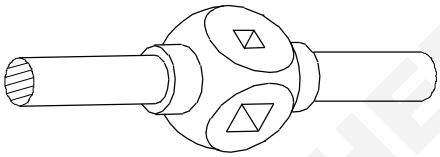
This is not suitable for holding large diameter taps.

Solid Type Tap Wrench (Fig 5)

These Wrenches are not adjustable They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches and thus prevents damage to the taps.

Fig 5



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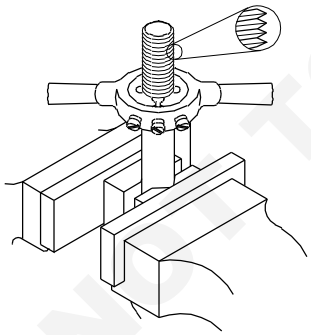
Die and die stock

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

Uses of Dies

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

Fig 1



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Types of Dies

The following are the different types of dies.

Circular Split Die (Button die)

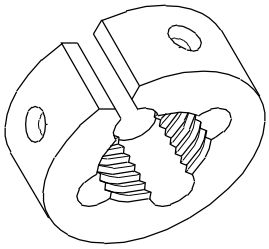
Half Die

Adjustable Screw Plate Die

Circular Split Die/Button Die (Fig 2)

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

Fig 2



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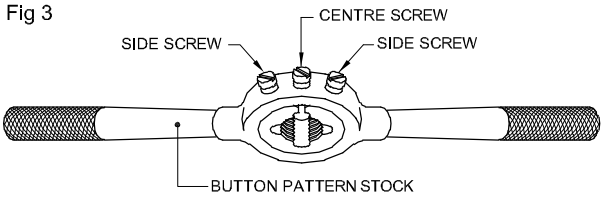
When held in the diestock, variation in the size can be made by using the adjusting screws. This permits increasing or decreasing of the depth of cut. When the side screws are tightened the die will close slightly. (Fig 3)

Fig 3



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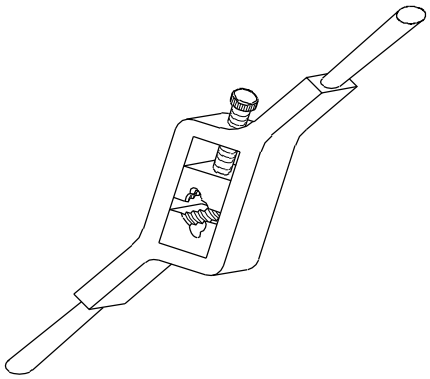
For adjusting the depth of the cut, the centre screw is advanced and locked in the groove. This type of die stock is called button pattern stock.

Half Die (Fig 4)

Fig 4



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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.

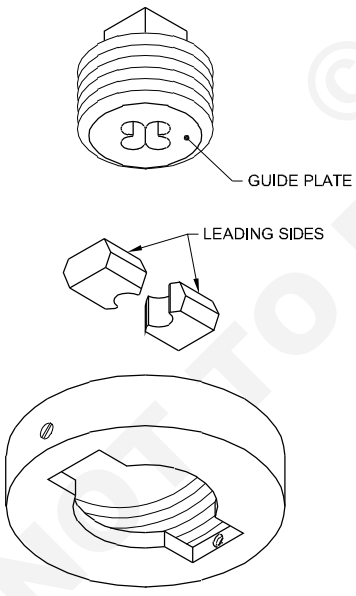
By adjusting the screw of the diestock, the die pieces can be brought closer together or can be moved apart.

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.

Fig 5



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This provides greater adjustment than the split die.

The two die halves are held securely in a collar by means of a threaded plate (guide plate) which also acts as a guide while threading.

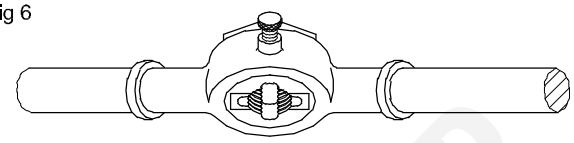
When the guide plate is tightened after placing the die pieces in the collar, the die pieces are correctly located and rigidly held. (Fig 5)

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

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

Both pieces should have the same serial numbers.

Fig 6



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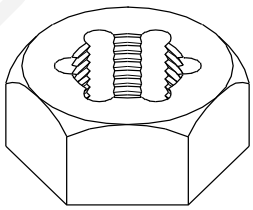
Die Nut (Solid Die) (Fig 7)

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

The die nut is turned with a spanner.

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

Fig 7



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

screw extractor

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.

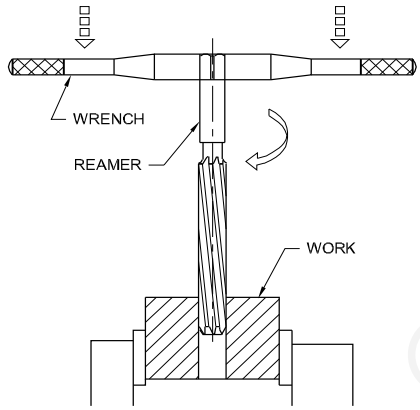
Hand Reamers

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

What is reamer?

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

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

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

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

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

Fig 2

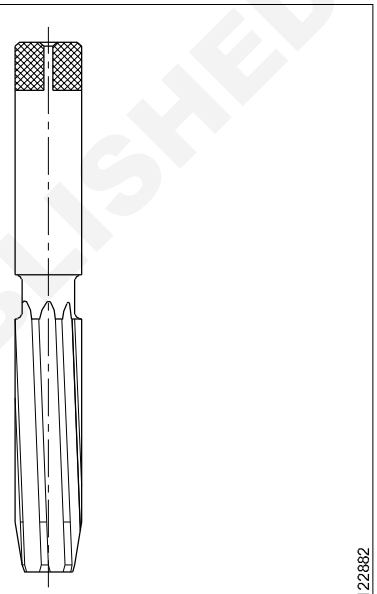
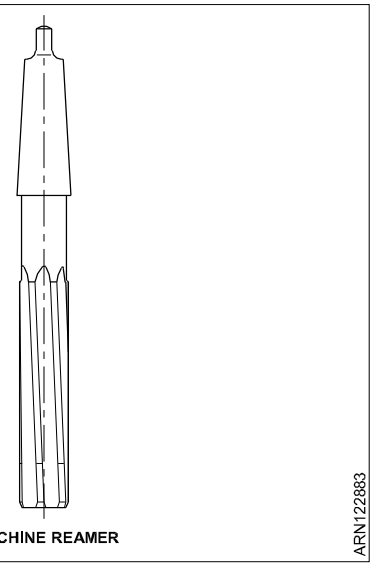


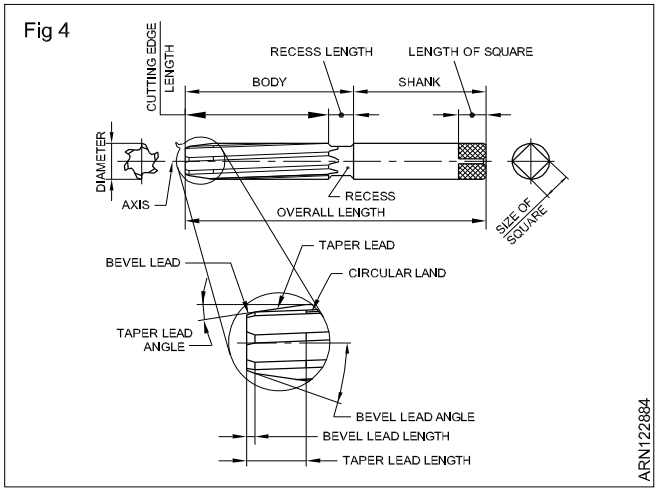
Fig 3



Parts of a hand reamer

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

Fig 4



Types of sheet metals and their application

Objectives: At the end of this lesson you shall be able to
- **state the types of metals used in sheet metal work**
- **state the uses of the different types of metals.**

In sheet metal work, different types of metal sheets are used. The sheets are specified by standard gauge numbers.

It is very essential to know the different uses and applications of these metal sheets.

Black Iron

The cheapest sheet metal is black iron, which is rolled to the desired thickness. It has a bluish black appearance, and is often referred to as uncoated sheet. Since it is uncoated, it corrodes rapidly.

The use of this metal is limited to articles that are to be painted or enamelled such as tanks, fans, stoves, pipes etc.

Galvanised iron

Zinc-coated iron is known as 'galvanised iron'. This soft iron sheet is popularly known as GI sheet. The zinc coating resists rust, improves the appearance of the metal and permits it to be soldered with greater ease. Because it is coated with zinc, galvanised sheet iron withstands contact with water and exposure to weather.

Articles such as fans, buckets, furnaces, heating ducts,cabinets, gutters etc. are made mainly from GI sheets.

Stainless sheet

This is an alloy of steel with nickel, chromium and other metals. It has good corrosive resistance and can be welded easily. Stainless steel used in a sheet metal shop can be worked as galvanised iron sheets, but is tougher than GI sheets. The cost of stainless steel is very high. Stainless steel is used in dairies, food processing, chemical plants, kitchenware etc.

Copper sheet

Copper sheets are available either as cold-rolled or hotrolled sheets. Cold-rolled sheets being resistant to corrosion and worked easily are commonly used in sheet metal shops. Copper sheet has better appearance than other metals.

Gutters, expansion joints, roof flashings, hoods, utensils and boiler plates are some of the common examples where copper sheet is used.

Aluminum

Aluminum cannot be used in its pure form, but is mixed with a very small amount of copper, silicon, manganese and iron. It is whitish in colour and is light in weight. It is highly resistant to corrosion and abrasion.

Aluminum is now widely used in the manufacture of articles such as household appliances, refrigerator trays, lighting fixtures, windows, and also in the construction of airplanes and in many electrical and transport industries.

Tinned plate

Tinned plate is sheet iron coated with tin to protect it against rust. This is used for nearly all solder work, as it is the easiest metal to join by soldering. This metal has a very bright silvery appearance and is used in the making of roofs, food containers, dairy equipment, furnace fittings, cans and pans, etc.

Lead

Lead is very soft and heavy. Lead sheets are used for making the highly corrosive acid tanks.

Properties of an auto body sheet metal

Objectives: At the end of this lesson you shall be able to
• describe the properties of an auto body sheet metal.

Properties of auto body sheet metal: The sheet metal used in the production of automobile surface panels must contain certain properties of qualities such as plasticity, elasticity and work hardening.

Direct and indirect damages: Damage to the body sheet metal can be classified as either direct or indirect damage.

Direct damage results from the impact of an object stilling the sheet metal. The area of damage is called the point of impact. Direct damage can be in the form of deep scratches, gauges, tears in the metal or in the case of severe impact, crumpled or mangled sheet metal.

The force of the direct damage is transmitted or transferred from the impact area to different parts of the panel thus causing indirect damage in the form of roll buckles, valleys or sharp ridges.

When straightening a panel with direct and indirect damage, the indirect damage should be straightened first.

Notches in sheet metal

Objectives: At the end of this lesson you shall be able to
• state the purpose of notches
• name the types of notches
• distinguish the features of different notch forms.

Notches

Notches are the spaces provided for joining the edges when sheet metals are cut form the layout.

Purpose of notches

Notch helps:

- to prevent surplus material from overlapping and causing a bulge at the seam and edges.
- to allow the work to be formed to the required size and shape.
- to allow the work to assemble better.

Types of notches

Straight notch of slit (Figs 1 & 2)

Straight cuts made in the edge of the sheet where it is to be bent is know as a straight notch.

Fig 1

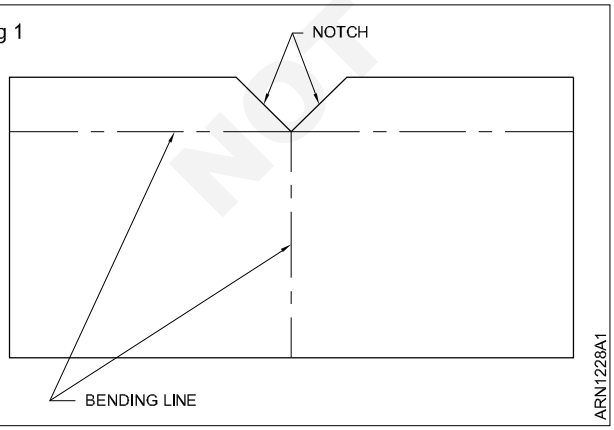
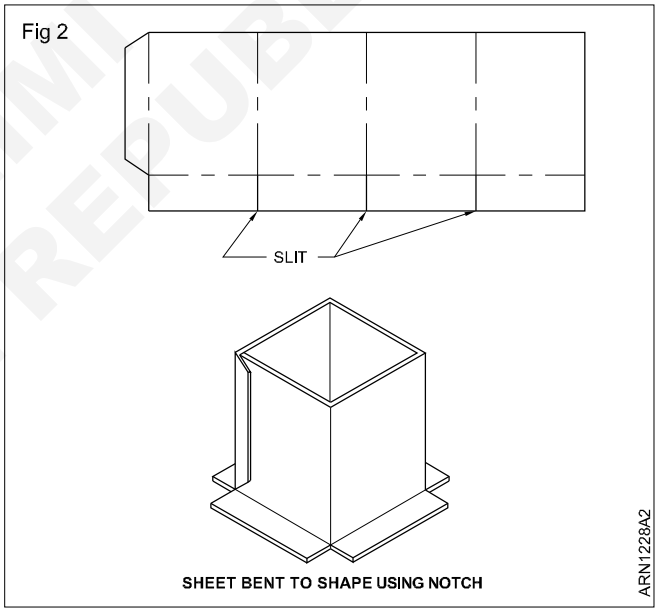


Fig 2



Square notch (Figs 3, 4 & 5)

A square notch is used for forming a square or rectangular box.

Fig 3

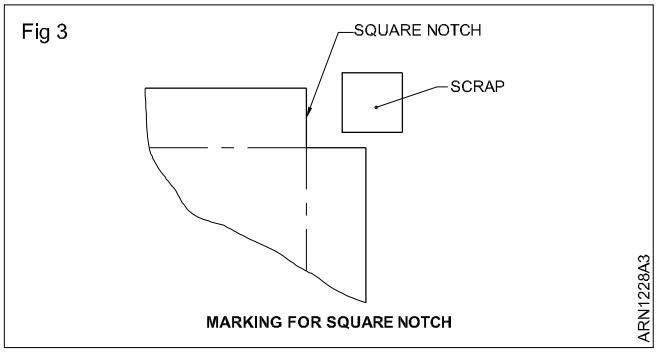
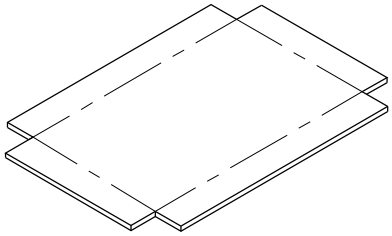


Fig 4



SQUARE NOTCH CUT

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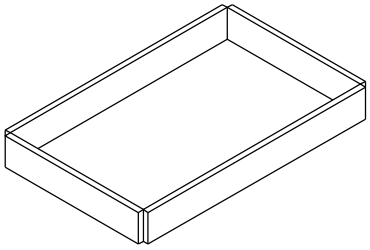
Fig 5



SHEET BENT TO SHAPE USING SQUARE NOTCH SLIT

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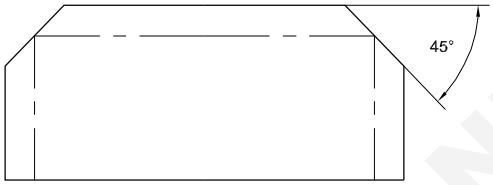
Slant notch (Fig 6)

This Notch is cut at an angle of 45° to the corner of the sheet. It is used when a single hem meets at right angles.

Fig 6



NOTCH CUT AFTER MARKING

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'V' Notch (Figs 7 & 8)

In this notch, both the sides are cut at a 45° angle to the edge of the sheet.

Fig 7

BENT TO SHAPE USING SLANT NOTCH

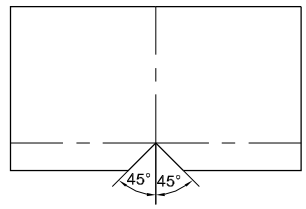
ARN1228A7

The sides of the notch meet at 90° . This notch is used when making a job with a 90° bend and an inside flange.

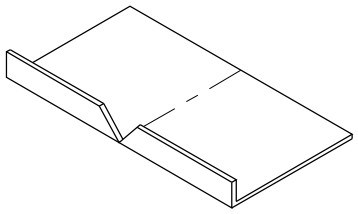
Wire notch (Figs 9 & 10)

The angle of this notch is usually 30° and the distance from which the notch is started is 3 times the diameter of the wire.

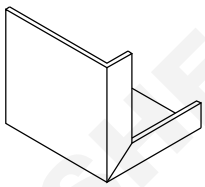
Fig 8



'V' NOTCH MARKED AND OUT



FIRST FOLDING NOTCH



BENT TO SHAPE USING 'V' NOTCH

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Fig 9

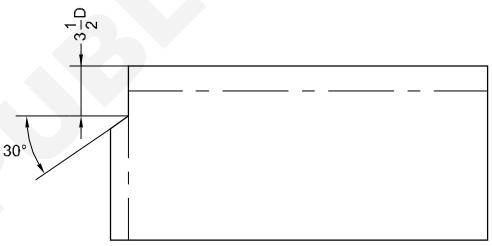

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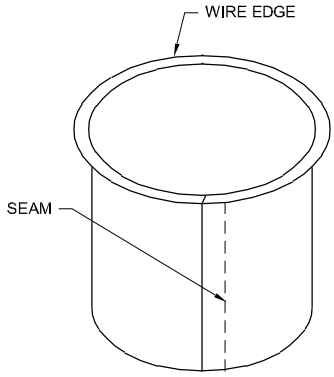
Fig 10



AN EDGE WIRED USING WIRE NOTCHES

ARN1228AA

Uses

The wire notch is used on a work which has wired edges.

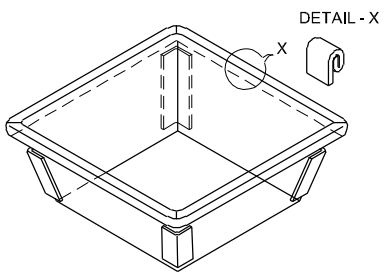
This notch must be provided to prevent the wired edge from overlapping at the seam.

Edge Stiffening

Objectives: At the end of this lesson you shall be able to
- **state what is a hem**
- **state the types of hems**
- **state the uses of the different types of hems.**

The edges of light gauge sheet metal articles (Fig 1) are very sharp and unsafe to handle. Safe edges are provided to strengthen the sheet metal and to enhance the appearance of the finished article.

Fig 1



What is a hem?

A hem is an edge or border made by folding.

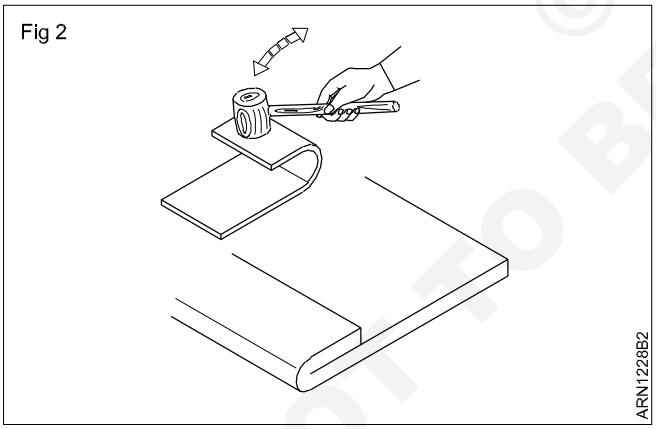
It stiffens the sheet of the metal and avoids sharp edges.

Types of hems

- Single hem
- Double hem
- Wired edge

Single hem (Fig 2)

Fig 2



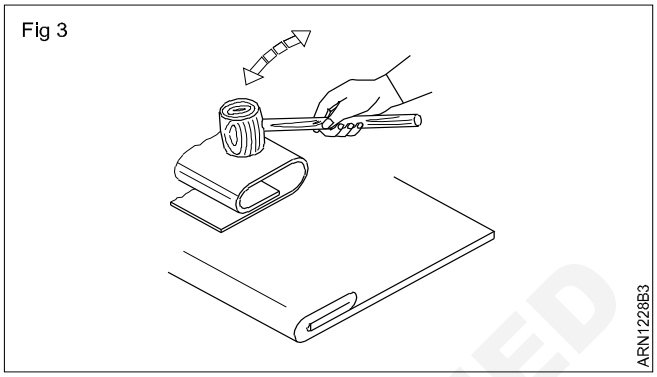
A single hem is made by folding the edge of the sheet metal with a single folding.

It makes the edge smooth and stiff and is done while making small articles.

Double hem (Fig 3)

A double hem is made by folding the edges over twice to make it smooth and this is done normally to strengthen the edges of lengthy articles.

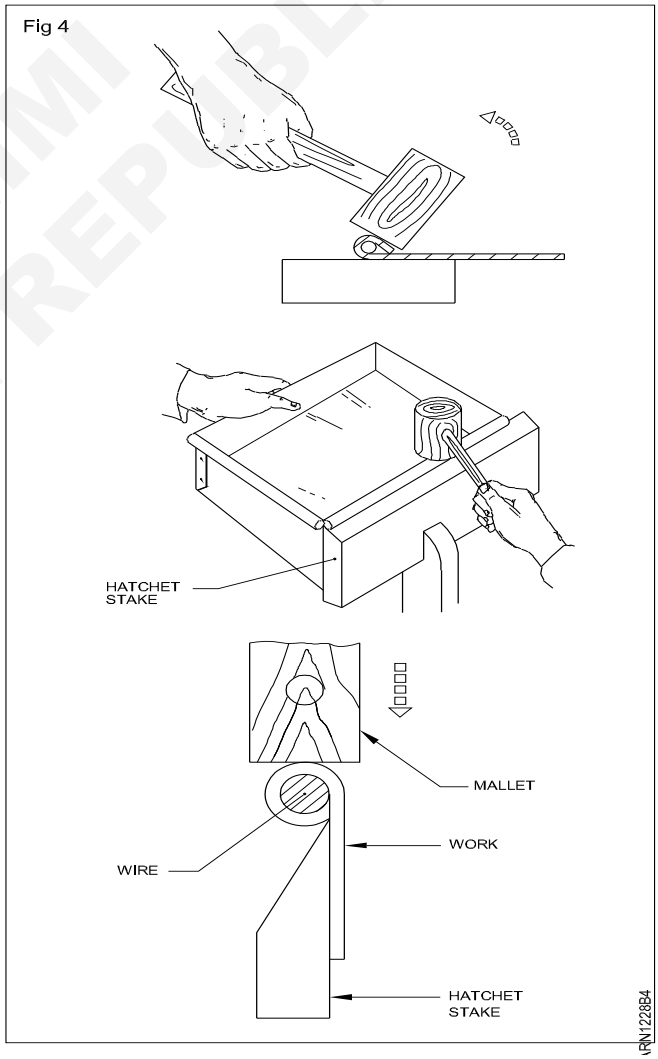
Fig 3



Wired edge (Fig 4)

The wired edge is done for round and lengthy articles to enhance the appearance and increase the strength. The wired edge is smooth and is very strong.

Fig 4



Sheet Metal Joints

Objectives: At the end of this lesson you shall be able to
- **state what is a seam**
- **state the types of seams**
- **state the uses and application of the different types of seams.**

Sheet metal working incorporates a wide variety of seams

What is a seam?

A seam is a joint made by the fastening of two edges of two pieces of metal together.

Types of seams

Lap seam

The lap seam is the simplest type of seam and can be prepared as a lap joint. This joint is also known as edged on joint. This joint is used to fit the top and bottom to cylindrical shapes. This joint is finally secured by soldering or brazing.

Grooved seam

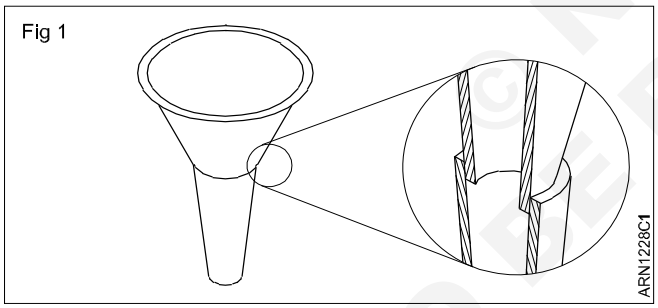
A grooved seam is used to join two pieces of straight or curved metal of light gauge and then locking them by a groove.

Single seam (Fig 1)

The single seam is used to join a bottom to vertical bodiesof various shapes. This joint is called paned-down joint.

This joint is also secured by soldering or brazing.

Fig 1



Double seam (Figs 2 & 3)

Fig 2

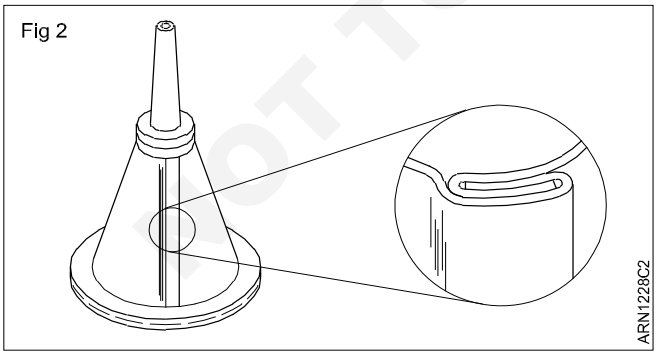
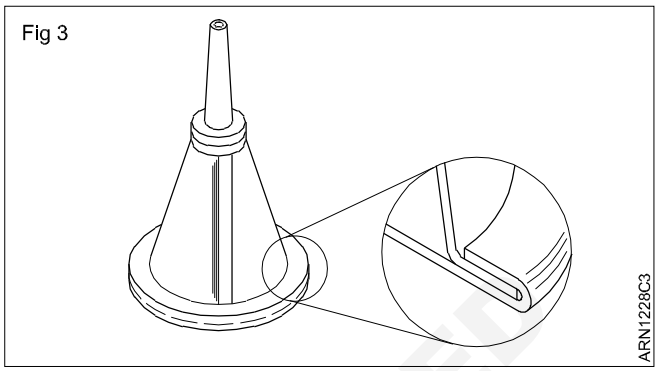


Fig 3



The double seam is similar to a single seam joint except that its forward edge is bent upward against the body.

This joint fulfils the same function as the edged-on and paned-down joints, but it is the strongest of the three.

Double grooved seam (Figs 4 & 5)

Fig 4

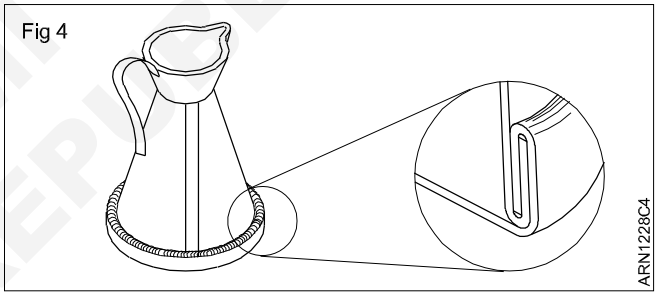
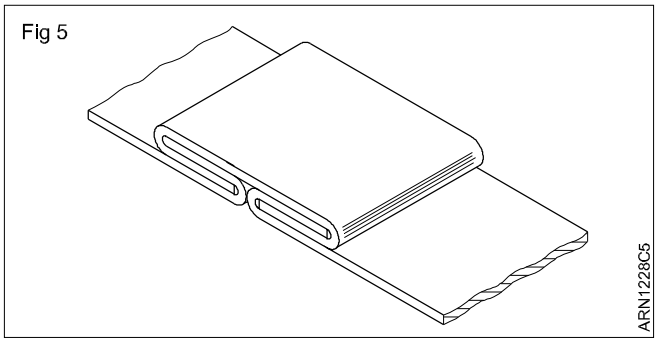


Fig 5



The double grooved seam (Fig 5) is similar to the dovetail joint in carpentry and it is used for roofing and paneling joints.

Folding and Joining Allowances

Objectives: At the end of this lesson you shall be able to
- **state the necessity for providing allowances in sheet metal operations.**

When making self-secured joints or seams, it is necessary to make an allowance for the extra material to be added for the preparation of the edges and seams.

The allowance is necessary for maintaining the correct size of the finished product and for improving the strength at joints of all edges.

Allowance is also necessary for avoid cracking or warping, and for obtaining the required finish.

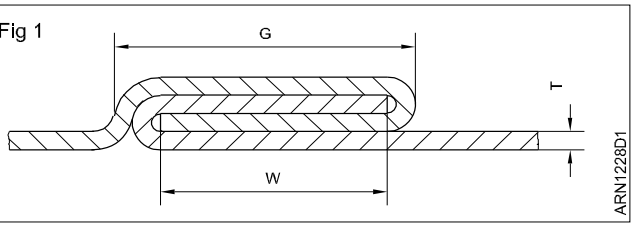
This allowance depends upon the width of the folded edge and the thickness of the metal.

Allowances: In the making of various types of hems and seams, no allowance is necessary for thinner sheets of 0.4 mm or less.

Allowance for grooved joints/seams (Fig 1)

If we fold over the edges to width W and form the joint, the final completed width of the joint G will be greater than W. It can be seen that the final width of the groove will have a minimum value of W + 3T, where T represents the metal thickness.

Fig 1



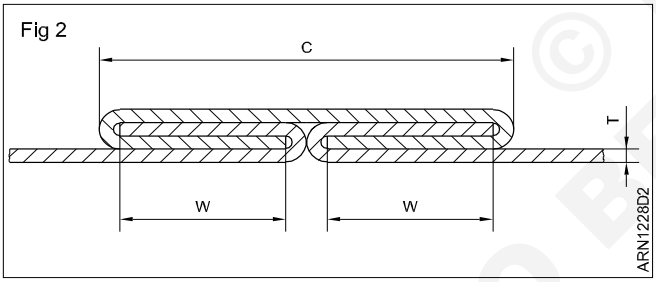
The allowance for a grooved seam is three times the thickness of the sheet.

Allowance for double grooved seam/joint (Fig 2)

It will be seen from the figure that the width of the capping strip is equivalent to two times the width of the folded edge plus four times the thickness of the metal size.

C = 4W + 4T

Fig 2



The complete allowance for the double grooved seam/joint will be four times the width of the folded edge plus four times the thickness of the metal.

Allowance for paned down and knocked-up joints (Figs 3 & 4)

The size of paned down and knocked-up joints is determined by the width of the single folded edge.

'P' represents the size of the paned down joint and 'K' represents the size of the knocked-up joint.

P = 2W + 2T

K = 2W + 3T

Fig 3

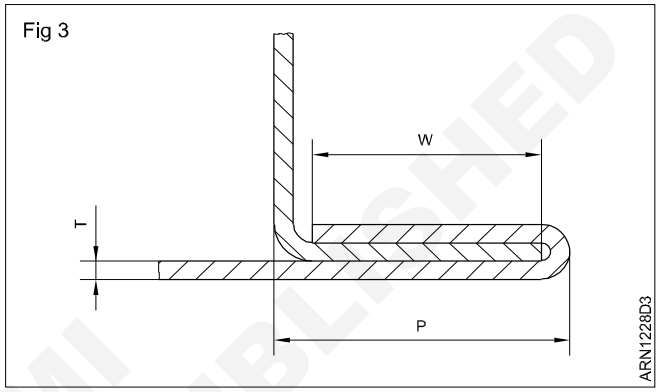
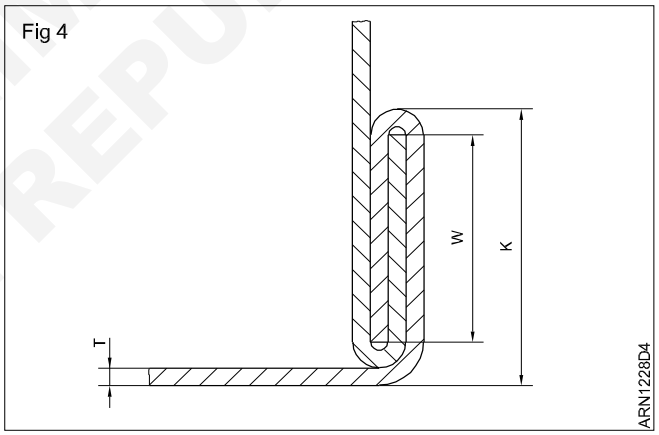


Fig 4



Sheet metal shearing, drawing, squeezing

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of the power press**
- **name the different types of power presses**
- **state and explain the different operations that can be performed on the power press**
- **state the safety precautions while working in the press shop.**

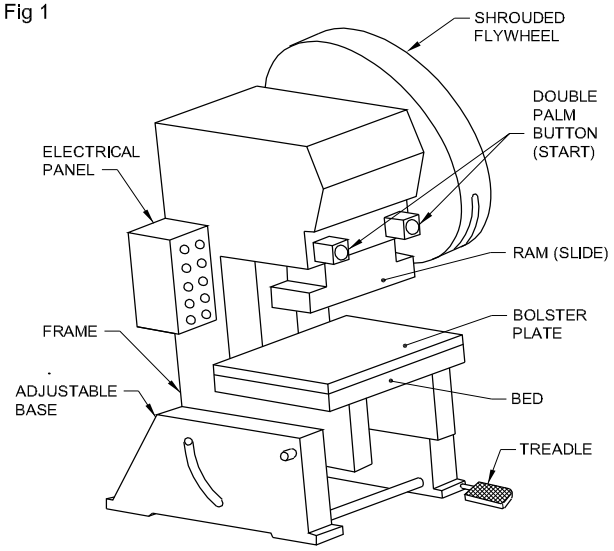
The constructional feature of the power press is almost similar to that of a fly press or hand press. (Fig 1) Except that the ram is driven by power. The power presses may be identified as Mechanical or Hydraulic, according to the type of working mechanism used to transmit power to the ram. In a mechanical press, the rotary motion of the electric motor is converted into a reciprocating motion of the ram by using various mechanical devices. In a hydraulic press, the fluid under high pressure is pumped on one side of the piston and then to the other side in a hydraulic cylinder to drive the reciprocating movement.

The power presses are designated according to the power sources, Frame construction, Number of slides in action.

Power press operations (Fig 2)**:** The press operations are classified based on the operations performed.

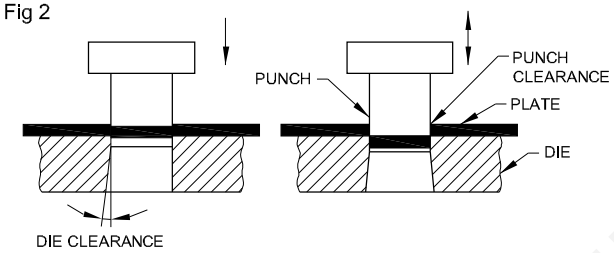
Shearing : Shearing is an operation of cutting sheet metal with the help of a punch and die on a power press. The sheet is placed on the die and when the punch descends on the metal, it causes a rupture and forces the metal to be severed and ram the sheet metal. As the clearance between the punch and die is very small it forces the metal to drop down from the die opening.

Fig 1



POWER PRESS

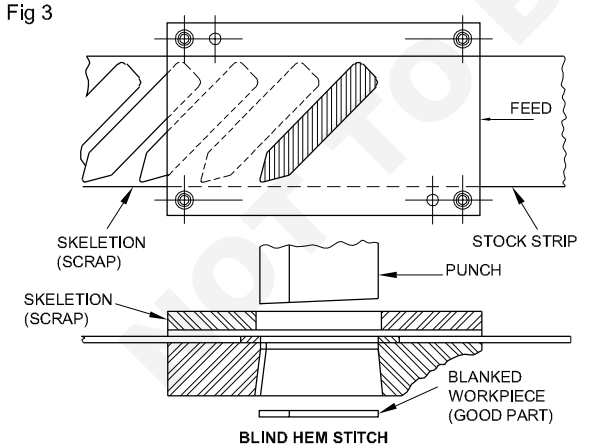
Fig 2



SHEARING OPERATION

a Blanking (Fig 3)**:** Blanking is an operation of producing a flat component from a strip of sheet metal. The metal cutout is the required component and the sheet with the cut on the die is the scrap. In blanking, the size of the blank is governed by the size of the die and the clearance is left on the punch.

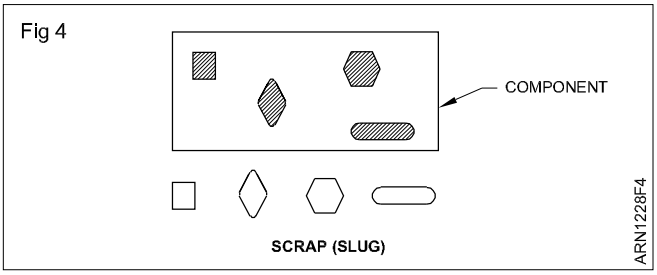
Fig 3



BLIND HEM STITCH

b Piercing (Fig 4)**:** Piercing is an operation of making a cutout on a component. The cutout can be of any shape. The material punched out which comes out of the die is the scrap and the metal with the cutout which is on the die is the component. The punch governs the size of the cutout and the clearances is provided on the die.

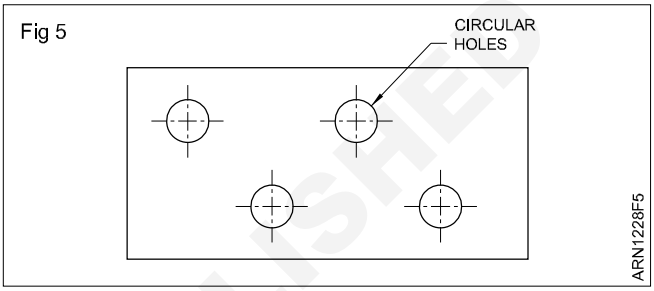
Fig 4



SCRAP (SLUG)

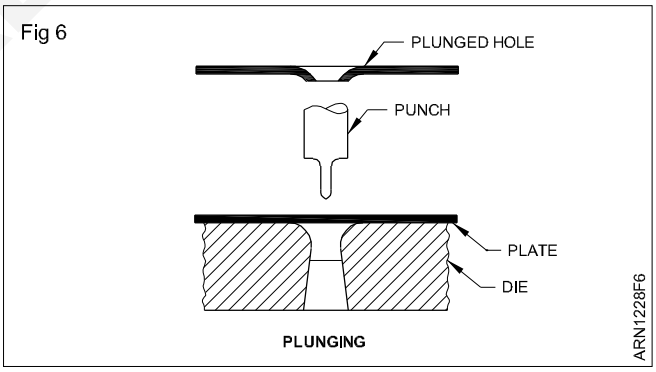
c Punching (Fig 5)**:** Punching is an operation of punching out circular holes. The difference between punching and piercing is that this cutout made by piercing can be of any shape. But in punching only circular holes are made. The size of the hole is governed by the size of the punch and the clearance is provided on the die.

Fig 5



d Perforating (Fig 6)**:** Perforating is an operation of punching circular holes in a regular pattern or evenly spaced. Metal this is done by dimpling operation where the metal will be punched and a dimpling tool will be kept at the extreme of the hole and using a hammer the forming will be completed to accommodate the heads of countersunk screws and countersunk rivets.

Fig 6



PLUNGING

Drawing: Drawing is the operation of producing cup shaped articles from flat sheet metal blanks. The blank is placed on the die and while the punch comes down, the pressure pad holds the blank firmly on the die. As the punch further comes down the metal blank is pushed into the die opening and the metal is made to flow down the die plastically to form the sides of the cup. The pressure pad avoids the formation of wrinkles developed while forming. The size of the blank required to draw out a cup can be calculated by the formula given below.

D = O d2 +4dh

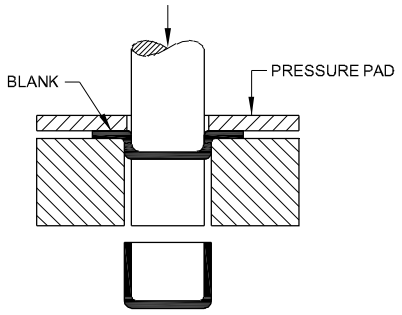
Where D = The diameter of the blank

d = The diameter of the cup

h = The height of the cup

a Cupping (Fig 7)**:** Cupping is the operation of forming cup shaped articles by drawing operation.

Fig 7



DRAWING OPERATION

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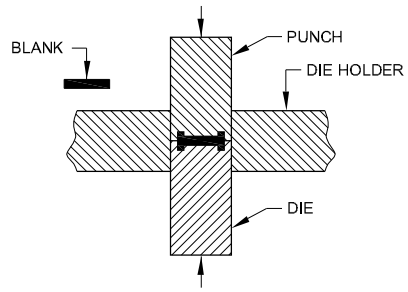
Squeezing: Squeezing operation is the most sever of all cold press operations. More pressure is required to squeeze the metal into the cavity of the die and punch to get the required shape. Hydraulic presses are most suited for this operation.

b Coining (Fig 8)**:** Coining is the operation of producing coins, medals or other ornamental work. The metal having good plasticity and correct size is places into the tool and pressure is applied on the tool form both ends. Compressive load the metal flows under severe and fills into the cavity of the punch and die. The component gets sharp impression on both sides according to the engravings on the punch and die.

Fig 8



COINING

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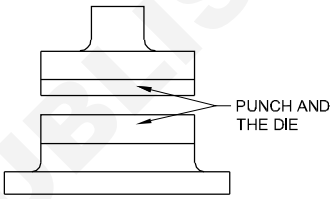
c Embossing: Embossing is the operation of forming impressions of figures, letters or designs on sheet metal. The punch or the die or both of them may have the design engraved on them which are formed on the sheet metal by squeezing and with the plastic flow of metal.

Flattening or Planishing (Fig 9)**:** Flattening or Planishing is the operatioin of straightening the curved or bent sheet metal parts, on a press using a planishing tool.

Fig 9



PLANISHING PUNCH AND DIE SET UP

ARN1228F9

Bending Sheet Metal

Objectives: At the end of this lesson you shall be able to
- **state what is a bend radius**
- **state the need for a bend radius**
- **state what is a spring back**
- **state the factors governing spring back.**

Bending sheet metal neutral line (Figs 1, 2 & 3)

When a sheet metal is bent the plane (or line) Where neither extension nor contracton occurs but only a bend takes place, is called the neutral plane (or line).

Fig 1

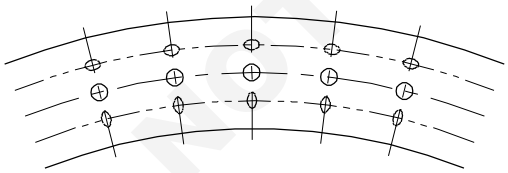


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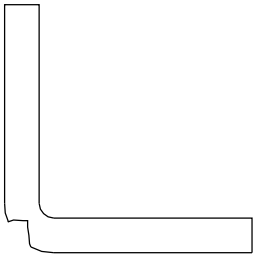
Fig 2



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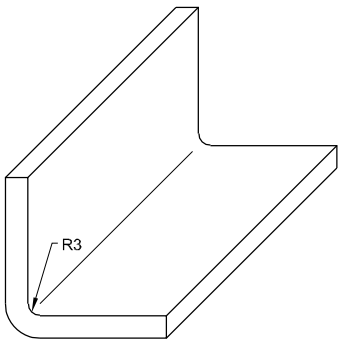
While performing a bend, if the inside of the sheet is not rounded, the outside of the sheet will be much pulled. In order to avoid it, the sheet is often bent after providing the radius as shown in the (Fig 3).

Fig 3



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The radius of the roundness is called the bend radius.

Least bend radius

The radius of the least roundness with which the sheet can be bent without occurances of a crack in the outside

of the bend is called the least bend radius.

The least bend radius varies depending on the

- material
- thickness
- direction of the plate
- working temperatures. etc.

Table 1 gives the least bend radius generally used. Where the material is soft and the bend line is at right angle to the rolling direction of the sheet, a small value is used, and where the metal is hard and the bend line is parallel with the rolling direction, a higher value is used.

Table 1

Least bend radius

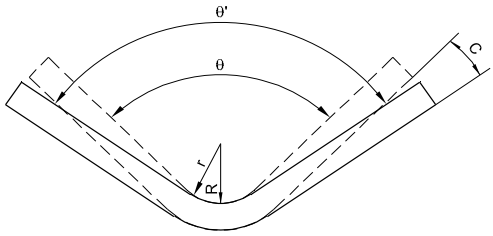
Material	Least bend radius R
Cold rolled steel plate	t x (0 - 0.5)
Semi-hard steel plate (C 0.35 - 0.40%)	t x (0.3 - 1.5)
Sheet of copper group	t x (0 - 2.0)
Brass/Aluminium sheet	t x (0 - 1.0)
Soft Aluminium	t x (1.0 - 2.5)
Duralumin	t x (2.0 - 4.0)

Plate thickness

What is spring back (Fig 4)

When a sheet of steel is bent, if the bending force is removed, a part of the elastic deformation returns to the original state of the material before deformation. This phenomenon is called spring back.

Fig 4



Factors governing spring back

The spring back varies depending on the

- material
- thikness of the sheet
- system of working
- bend radius
- bending pressure, etc.

It is difficult to calculate the accurate degree of spring back. When the job is actually performed, the sheetis experimentally bent and the pressure adjusted so that an accurate bend angle can be made after allowing for the spring back.

Soldering

Objectives: At the end of this lesson you shall be able to
• state the process of soldering
• state the method of applicatoin of soldering iron
• state the different types of solder and their application.

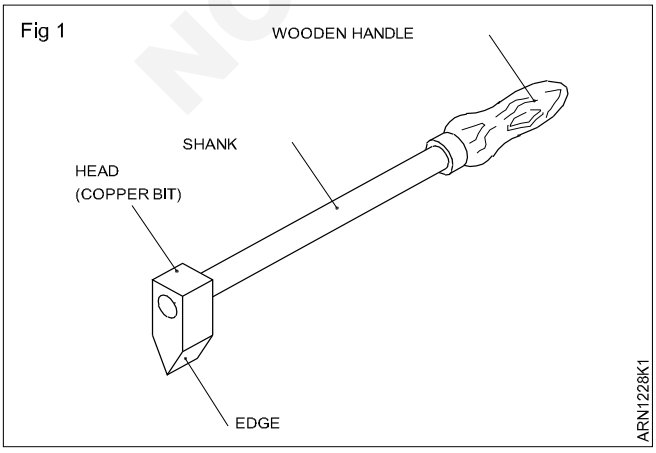
There are different methods of joining metallic sheets.

Soldering is one of them.

Soldering is the process by which metallic materials are joined with the help of another liquified metal (solder) The melting point of the solder is lower than that of the materials being joined. The solder wets the base material without melting it.

Soldering iron (Fig 1)

Fig 1



The soldering iron is used to melt the solder and heat the metal that are to be joined together.

A soldering iron has the following parts.

- Head (copper bit)
- Shank
- Wooden handle
- Edge

Shape of head (Fig 1, 2, 3 & 4)

The head of the iron is made of forged copper. This is because copper has a good heat conductivity and has a strong affinity for the solder so that the solder melts easily and sticks to the bit. The edge is 'V' shaped from two sides of a square. This is called Hatchet type soldering iron

This type is used for straight soldering joints. The other type is the square pointed soldering iron or a standard workshop pattern soldering iron. For this type the edge is shaped to an angle on four sides to form a pyramid shape.

Fig 2

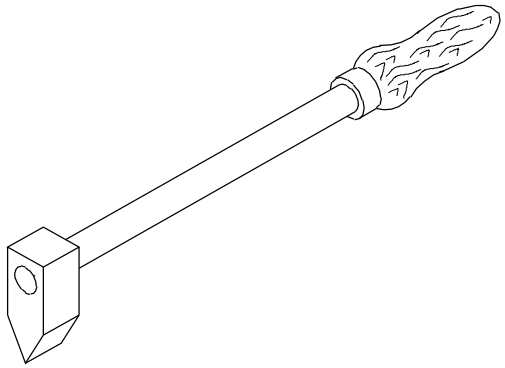


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Fig 3

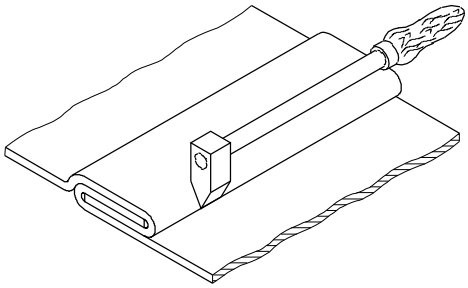

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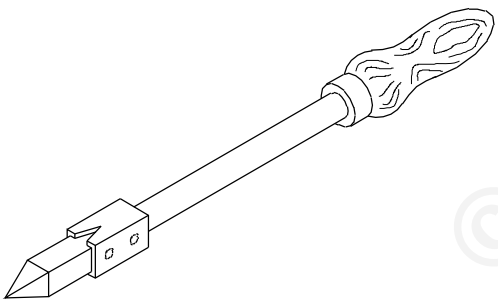
Fig 4



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Metal : The fitter metal is distributed between the closely fitted surfaces of the joint by capillary action Coalescence is a joining or uniting of materials. (Figs 5 & 6)

Brazewelding : A welding process variation in which a filler metal, having a liquidus above 840°F (450°C) and below the solidus of the base metal, is used. Unlike brazing, in braze welding the filler metal is not distributed in the joint by capillary action.

Fig 5

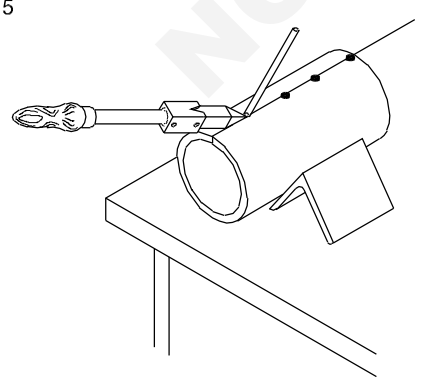

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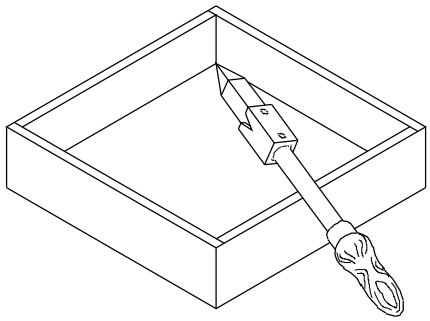
Fig 6



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Brazing has been used for centuries. Blacksmiths, jewelers, armorers and other crafters used the process on large and small articles before recorded history. This joining method has grown steadily both in volume and popularity. It is an important industrial process, as wellas jewelry making and repair process. The art of brazing has become more of a science as the knowledge of chemistry, physics and metallurgy has increased.

The usual terms Brazing and Braze welding imply the use of a nonferrous alloy. These nonferrous alloys consist of alloys of copper, tin, zinc, aluminum, beryllium, magnesium, silver, gold and others

Brass is an alloy consisting chiefly of copper and zinc. Bronze is an alloy consisting chiefly of copper and tin. Most rods used in both brazing and braze welding on ferrous metals are brass alloys rather than bronze. The brands which are called bronze usually contain a small percent (about one percent) of tin.

Brazing and braze welding principles: Brazing is an adhesion process in which the metals being joined are heated but not melted; the brazing filler metal melts and flows at temperatures above 840°F (450°C). Adhesion is the molecular attraction exerted between surfaces.

A brazed joint is stronger than a soldered joint because of the strength of the alloys used. In some instances it is as strong as a welded joint. It is used where mechanical strength and leakproof joints are desired. Brazing and braze welding are superior to welding in some applications. since they do not affect the heat treatment of the original metals as much as welding.

Brazing and braze welding wrap the original metals less and it is possible to joing dissimilar metals. For example. steel tubing may be brazed to cast iron, copper tubing brazed to steel and tool steel brazed to low carbon steel. Brazing is done on metals which fit together tightly. The metal is drawn into the joint by capillary action (A liquid will be drawn between two tightly fitted surfaces. This drawing action is known as Capillary action). Very thin layers of filler metals are used when brazing. The joints and the material being brazed must be specially designed for the purpose. When brazing, poor fit and alignment result in poor joints and in inefficient use of brazing metal.

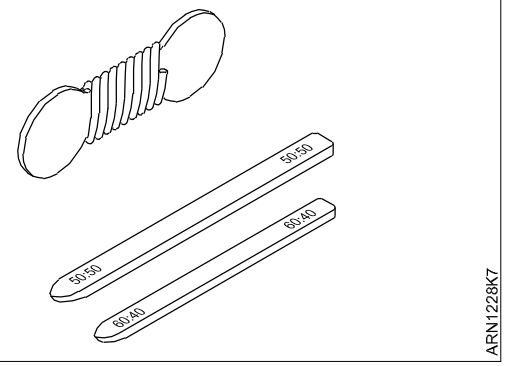
In braze welding, joint designs used for oxyfuel gas or arc welding are satisfactory. When braze welding, thick layers of the brazing filler metal is used.

Solders (Fig 7)

Pure metals or alloys are used for solders

Solders are applied in the form of wires, sticks, ingots, rods, threads, tapes, formed sections, powder and pastes

Fig 7



Types of solders

There are two types of solders

- soft solder
- hard solder

One distinguishes between soft solders whose melting points are below 450°C and hard solders whose melting points are above 450°C.

Soft solders

These are alloys of the metals-tin, lead, antinomy, copper, cadmium and zinc and are used for soldering heavy (thick) and light metals.

Hard solders

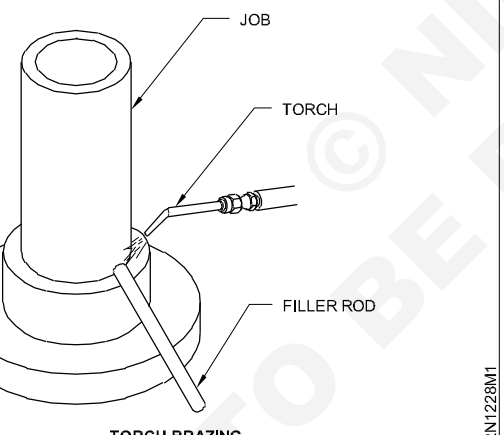
These are alloys of copper, tin, silver, zinc, cadmium and phosphorus, and are used for soldering heavy metals.

Brazing

Objectives: At the end of this lesson you shall be able to
- **describe the method of brazing**
- **state advatnages and disadvantages of brazing.**

Brazing (Fig 1): Brazing is a metal joining process which is done at temperature of above 450°C as compared to soldering which is done at below 450°C.

Fig 1



TORCH BRAZING

Process: Clean the area of the joint thoroughly by wire brushing, emerying and by chemical solutions for removing oil, grease paints etc.

Flame joints tightly using proper clamping, (Maximum gap permitted between the two joining surfaces is only 0.08mm)

Apply the flux in paste form (for brazing iron and steel a mixture of 75% borax powder with 25% boric acid (liquid form) to form a paste is used). Usually the brazing flux contains chlorides, fluorides, borax, borates, fluroborates, boric acid, wetting agents and water. So suitable flux combination is selected based on metal being used.

Brazing is employed where a ductile joint is required. Brazing filler rods/metals melt at temperature from 860°C 950°C and are used to braze iron and its alloys.

Brazing fluxes: Fused borax is the general purpose flux of post metals. It is applied on the joint in the form of a past made by mixing up with water. Brazing is to be done at a lower temperature, fluorides of alkali materials are commonly used. These fluxes will remove refractory oxides of aluminium, chromium, silicon and berrylium.

Torch brazing: The base metal is heated to the required temperature by the application of the oxy-acetylene flame.

Conditions to obtain satisfactory brazed or soldered joint

Wet the base metal

Spread the filler metal and make contact with the joint surfces. The solder will be drawn into the joint by capillary action.

Suggested joint designs for solidering and brazing.

Advantages of brazing

The completed joint requires little or no finishing

The relatively low temperature at which the joint is made minimizes distortion.

There is no flash or weld spatter.

The brazing technique does not require as much skill as the technique for fusion welding

The process can be easily mechanised

The process is economical owing to the above advantages.

Disadvantages of brazing

If the joint is exposed to corrosive media, the filler metal used may not have the required corrosive resisteance.

All the brazing alloys loose strength at an elevated temperature.

The colour of the brazing alloy which ranges from silver white to copper red may not match the base metal very closely.

Brazing and braze welding: Both brazing and braze welding are metal joining processes which are performed at temperatures above 840°F (450°C) as compared to soldering which is performed at temperatures below 840°F (450°C)

The American Welding Society defines these processes as follows:

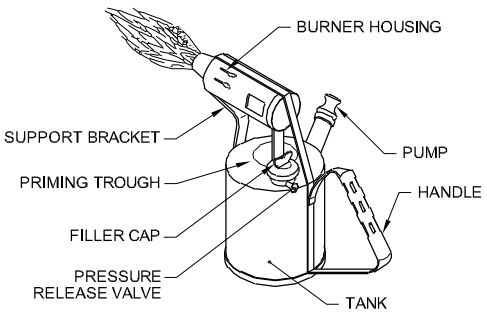
Brazing - 'A group of welding processes which produces coalscence of materials by heating them to a suitable temperature and by using a filler metal having a liquids above 840°F (450°C) and below the solidus of the base.

Blow lamp

Objectives: At the end of this lesson you shall be able to
- **state the constructional feature of blow lamp**
- **name the parts of blow lamp**
- **describe the operation of blow lamp.**

Blow lamp (Fig 1)**:** The kerosene is pressurized to pass through pre-heated tubes, thus becoming vaporised. The kerosene vapour continues through a jet to mix with a air and when ignited directed through a nozzle, producing a forceful flame.

Fig 1



BLOW LAMP

The flame within the housing provides the heat to maintain vaporisation of the kerosene. The free flame at the nozzle outlet is used to heat the soldering bit.

Blow lamp is a portable heating appliance used as a direct source of heat for soldering irons or other parts to be soldered. Fig.1 shows parts of blow lamp.

It has an tank made of brass, filler cap is fitted at its top to fill kerosene. A pressure relief valve is connected to the mouth to switch ON/OFF and control the flame.

Priming trough is provided for filling mentholated spirit for lighting the blow lamp. Set of nozzle is provided to direct the kerosene vapor to produce forceful flame. Burner housing is mounted on support brackets on which soldering iron is placed for heating as shown in figure.

Pump is provided to pressurise the kerosene in the tank.

Pipes and pipe fittings

Objectives: At the end of this lesson you shall be able to
- **state the uses of pipes**
- **name the common types of pipes**
- **list the standard pipe fittings and state their uses.**

Various types of pipes and tubes are used for the following purposes.

- Domestic hot and cold water supplies
- Waste water outlets
- High pressure steam supplies.
- Hydraulic oil supplies
- Lubricating oil supplies
- Special fluid and gases for industrial processes.
- Pneumatic systems
- Refrigeration systems
- Fuel oil supplies

The common types of pipes classified according to material are:

- galvanized iron pipes
- mild steel pipes
- C.I. soil pipes
- copper pipes
- aluminum pipes
- brass pipes
- lead pipes
- P.V.C. pipes
- rubber pipes
- plastic pipes
- stoneware pipes

Standard pipe fitting: Pipe fittings' are those fittings that may be attached to pipes in order to:

- change the direction of the pipe
- connect a branch with a main water supply pipe

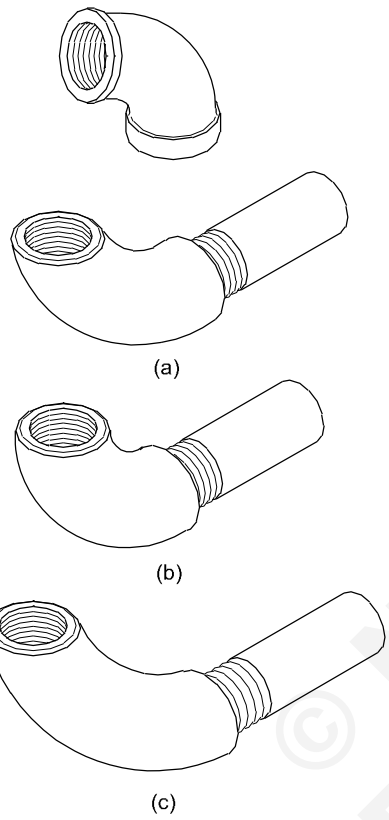
- connect two or more pipes of different sizes
- close the pipe ends

Standard Pipe Fittings

Elbows (Fig 1**):** Elbows and bends provide deviations of 90 and 45° in pipe work systems.

Long radius elbows have a radius equal to 1 1/2 times the bore of the pipe (Fig 1a)

Fig 1



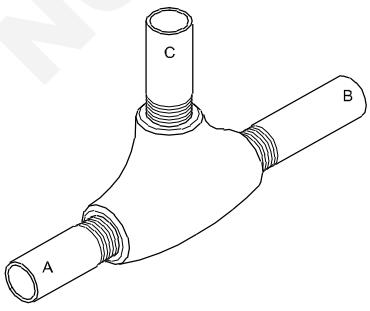
Short radius elbows have a radius equal to the bore of the pipe. (Fig 1b)

The 45° elbows allow pipe deviation of 45° (Fig 1c)

Tee branch: A tee joint helps the pipe line to branch off at 90°. The branches may be equal in diameter or there may be one reducing branch.

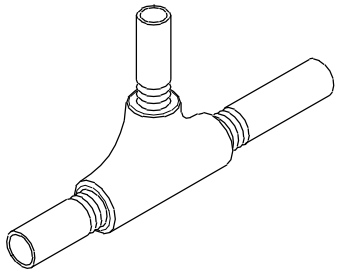
Dimensions of a branch are always quoted as A x B x (Fig 2)

Fig 2



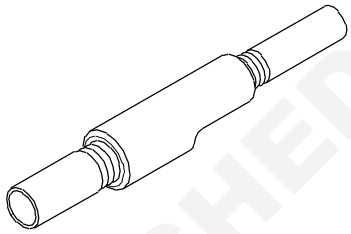
Reducing tee branch : Reducers are fitted where a change in pipe diameter is required (Fig 3)

Fig 3



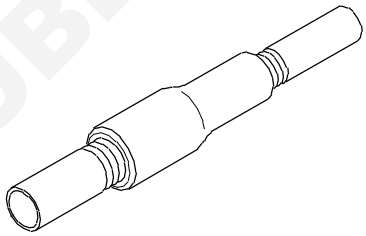
Eccentric reducer : Used mainly in horizontal position (Fig 4)

Fig 4



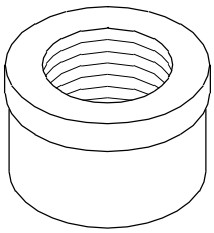
Concentric reducer : Used mainly in vertical position (Fig 5)

Fig 5



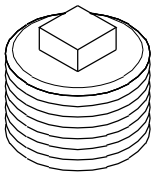
Caps: Caps are used for closing the end of a pipe or fitting which has an external thread. (Fig 6)

Fig 6



Plug: A plug is used for closing a pipeline which has an internal thread (Fig 7)

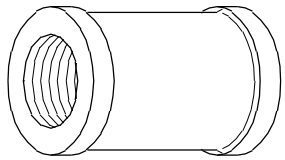
Fig 7



Coupling (Fig 8): A coupling is used to connect two pipes.

Couplings have internal threads at both ends of fit the external threads on pipes.

Fig 8



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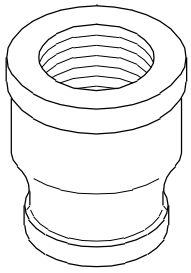
Reducer (Fig 9)**:** A reducer coupling is used to connect two pipes with different diameters.

Fig 9



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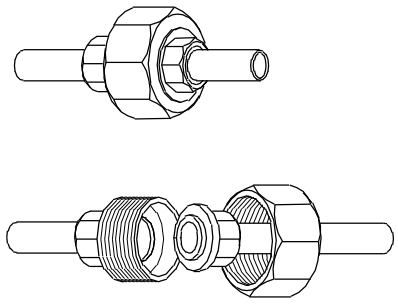
Union : A device used to connect pipes. Unions are inserted in a pipe line to permit connections with little change to the position of the pipe. (Fig10)

Fig 10



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When unions are used in pipe lines, it is easy to dis mantle and repair.

Pipe nipples (Figs 11, 12, 13 & 14)**:** Pipe nipples are tubular pipe fittings used to connect two or more pipes of different sizes

Close nipple (Fig 11)

Short nipple (Fig 12)

Long nipple (Fig 13)

The hexagonal nut (Fig 14)**:** The hexagonal nut in the centre of the nipple is for tightening with a spanner or wrench.

Fig 11

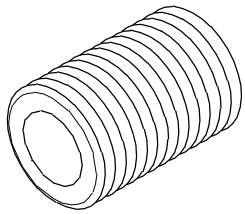

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Fig 12

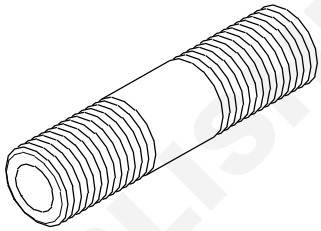

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Fig 13

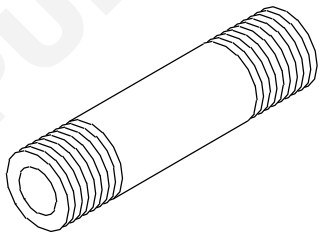

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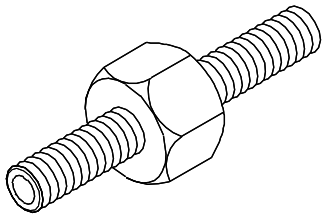
Fig 14



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Electricity principles

Objectives: At the end of this lesson you shall be able to
- **describe an atom**
- **describe electricity**
- **describe electron flow**
- **describe conductors**
- **describe insulators**
- **describe semiconductors.**

Introduction

Electricity is one of today's most useful sources of energy. Electricity is of utmost necessity in the modern world of sophisticated equipment and machinery. Electricity in motion is called electric current. Whereas the electricity that does not move is called static electricity.

Examples of Electric current

- Domestic electric supply, industrial electric supply.

Examples of static electricity

Shock received from door knobs of a carpeted room.

Attraction of paper of the comb.

Structure of matter

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

Matter is defined as anything that has mass and occupies space. A matter is made of tiny, invisible particles called molecules. A molecule is the smallest particle of a substance that has the properties of the substance. Each molecule can be divided into simpler parts by chemical means. The simplest parts of a molecule are called atoms. Basically, an atom contains three types of sub-atomic particles that are of relevance to electricity. They are the electrons, protons and neutrons. The protons and neutrons are located in the centre, or nucleus, of the atom, and the electrons travel around the nucleus in orbits.

Atomic Structure

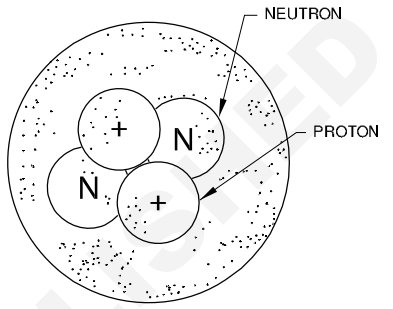
The Nucleus

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

Protons

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

Fig 1

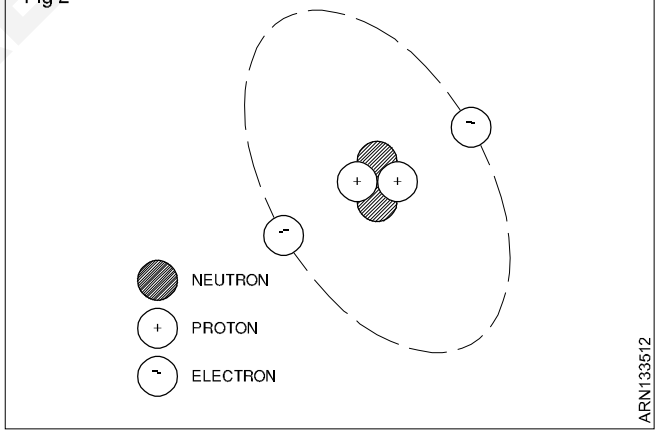


NUCLEUS OF AN ATOM

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 2



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

Neutron

A neutron is actually a particle by itself, and is electrically neutral. Since neutrons are electrically neutral, they are

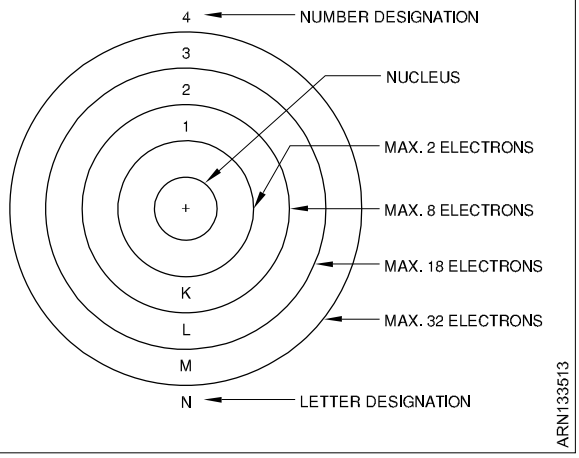
not too important to the electrical nature of atoms.

Energy Shells

In an atom, electrons are arranged in shells around the nucleus. A shell is an orbiting layer or energy level of one or more electrons. The major shell 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 sheel. (Fig 3) illustrates the relationship between the energy shell level and the maximum number of electrons it can contain.

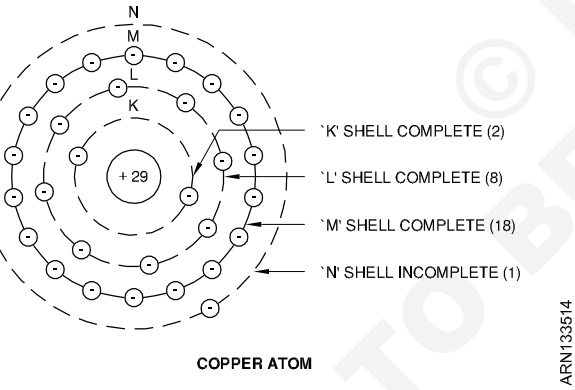
Fig 3



If the total number of electrons for a given atom is known, the placement of electrons in each shell can be easily determined. Each shell layer, beginning with the first, is filled with the maximum number of electrons in sequence.

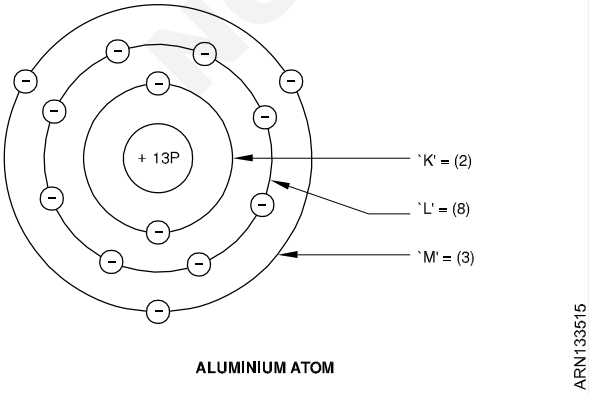
For example, a copper atom which has 29 electrons would have four shells with a number of electrons in each shell as shown in (Fig 4).

Fig 4



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

Fig 5



Electron distribution

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

Atoms that are chemically active have one electron more or one less than a completely filled shell. Atoms that have the outer shell exactly filled are chemically inactive.

They are called inert elements. All inert elements are gases and do not combine chemically with other elements.

Metals possess the following characteristics

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

The outer shell of the atom is called the valence shell and its electrons are called valence electrons. Because of their greater distance from the nucleus, and because of the partial blocking of the electric field by electrons in the inner shells, the attracting force exerted by nucleus 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 Semi condutors

Conductors

A conductor is a material that has many free electrons permitting electrons to move through it easily. Generally, conductors have incomplete valence shells of one, two or three electrons. Most metals are good conductors.

Some common good conductors are Copper, Aluminium, Zinc, Lead, Tin, Eureka, Nichrome, Silver and Gold.

Insulators

An insulator is a material that has few, if any, free electrons and resists the flow of electrons. Generally, insulators have full valence shells of five, six or seven electrons. Some common insulators are air, glass, rubber, plastic, paper, porcelain, PVC, fibre, mica etc.

Semiconductors

A semiconductor is a material that has some of the characteristics of both the conductor and insulator. Semiconductor have valence shells containing four electrons.

Common examples of pure semiconductor materials are silicon and germanium. Specially treated semiconductors are used to produce modern electronic components such as diodes, transistors and integrated circuit chips.

Ohm's Law

Objectives: At the end of the lesson you shall be able to
- **describe the current**
- **describe the resistance**
- **describe the ohm's law**
- **describe the electrical power**
- **describe the electrical energy**
- **identification of AC and DC motors.**

Electrical terms and definitions EMF and Pd

The force tending to make electrons to move along a conductor is called the potential difference (pd) in the conductor and is expressed in volts. This is also called the electric pressure or voltage.

The voltage developed by a source such as a generator is called as electromotive force. (emf)

When one ampere current flows through one ohm resistance the p.d. across the resistance is said to be one "Volt". Voltmeter is used to measure the voltage of a supply and is connected in parallel to the supply. EMF/Pd is denoted by letter "V".

Current

The flow of electrons is called current. Its unit is ampere. When one volt is applied across a resistance of one ohm the amount of current passes through the resistance is said to be one "Ampere". It is denoted by "A". Smaller units are milliampere and microampere. Ammeter should be connected in series with the load.

Resistance

It is the property of a substance which opposes the flow of electricity. Its unit is ohm. The resistance of a conductor, in which a current of one ampere flows when potential difference of one volt is applied across its terminals, is said to be one ohm.

An ohmmeter is used to measure the resistance of an electric circuit. It is denoted by "Ω" Bigger units are Kilo ohms and Mega ohms.

1 K Ω = 10^3 ohms

1 Mega Ω = 10^6 ohms

Ohmmeter should be connected in parallel with the load and should not be connected when there is a supply.

There is a definite relationship between the three electrical quantities of Voltage, Current and Resistance.

Ohm's Law states

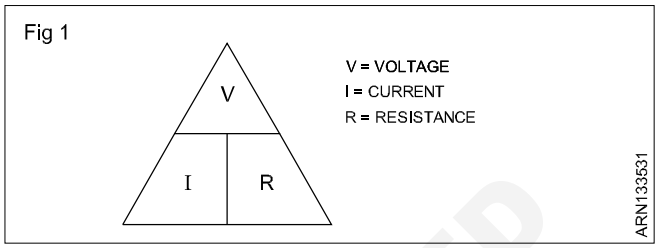
`The current is directly proportional to the voltage and inversely proportional to the resistance' when the temperature remains constant.

An aid to remember the Ohm's law relationship is shown in the divided triangle.(Fig 1)

Written as a mathematical expression, Ohm's Law is -

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

Fig 1



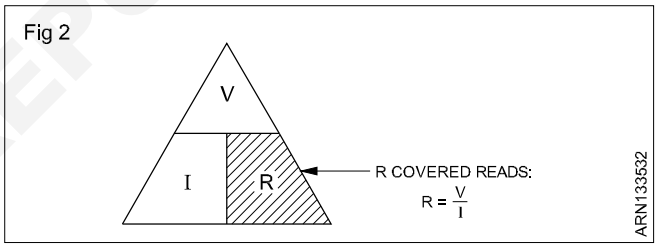
$$\text{or } I = \frac{V}{R}$$

Of course, the above equation can be rearranged as:

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

$$\text{or } R = \frac{V}{I}$$ (Refer Fig 2)

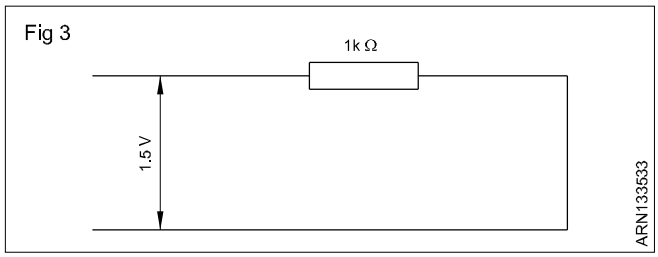
Fig 2



Example

How much current(I) flows in the circuit shown in (Fig 3)

Fig 3



Given:

Voltage(V) = 1.5 volts

Resistance(R) = 1 k ohm

= 1000 ohms.

Find:

Current(I)

Known:

$$I = \frac{V}{R}$$

Solution:

$$I = \frac{1.5\ V}{1000\ ohms} = 0.0015\ amp$$

Answer:

The current in the circuit is 0.0015 A

or

the current in the circuit is 1.5 milliampere (mA).

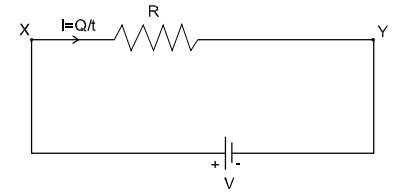
(1000 milliamps = 1 ampere)

Electrical power (Fig 4)

The rate which work is done in an electric circuit is called electrical power.

When voltage is applied to a circuit, it causes current to flow through it or in other words it causes electrons or charge through it, clearly certain amount of work is being done in moving these electrons in the circuit. This work done in moving the electrons in unit time is called as electrical power, From Fig 4.

Fig 4



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V = P.D. across xy in colts,

I = Current in amps.

R = resistance between xy in

t = time in sec for which current flows.

The total charge flows in t secs is Q = I X T coulombs

As per earlier definition the P.d, $V = \frac{work}{charge} = \frac{work}{Q}$

$\therefore$ Work = VQ.

= VIt (Q = IT).

$\therefore$ Electrical power $P = \frac{Workdone}{time} = \frac{Vit}{t}$

W = VI joules/secs. (or) watts.

Wattmeter is used to measure the electrical power.

Electrical power in watts = Voltage in volts X current in ampere

The digger units of electric power are kilowatts (KW) and Megawatts (MW).

1 KW = 1000 watts(or) 10^3 watts

1 MW = 1000000 watts (or) 10^6 watts

Electrical Energy: (E)

The total work done in an Electric circuit is called as Electrical Energy.

Electrical Energy = Electrical power X time

= VI X t = VIT

i.e Electrical power multiplied by the time for which the current flows in the circuit is known as Electrical energy. The meter used to measure electrical energy is energy meter. The symbol for electrical energy is E.

The unit of electrical energy will depend upon the units of electric power and time.

a If power is in watts and time is in seconds then the unit of Electrical energy will be watt-sec.

i.e. Electrical energy in watt - secs. = Power in watts Time In secs.

b If power is in watts and time is in hours then the unit of Electrical Energy will be watt-hours.

i.e. Electrical energy in watt - hours = power in watts time in hours

C If Power is in kilowatts (10 watts (or)1000 watts) and time is in hours then the unit of electrical energy will be kilowatt - hour (Kwh).

i.e. Electrical energy in kwh = power in kilowatt time in hours

In practice the electrical energy is measured in kilowatt-hours (KWh). The electricity bills are made on the basis of total electrical energy consumed by the consumer. 1KWh of electrical energy is called as Board of Trade (B.O.T.) Unit or simply 1 unit. i.e. 1KWh = 1Unit.

1Kwh = 1 Unit	=	power in watts time in sece
	=	Watts, secs (or) joules.
	=	1000 60 60 joules
	=	36 105 joules (or) watt-sec.
1 calorie	=	4. 186 joules (or)
1 kilo calorie	=	4186 joules.
1kwh = calories	=	860009.557
	=	860000 calories = 860 10^3 calories
	=	860 kilo calories.
$\therefore$ 1 kwh	=	860 Kcal.

Identification of AC and DC Meters

AC and DC meters can be identified as follows

1 By the symbol available on the dial / scale.

a Direct current

b Alternating current

2 By seeing the graduation on the dial / scale

a If the graduation of dial is uniform throughout, it is a D C meter.

b If the graduation of dial is cramped at the beginning and at the end, it is an A.C. meter

3 By seeing the terminals

a In the d C meter the terminals are marked with + and– The positive (+) terminal is Red in colour and the negative (–) terminal is Black in colour.

b In the A.C. meter there is no marking on the terminals and no difference in colour.

iii current :

$I = V / R$

$= P / V$

$= \sqrt{P / R}$

iv Voltage :

$V = I R$

$= P / I$

$= \sqrt{PR}$

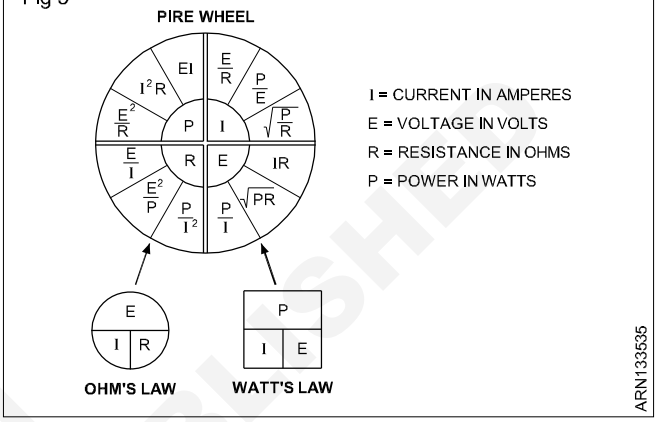
The formulae (or equations) to solve for unknown voltage, current, resistance or power can be obtained by combining Ohm's law and Power law. This is shown in (Fig 5).

Thu when we say a consumer has consumed 75 units of electricity means the electrical energy consumed by the consumer is 75 KWh.

In and Electrical circuit if 100 watts (or) 1Kw of power is supplied for 1 hour then the electrical energy expended is one kilowatt-hour (1KWH) or 1 electrical unit (Or) 1 unit.

1Kwh = 1 Unit = power in watts time in sec.

Fig 5



Law of Resistances

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

- **state the Laws of Resistance, compare resistances of different materials**
- **state the formula giving the relationship between the resistance and dimensions of a conductor**
- **state the effect of temperature on resistance and describe the temperature coefficient of resistance**
- **calculate the resistance of a conductor.**

Laws of resistance (Fig 1)**:** The resistance R offered by a conductor depends on the following factors.

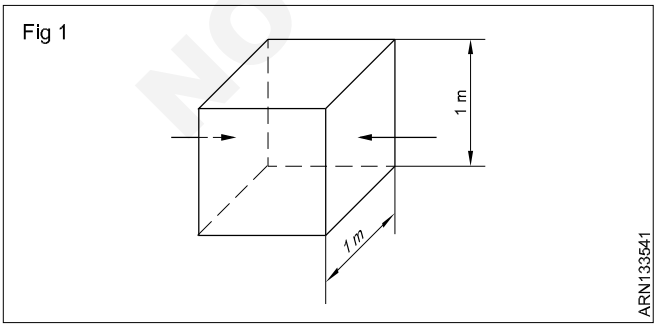
– The resistance of the conductor varies directly with its length.

– The resistance of the conductor is inversely proportional to its cross-sectional area.

– The resistance of the conductor depends on the material with which it is made of.

– It also depends on the temperature of the conductor.

Fig 1



Ignoring the last factor for the time being,we can say that

$$R = \frac{PL}{a}$$

where r is a constant depending on the nature of the material of the conductor, and is known as its specific resistance or resistivity.

If the length is one metre and the area, 'a' = 1 m^2, then R = r.

Hence, specific resistance of a material may be defined as `the resistance between the opposite faces of a metre cube of that material'. (sometimes, the unit cube is taken in centimetre cube of that material).

We have $\rho = \frac{aR}{L}$

In the SI system of units

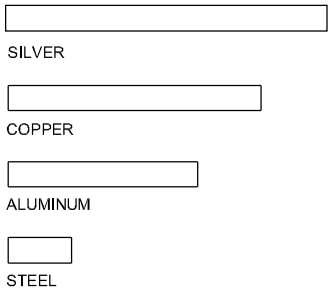
$$\rho = \frac{a \text{ metre}^2 \times R \text{ ohm}}{L \text{ metre}}$$

$$= \frac{aR}{L} \text{ ohm-metre}$$

Hence the unit of specific resistance is ohm metre (Wm).

Comparison of the resistance of different materials: (Fig 2) gives some relative idea of the more important materials as conductors of electricity. All the conductors have the same cross-sectional area and the same amount of resistance. The silver wire is the longest while that of copper is slightly short and that of aluminium is shorter still. The silver wire is more than 5 times longer than the steel wire.

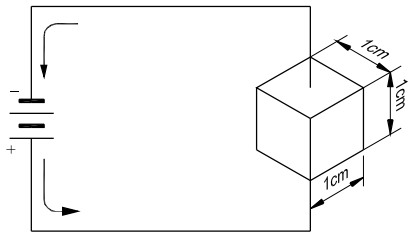
Fig 2



THE CONDUCTANCE OF DIFFERENT MATERIALS

Since different metals have different conductance ratings, they must also have different resistance ratings. The resistance ratings of the different metals can be found by experimenting with a standard piece of each metal in an electric circuit. If you cut a piece of each of the more common metals to a standard size, and then connect the pieces to a battery, one at a time, you would find that different amounts of current would flow. (Fig 3)

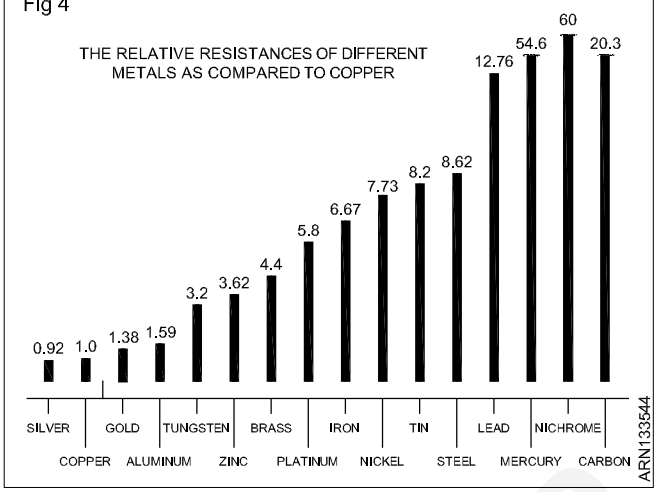
Fig 3



THE MORE RESISTANCE A MATERIAL HAS, THE LESS CURRENT THE MATERIAL WILL CONDUCT. GOOD INSULATORS, SUCH AS GLASS, RUBBER, MICA, POLYSTYRENE, ETC., HAVE CONSIDERABLY MORE THAN A MILLION TIMES THE RESISTANCE OF ANY GOOD CONDUCTOR

The bar graph (Fig 4) shows the resistance of some common metals as compared to copper. Silver is a better conductor than copper because it has less resistance. Nichrome has 60 times more resistance than copper, and copper will conduct 60 times as much current as Nichrome, if they were connected to the same battery, one at a time.

Fig 4



Resistors

These are the most common passive component used in electronic circuits. A resistor is manufacture with a specific value of ohms resistance. The purpose of using a resistor in circuit is either to limit the current to specifc value or to provide desired voltage drop (IR) The power rating of resistors may be from O.1.W. to hundred of Watts.

Wire - wound resistors

Wire-wound resistors are manufactured by using resistance wire (nickel - chrome alloy called Nichrome) wrapped around an insulating core, such as cerami porcelain bakelite pressed paper etc (Fig 4). The bare wire used in the unit is generally enclosed in insulating material. Wire wound resistors are used for high current application. They are available in wattage ratings from one watt to 100 watts or more. The resistance can be less than 1 ohm and go up to several thousand ohms. They are also used where accurate resistance values are required.

One type of Wire-wound resistor is called as fusible resistor enclosed in a porcelain case. The resistance is designed to open the circuit when the current through it exceeds certain limit.

This type of ballast resistor is used in the automobile vehicle flasher unit. Due to which the indicator lamp flash at the regulation of 70-100 times / min.

Basic types of electrical meters

Objectives: At the end of this lesson you shall be able to
- **state the use of an ammeter**
- **describe the care to be taken of an ammeter**
- **describe the use of a voltmeter**
- **describe the care to be taken of voltmeters**
- **state the use of an ohmmeter**
- **describe the care to be taken of ohmmeters**
- **state the simple electric circuit**
- **state the open electric circuit**
- **state the short electric circuit**
- **state the series circuits & parallel circuits.**

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

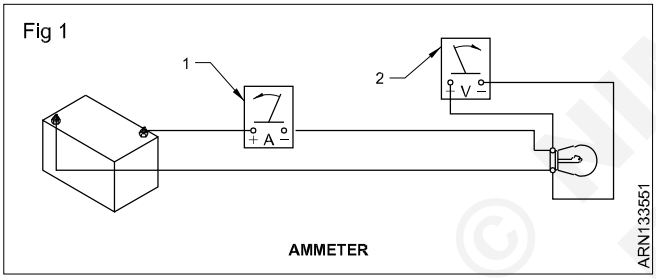
– Ammeter
– Voltmeter
– Ohmmeter

Ammeter (Fig 1)

The ammeter (1) is fitted on the vehicle panel board/ dashboard.

It is connected in series in the circuit. (Fig 1)

Fig 1



Uses of ammeter

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

This is connected in series with the load.

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

Care

Do not connect an ammeter in parallel in the circuit.

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

Use DC meter for automobile charging system.

Select and use an ammeter as per the required range.

Voltmeter

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

Uses of a voltmeter

To measure the voltage at any point of circuit.

To measure the voltage drop in the circuit.

To check the condition of the battery.

Care

Select the voltmeter as per the required range.

Do not connect the voltmeter in series in the circuit.

Ohmmeter (Fig 2)

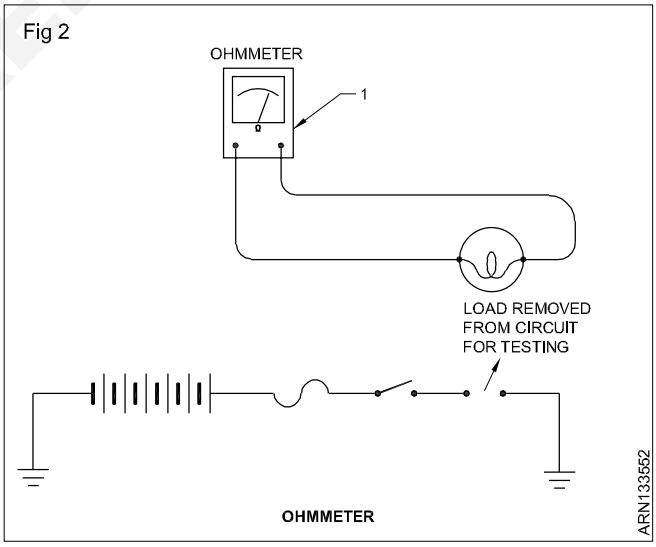
An ohmmeter (1) is also known as resistance meter.

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.

Fig 2



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 :

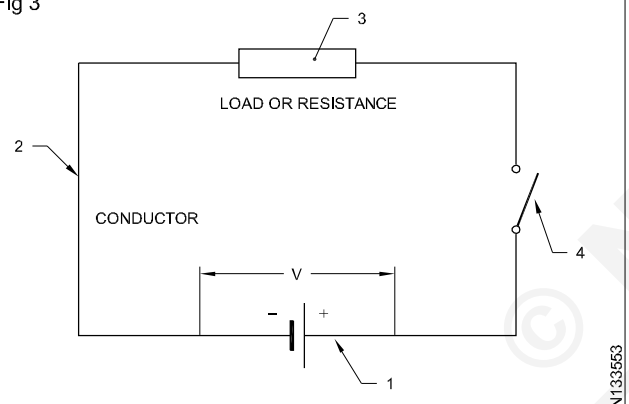
– a voltage source (1)

– connecting wires (conductors) (2)

– a load (lamp or motor) (3)

– switch (4).

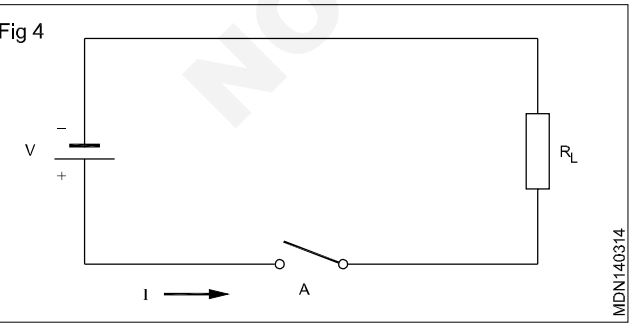
Fig 3



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.

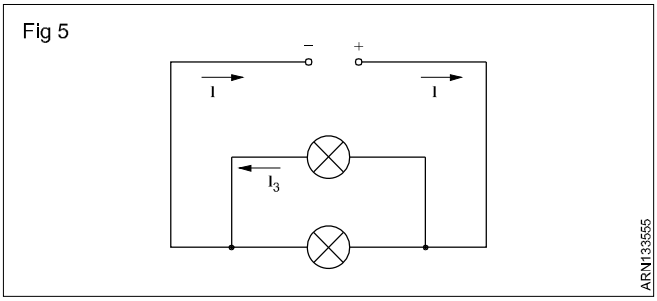
Short circuit : A short circuit will occur when two terminals of the same circuit touch each other. A short circuit may also occur if the insulation between the two cores of the cable are defective. This results in a lower resistance. This causes a large current to flow which can become a hazard.

Fig 4



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

Fig 5



Example

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

The formula to calculate resistance in a parallel circuit is:

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

where

I = current
R = resultant resistance
R_1, R_2, R_3 = resistance of each load.

Series circuit : This circuit consists of only one load and one source of supply. It has one continuous path for the flow of current. Hence the current flows through all the load in a sequence in circuit. If any of the parts fails the circuit breaks and the current stops flowing.

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

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

Voltage = Current (I) x Resistance (R)

Types of resistance

Based on the ohmic value of resistance it is grouped as low, medium and high resistance.

Low resistance

Range : 1 Ohm and below.

Uses : Armature winding, ammeter.

Medium resistance

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

Uses : Bulbs, heaters, relay starters.

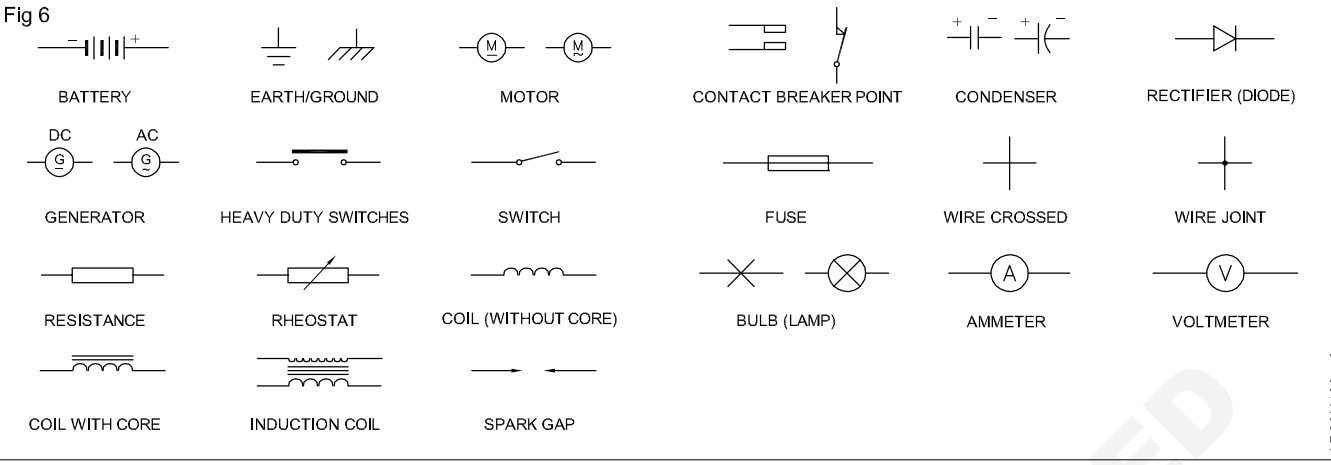
High resistance

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

Use : Lamps.

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

Fig 6



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 of making as follows.

Carbon composition resistors

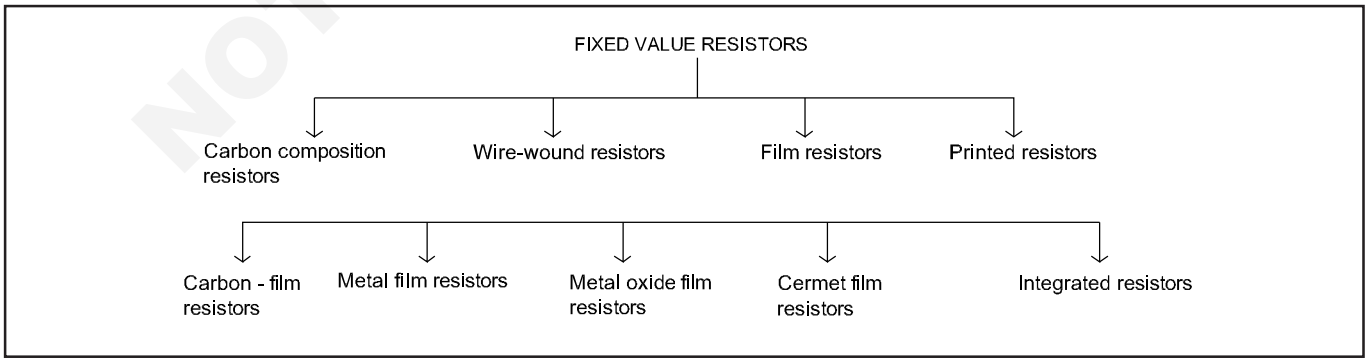
Construction (Fig 1)

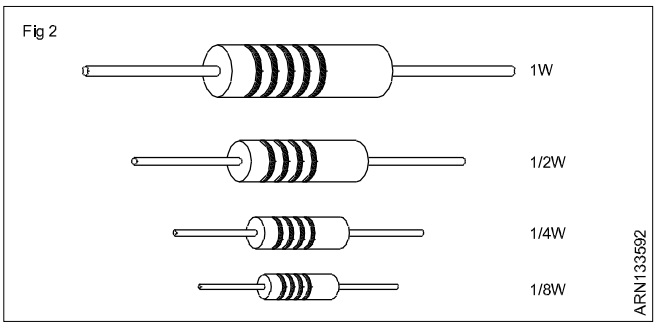
These are the simplest and most economical of all other types. Brief constructional detail of the simplest type of carbon composition resistors commonly called carbon resistor.

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

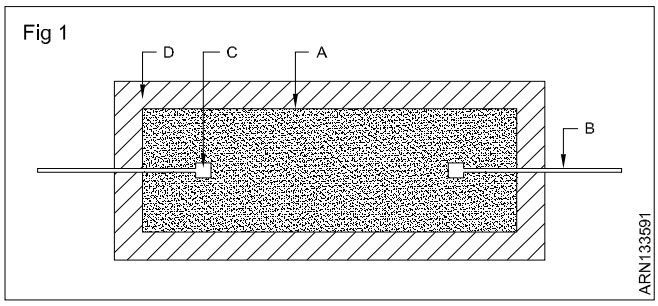
Resistor values - coding schemes (Fig 2)

For using resistors in circuits, depending upon the type of circuit in which it is to be used, a particular type, value and wattage of resistor is to be chosen. Hence before using a resistor in any circuit, it is absolutely necessary to identify the resistor's type, value and power rating.





Selection of a particular type of resistor is possible based on its physical appearance. The resistance value of a resistor will generally be printed on the body of the resistor either directly in ohms as shown in (Fig 3a) or using a typographic code as shown in (Fig 3b) or using a colour code as shown in (Fig 3c).

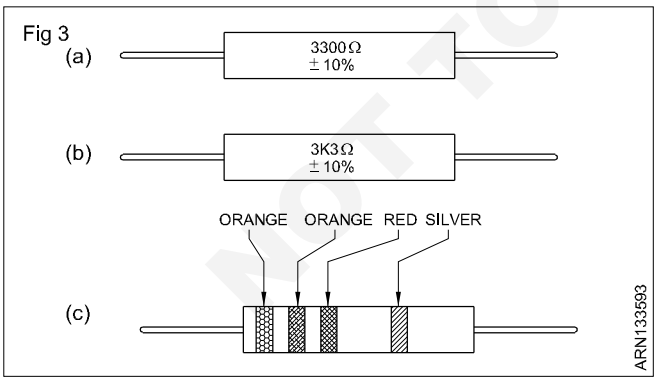


Colour band coding of resistors

Colour band coding as shown in Fig 3c is most commonly used for carbon composition resistors. This is because the physical size of carbon composition resistor is generally small, and hence, printing resistance values directly on the resistor body is difficult. Refer Table 1.

Tolerance

In bulk production/ manufacturing of resistors, it is difficult and expensive to manufacture resistors of particular exact values. Hence the manufacturer indicates a possible variation from the standard value for which it is manufactured.



This variation will be specified in percentage tolerance. Tolerance is the range(max -to- min) within which the resistance value of the resistor will exist.

Applications

Carbon composition, fixed value resistors are the most widely used resistors in general purpose electronic circuits such as radio, tape recorder, television etc. More than 50% of the resistors used in electronic industry are carbon resistors.

Types of resistor leads

Resistors are available with different types of lead attachment as shown in Fig 4. This make it easy for the user to mount the resistors in different ways on lug boards, PCBs and other types of circuit boards.

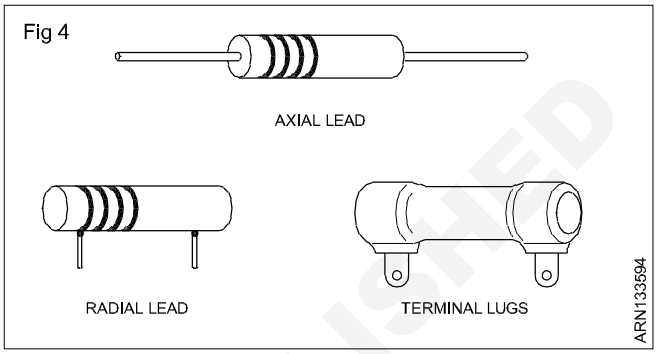


Table 1

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

Parallel Capacitors

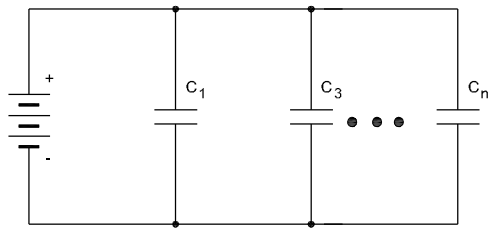
Capacitors connected in parallel will add their capacitance together.

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

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

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

Fig 5



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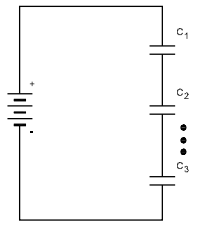
Series Capacitors

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

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

Fig 6



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Series capacitors are generally avoided in power circuits.

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.**

Multimeter

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

There are two major types of multimeters

1 Ordinary multimeters having passive components.

2 Electronic multimeters having active and passive 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.

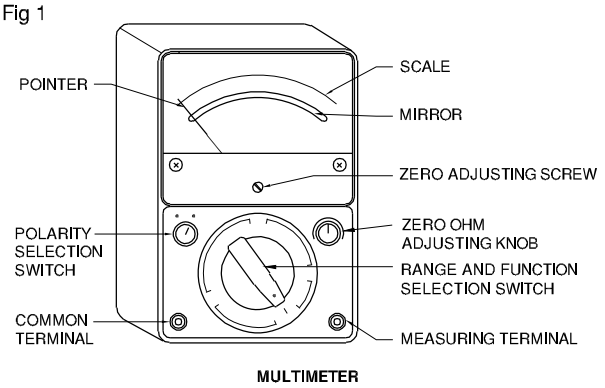
There are several types of multimeters available in the market, manufactured by various manufactures. Each model differs from the others by the extra facilities available. It is a versatile tool for all automobile. With proper usage and care, it could give service for many years.

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



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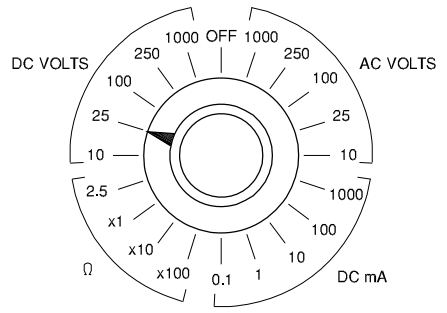
Controls

The meter is set to the required current, voltage or resistance range - by means of the range selector switch. in (Fig 2), the switch is set to DC, 25 volts.

Fig 2



FUNCTION AND RANGE SWITCH

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Scale of multimeter

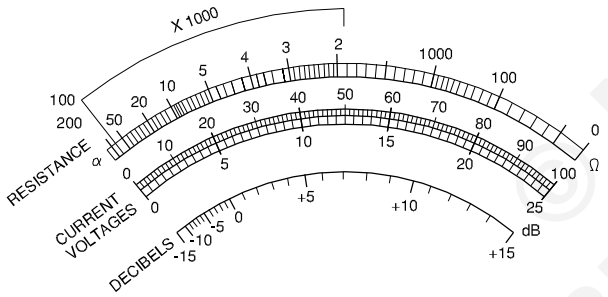
Separate scales are provided for :

- resistance
- voltage and current.

The scale of current and voltage as uniformly graduated (Fig 3)

The scale for resistance measurement is non-linear. That is, the divisions between zero and infinity (α) are not equally spaced. As you move from zero to the left across the scale, the division become closer together.

Fig 3



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The scale is usually 'backward', with zero at the right.

Zero adjustment

When the selector switch is in the resistance range and the leads are open, the pointer is at left side of scale, indicating infinite (α) resistance (open circuit). When the leads are shorted, the pointer is at right side of the scale,indicating zero resistance.

The purpose of the zero ohm adjusting knob is to vary the variable resistor and adjust the current so that the pointer is at exactly aero when the leads are shorted. It is used to compensate for changes in the internal battery voltage due to aging.

Multiple range

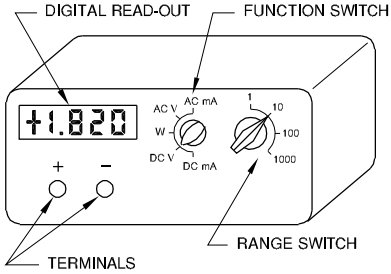
Shunt (parallel) resistors are used to provide multiple ranges so that the meter can measure resistance values from very small to very large values. For each range, a different value of shunt resistance is switched on. The shunt resistance increases for the higher ohm ranges and is always equal to the centre scale reading on any range. These range settings are interpreted differently from those of the ammeter or voltmeter. The reading on the ohmmeter scale is multiplied by the factor indicated by the range setting.

Remember, when a multimeter is set for the ohmmeter function, the multimeter must not be connected to the circuit with the circuit's power is on.

Digital multimeter (DMM)

In a digital multimeter the meter movements is replaced by a digital read - out. (Fig 4) this read-out is similar to that used in electronic calculators. The internal circuitry of the digital multimeter is made up of digital integrated circuits. Like the analog-type multimeter, the digital multimeter has also a front panel switching arrangement. The quantity measured is displayed in the form of a four digit number with a properly placed decimal point. When d quantities are measured, the polarity is identified be means of a + or - sign displayed to the left of the number.

Fig 4



DIGITAL MULTIMETER

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Introduction to the hydraulics and pneumatics

Objectives: At the end of this lesson you shall be able to
- **define the term of fluid power**
- **explain the working principle of pneumatic systems**
- **explain the working principle of hydraulic systems.**

Fluid Power Systems

Fluid power is the driving force in most industrial and mobile applications. A bulldozer or excavator used for moving soil where a new project is being built, and a brake used in a car or truck are some examples of where fluid power is used. Fluid power involves the use of a fluid medium, such as air or oil, in a controlled manner, to get some useful work. Two specialized areas cover the scope of the definition of the term 'fluid power'. They are: (1) Pneumatics and (2) Hydraulics. Transmission and control of power by means of air is called pneumatics and transmission and control of power by means of liquid is called hydraulics.

Pneumatic Systems

In a pneumatic system, energy in the form of compressed air is transmitted to an actuator, where work is to be done. The basic elements of the system are power source, control valves and actuators, as shown in Figure, Air compressor is used as the power source to increase the pressure of the related air medium to the required level. However, the process of pressure development in the system is quite slow. The slow response of the air compressor in developing sufficient pressure necessitates storage of compressed air in a receiver tank. The energy that is stored in the receiver tank can be transmitted, in a controlled manner, to an actuator to perform some useful work.

Pneumatic Systems

An important advantage of pneumatic systems is that they can produce linear motion quite easily. They can also produce high-speed operation. Speed control can also be achieved easily by using simple flow control valves. However, pneumatic systems are not suitable for providing uniform motion. Operating pressures in pneumatics are generally much lower than that used in hydraulics. Therefore, pneumatic systems are ideal for applications that involve small magnitude of linear forces.

Hydraulic Systems

In a hydraulic system, energy in the form of pressurized liquid (oil) is transmitted to an actuator, where work is to be done. The basic elements of the system are power source, control valves and actuators, as shown in Figure. In the hydraulic power transmission, a pump is used as the power source to create flow and subsequently raise the pressure of an enclosed incompressible oil medium to the required level almost instantaneously. The hydraulic energy can, then, be transmitted through the pressurised oil medium, in a controlled manner, to an actuator to perform some useful work.

Hydraulic Systems

A major advantage of hydraulic systems is that they can easily generate linear motion through the basic actuator, cylinder. Operating pressures in hydraulics are generally much higher than that used in pneumatics. Therefore, high-pressure hydraulic systems are capable of generating large magnitude of forces economically to drive heavy loads. Speed control of an actuator can also be achieved easily by regulating the flow rate of oil to the actuator. Precise control of speed even at low values is another advantage of hydraulic systems.

Extensive use of hydraulics is due to the following facts

- Oil is practically incompressible
- Oil can transmit high forces rapidly and accurately
- Simple step-less control of speed, force or torque
- Have simple over load protection
- Simple, compact and highly reliable

Hydraulic systems are used in the following subsystems in modern Automobiles and related maintenance equipment

- Fuel injection system
- Lubrication system
- Brake system
- Steering system
- Shock absorbers
- Adoptive suspension system
- Automatic transmission system
- Clutch actuating mechanism
- Jack
- Hoist
- Bearing puller etc.

Pascal's law - pressure viscosity

Objectives: At the end of this lesson you shall be able to
- **state the Pascal's Law**
- **understand the concept of force multiplication**
- **state many functions of hydraulic fluids**
- **define the term viscosity.**

Pascal's law (Blaisé Pascal, 1623-1662)

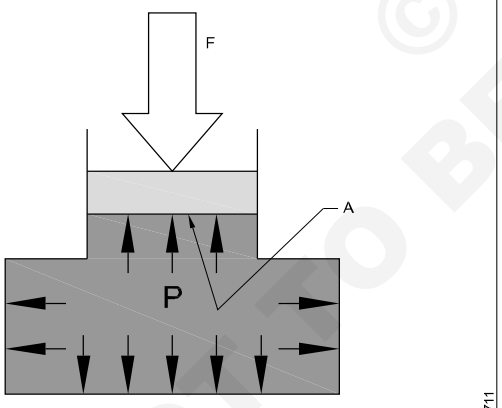
Pascal's law is the central law for the development of a number of machines, such as hydraulic brakes, hydraulic jacks, etc. The law states that 'pressure exerted on a fluid is transmitted equally in all directions, acting with equal force on equal areas'. The following sections explain how a pressure is developed in a hydraulic system with the application of a force through a pump mechanism and how a force is developed with the application of the pressure through an actuator mechanism.

Hydraulic Pressure

Pressure is the result of the resistance offered to compression when an incompressible oil medium is squeezed by the application of a force. This pressure is transmitted equally throughout the medium in all directions, according to the Pascal's law.

Fig 1 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,

Fig 1



DEVELOPMENT OF PRESSURE

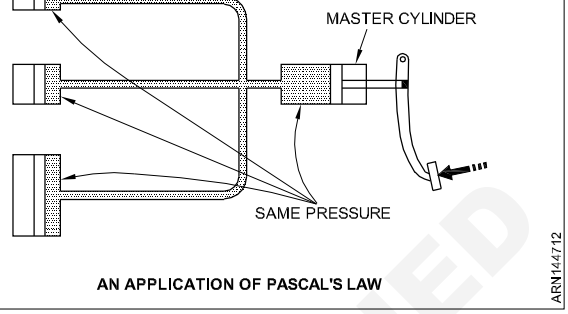
$$P = \frac{F}{A}$$

A typical Application of Pascal's Law

A feature of hydraulic theory can be seen in the illustration in Fig 2. which demonstrates the pressure in the master cylinder 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:

Fig 2



AN APPLICATION OF PASCAL'S LAW

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

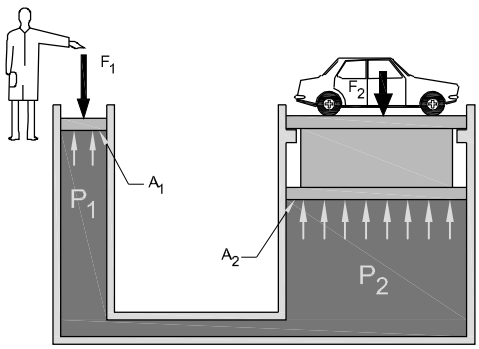
= 7281553 Pa = 72.8 bar

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

Fig 3 shows an arrangement of two cylinders with piston areas A_1 and A_2 ($A_2 > A_1$) respectively. These two cylinders are interconnected by a pipeline. Oil is enclosed in the cylinder chambers and in the pipeline. When the plunger piston A_1 is applied with a force F_1, a pressure (say P1) is developed in the oil, which acts equally in all directions through the oil. It means that the same pressure (P1) acts on the ram piston A_2. This causes the development of a force (say F_2). The governing equations for the forces developed in the cylinders are as follows:

Fig 3



ILLUSTRATING THE CONCEPT OF FORCE MULTIPLICATION

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$F_1 = P \times A_1$

$F_2 = P \times A_2$

Therefore,

$F_2 = F_1 \times (A_2 / A_1)$

We can see that by controlling the area ratio (A2/ A1) a larger output force can be obtained from a smaller input force. This principle is also used in many hydraulic machines. For example, a hydraulic jack used to lift cars at service stations, brakes in vehicles, etc., use the force multiplier principle for power amplification.

Example 2

To understand the idea of force multiplication, consider Fig 3 where applied force, F1= 25 N, cross sectional area of plunger, A1 = 10 cm2, ram piston area A2 = 100 cm2. What will be the force F2 required to lift the car placed on the ram platform?

Solution:

Pressure P_1 $= F_1 / A_1 = 25/10 = 2.5$ n.cm^2

P_1 $= P_2 = 2.5$ n.cm^2

Therefore, F_2 $= A_2 P_2$

$= 100 \times 2.5$ N

$= 250$ N

Exercises 2: A hydraulic car lift used in a service station has an input pump piston and an output plunger to support a loading platform. The pump piston has a radius of 0.012 m and the loading piston has a radius of 0.15 m. The total weight of the car and the plunger is 25000 N. If the bottom surfaces of the piston and plunger are at the same level, what input force is required to lift the car and output plunger? What pressure produces this force? [Ans: 160 N, 3.536 bar]

Oil Flow

A hydraulic system, with a pump pushing oil continuously through a pipeline, produces a oil flow between any two points in the pipeline as long as there is a pressure differential between these two points.

Flow Rate

Flow rate of oil is a measure of the volume of the oil passing a point per unit of time. It is usually measured in m^3/ s or litre per minute (lpm) or in other units.

Hydraulic Oil

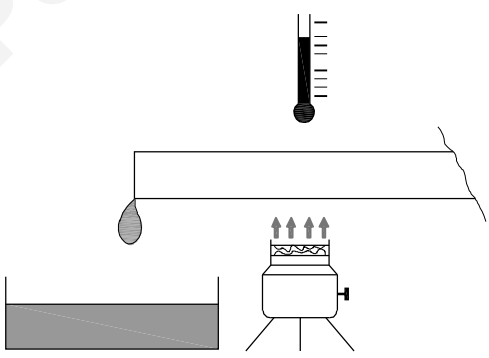
Hydraulic oil is the lifeblood of any hydraulic system. Its primary function is to transmit power from one part of the system to the other part. Apart from this function, it has to lubricate the internal moving parts of system components, seal clearance between the moving parts, and act as a heat transfer medium, as it flows through the system. Oil is usually composed of base stock ad many additives. Mineral-based oils (i.e., petroleum-based oils) are used in a majority of applications. The purpose of using additives in oil is to improve the performance of the oil for a give application. Oil's resistance to flow, expressed in terms of its viscosity, is an important parameter that must be considered.

Hydraulic oils are susceptible to the problem of contamination as they are generally used in harsh environments. Presence of particulates, water, air, and their reaction products in hydraulic oils can adversely affect the performance of these systems. Therefore, the most important requirement of any hydraulic system is to maintain its oil medium in a clean state. Hydraulic filters are used to remove solid contaminants in hydraulic oil.

Viscosity (Fig 4)

Viscosity is a measure of a liquid's resistance to flow. Thicker oil has more resistance to flow and possesses a higher viscosity. Viscosity is affected by temperature. Oil viscosity decreases as the temperature of oil increases.

Fig 4



ILLUSTRATING THE EFFECT OF TEMPERATURE ON VISCOSITY

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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

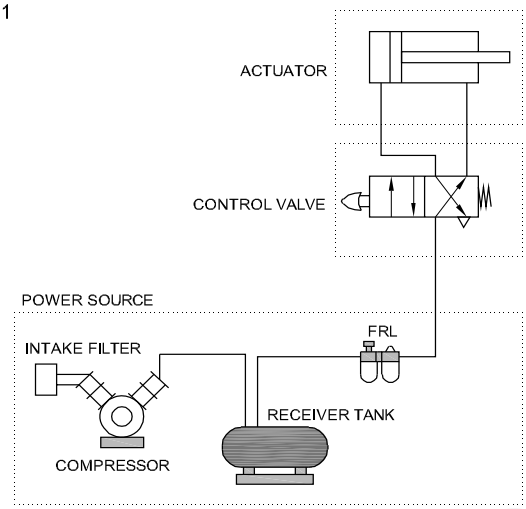
Pneumatic System

Objectives: At the end of this lesson you shall be able to
- **state the typical pneumatic system**
- **understand the working of a reciprocating compressor**
- **explain the functions FRL**
- **explain the working of pneumatic cylinders.**

A Typical Pneumatic System

A basic pneumatic system can be thought of consisting of the following three main blocks: (1) Power source, (2) Control valves and (3) Actuators. A typical pneumatic system with a number of components is depicted in fig 1. The power source includes compressor, receiver tank, FRL etc.

Fig 1



A SIMPLIFIED REPRESENTATION OF A PNEUMATIC SYSTEM

Air compressor

The compressor is the most common industrial energy supply unit that converts mechanical energy into pneumatic energy. The vast of pneumatic systems use air as the operating medium. It is designed to take in air at atmospheric pressure and deliver it into a closed system at a higher pressure, as per Boyle's Law.

Boyle's law

The relation between pressure and volume of a gas is given by Boyle's law. It states that: "At constant temperature, the volume of a given mass of gas is inversely proportional to the absolute pressure." Let V_1 is the volume of a gas at pressure p1. When this gas is compressed to a volume V_2 then the pressure will rise to a value of P_2. Mathematically,

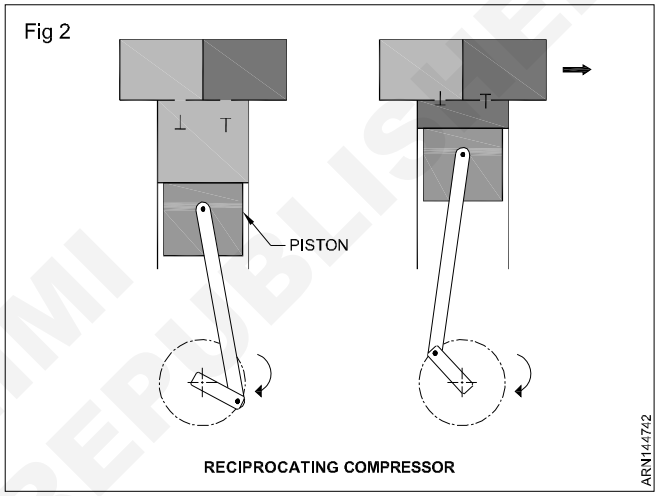
$$P_1V_1 = P_2V_2 \, T, \text{ Constant}$$

As air is compressed, energy used in this work is dissipated as heat, i.e., the temperature will rise as the air is reduced in volume. This is known as adiabatic compression.

Reciprocating piston compressor

Reciprocating piston compressors are very common and provide a wide range of pressures. Piston compressors are employed where high pressures (4-30 bar) are needed. Fig 2 shows the basic single-cylinder reciprocating compressor. As the piston moves down during the inlet stroke, the inlet valve opens and draws air into the cylinder. During the upward motion of the piston air is compressed and discharged through the opened outlet valve.

Fig 2

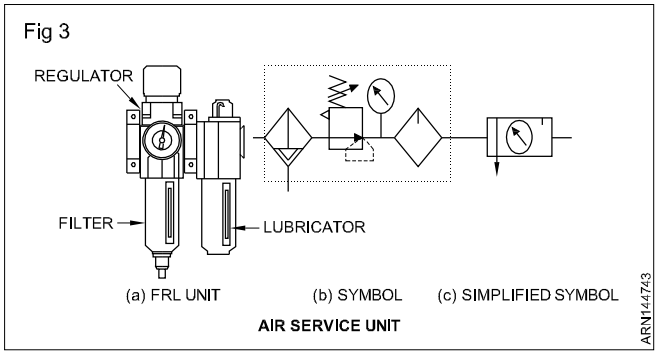


RECIPROCATING COMPRESSOR

FRL or air service unit

Compressed air, which is dry and clean, is the most important requirement for the satisfactory operation of any pneumatic system. As we are aware, compressed air in a pneumatic system is liable to be contaminated to a high degree. It is essential to remove fine dirt particles, to regulate the pressure, and perhaps to introduce a fine mist of oil in the compressed air to aid lubrication. These important functions can be accomplished through auxiliary airline equipment, namely, filter, regulator and lubricator (FRL). A combined FRL unit and detailed and simplified symbols are shown in (Fig 3).

Fig 3



AIR SERVICE UNIT

Pneumatic actuators

Pneumatic actuators are output devices for conversion of energy contained in compressed air to produce linear or rotary motion or apply a force. Linear actuators convert energy of compressed air into straight-line mechanical energy. Single-acting and double-acting cylinders are the two basic types of pneumatic linear actuators.

Valves in fluid power systems

In fluid power systems, power is conveyed and controlled through a fluid under pressure within a circuit. Therefore, pneumatic and hydraulic systems require valves to control or regulate the flow of pressurised fluid from power source to various actuators. According to their function, valves in fluid power systems can be divided into the following groups.

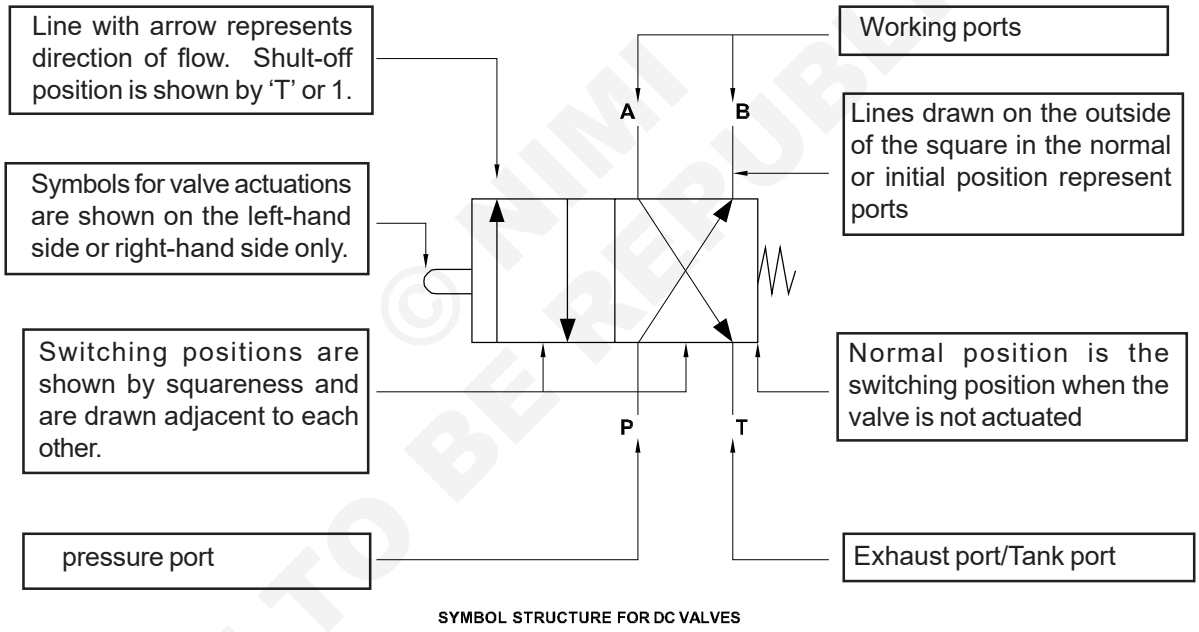
- Directional control valves (way-valves) control the direction of fluid flow.
- Non-return valves allow the fluid flow in only one direction and block the flow in the other direction.
- Pressure control valves regulate or limit the fluid pressure or generate a control signal when a set pressure is reached.
- Flow control valves restrict the fluid flow in order to reduce its flow rate.

Graphic representation

A symbol specifies only the function of the valve without indicating the design principle. Apart from that, a symbol also indicates the method of actuation and designations of ports of the concerned valve. Fluid power symbols are standardized and described in ISO 1219. This is a set of basic shapes and rules for the construction of fluid power symbols.

Port markings

Ports of pneumatic valves are designated using a number system in accordance with ISO 5599. Letter system for pneumatic valves is no longer used. Port markings of hydraulic valves are, however, designated using a letter system. Both systems of port marking are presented in table below.



SYMBOL STRUCTURE FOR DC VALVES

Table: Port markings of directional control valves

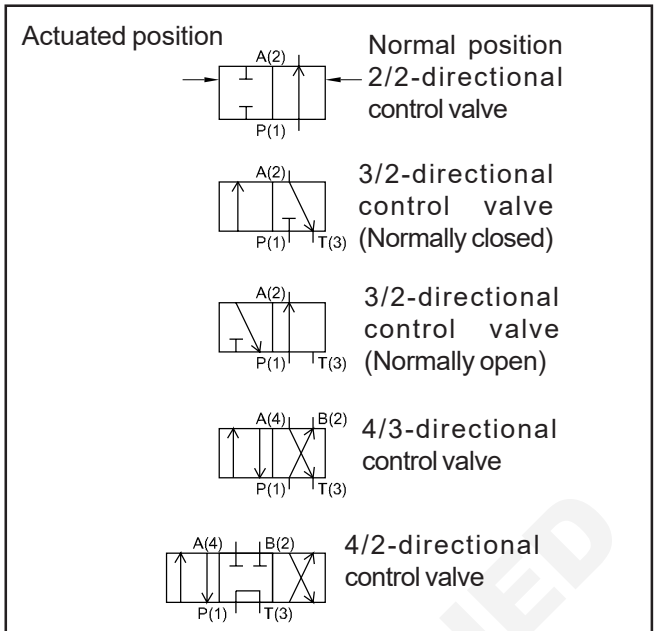
Port	Letter system	Number system	Comment
Pressure port	P	1	Supply port
Working ports	A,B	2,4	4/2 or 5/2 dc valve
Exhaust (tank) ports	R,S(T)	3,5	5/2 dc valve, T for tank
Pilot port	Z,Y	10,12,14	Pilot line

Ports and positions: Directional control valves are described by the number of port opening or "ways" which are to be controlled. For example: a 2-way or 3way. Or 4-way valve. A 2-2ay valve is a simple on-off valve used to control power supply through the pressure port and the working port of the valve. A 3-way valve controls air supply through the pressure port, the working port and the exhaust port of the valve. Directional control valves are further described by the number of switching positions available in the valve.

Directional control valves are specified according to the number of controlled connections and number of switching positions. For example, in a 3/2-way valve, there are 3 ports and 2 switching positions. In the case of valves with two switching positions, right-hand square usually represents the normal position and left-hand square represents the actuated position. The lines for pressure, working and exhaust ports are drawn attached to the square that represents the normal (initial) position.

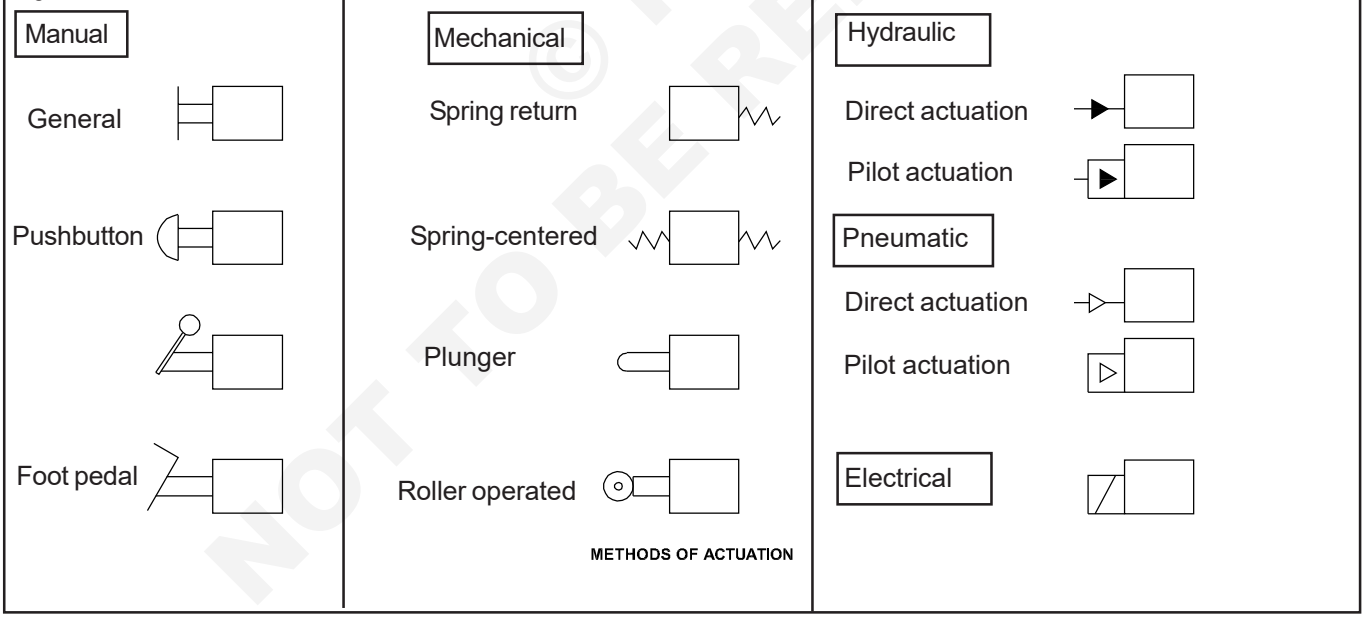
Graphic symbols for dc valves: Graphic symbols serve as an aid to functional identification of components in circuit diagrams of fluid power systems. A few more examples of valve representation are given in (Fig 4) to make the idea more clear.

Method of valve actuation: Another important feature of directional control valves is their methods of actuation. These valves can be actuated manually or mechanically or hydraulically or pneumatically or electrically or by an appropriate combination of the above four basic methods. When the controlling spool of a valve is held in one extreme position by the force of its resetting spring, the spool is said to be "spring offset" and when the spool is held in the centre position by the spring, it is said to be "spring-centred". Symbols for methods of valve actuation are presented in (Fig 5)



GRAPHIC SYMBOLS FOR DIRECTIONAL CONTROL VALVE

Fig 5



METHODS OF ACTUATION

History and developments of 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 automobile industry, new product.**

Auto industry - History, leading manufacturing: In 1887 first car rolled out in the streets of Calcutta the next year there were four cars in the street of Bombay.

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

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

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

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

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

Top and major manufactures in Automobile industry

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

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

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

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

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

Example: TATA, Hindustan Motor and ashok leyland etc.

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

Example: Ford, Hyundai, Audi etc.

Development in automobile industry

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

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

Due to this precise controls we could achieve,

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

Gasoline Direct Injection (GDI)

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

Hybrid vehicles

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

Electric vehicle (EV)

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

The electric cars available in India are:

Mahindra e2oplus

Mahindra e-Verito.

Tata Tigor Electric

Mahindra e-KUV 100

Tata Tiago Electric.

Fuel cells

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

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

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

Lean burn engines

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

Driverless Cars

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

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

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

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

Alternate fuel

Bio fuels are also considered a renewable source. Although renewable energy is used mostly to generate electricity, it is often assumed that some form of renewable energy of a percentage is used to create alternative fuels. Research is going on the search of more suitable bio fuel crops and improving the oil yields of these crops, Using the current yields, Vast amount of land and fresh water in needed to produce enough oil to completely replace fossil fuel usage. Alternative fuels, known as non-conventional and advanced fuels, any materials or substances that can be used as fuels, other than conventional feels like; fossil fuels (Petroleum (oil), coal, and natural gas.

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

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

It deals with road transport relating matters

Main Responsibilities of transport wing:

- Motor vehicle legislation
- Administration of the Motor Vehicles Act, 1988
- Taxation of motor vehicles.
- Compulsory insurance of motor vehicles.
- Administration of the Road transport corporations Act, 1950.
- And promotion of transport co-operatives in the field of motor transport
- Evolves road safety standards in the form of a national policy on road safety and by preparing and implementing the Annual road safety plan.
- Collects, compiles and analyses road accident statistics and takes steps for developing a road safety culture in the country by involving the members of public and organizing various awareness campaigns.
- Provides grants-in-aid to non-governmental Organisations in accordance with the laid down guidelines.

National automotive testing and R&D infrastructure project (NATRIP)

The largest and one of the most significant initiatives in Automotive sector so far, represents a unique joining of hands between the Government of India, a number of state Governments and Indian Automotive industry to create a state of the art testing, Validation and R&D infrastructure in the country.

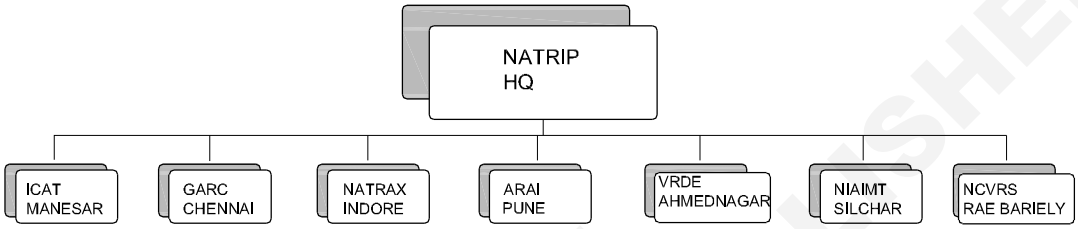
The project aims at creating core global competencies in Automotive sector in India and facilitate seamless integration of Indian Automotive industry with the world as also to position the country prominently on the global automotive map.

Create state- of - art research and testing infrastructure to drive India into the future of global automotive excellence.

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

- Creating core global competencies.
- Enhancing competitive skills for product development leading to deepening of manufacturing.
- Synergizing India's unique capabilities in information technology with the automotive sector.
- Facilitating seamless integration of Indian automotive industry with the world to put India strongly on the global automotive map.

Fig 1



Automotive Research Association of India (ARAI)

The Automotive Research Association of India (ARAI) has been Playing a crucial role in assuring safe, less polluting and more efficient Vehicles. ARAI provides technical Expertise in R & D, testing, certification, homologation and framing of vehicle regulations.

ARAI is research association of the Automotive Industry with Ministry of Heavy Industries and Public Enterprises, Government of India, It works in harmony and complete confidence with it members, customers and the Government of India to offer the finest services, which earned for itself ISO 9001,ISO 14001, OHSAS 18001 and NABL accreditations.

ARAI has a strong base of state-of-the-art technology equipments, laboratory facilities and highly qualified and experienced personnel. With these assets, ARAI has goals, strategies and action plans to achieve customer satisfaction. These are as follows.

to compete in service with excellence

to cover global market

to obtain recognition and accreditation

to build commitment of all personnel

to develop team sprit and sense of belonging amongst all.

Automotive research association of India

ARAI has been providing various services to the Indian Automotive Industry in the areas of design & development and know-how for manufacture & testing of components/ system to national /international standards. ARAI shall strive to achieve international recognition in these areas.

ARAI shall seek the valuable guidance and support from association members, from time to time to achieve growth and stability.

With the globalization of economy and business, ARAI shall enlarge its scope of services to meet the requirements of automotive industries anywhere in the world.

ARAI strongly believes that satisfaction of the customer needs on continuing basis is of prime importance to earn the loyalty of the customers. Therefore, emphasis shall be on meeting and exceeding the customer needs through continuing quality improvement with active participation of employees and also the customer.

Classification of vehicles

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

Classification of vehicles

Based on central motor vehicle act

- Motor cycle
- Invalid carriage
- Three wheelers
- Light motor vehicle

- Medium passenger motor vehicle
- Medium goods vehicle
- Heavy passenger motor vehicle
- Heavy goods vehicle
- Any other motor vehicle of a specified description

Based on wheel

Two wheeler

Three wheelers

Four wheelers

Six wheelers

Multi axles

Based on fuel used

Petrol vehicle

Diesel vehicle

Gas vehicle (CNG & LPG)

Electric vehicle

Based on body

Saloon (BMW,AUDI)

Sedan (Maruti ciaz, ambassador etc)

Hatch back (Alto, i10, santro, Tata Tiago)

Convertible (Jeep, maruti gypsy)

Station wagon (Innova, Ertiga, etc)

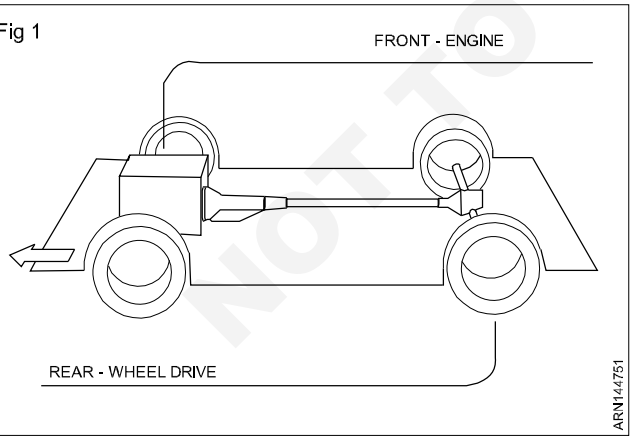
Van (Omni, Touristor)

Special purpose (Ambulance, Milk van, etc)

Based on drive

Front engine rear wheel drive (Sumo, Omni, Ambassador, etc) (Fig 1)

Fig 1



Rear engine rear wheel drive (Tata Nano, Bajaj auto, Valvo bus etc) (Fig 2)

Four wheel/ All wheel drive (jeep, Scorpio, Gypsy etc) (Fig 3)

Fig 2

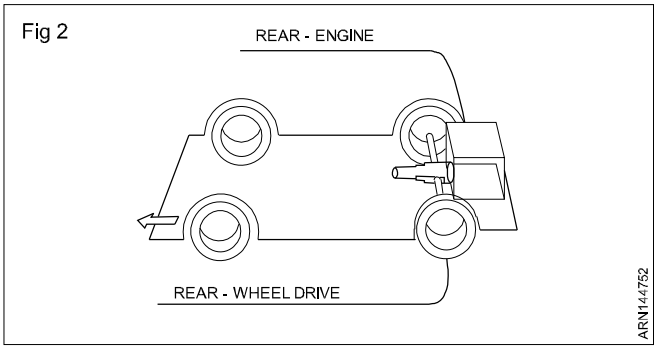
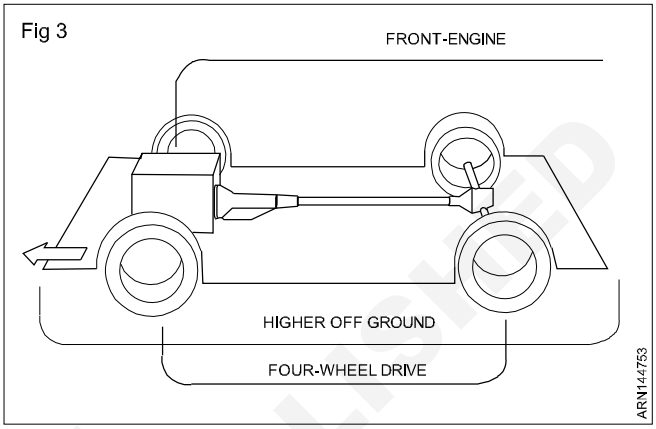
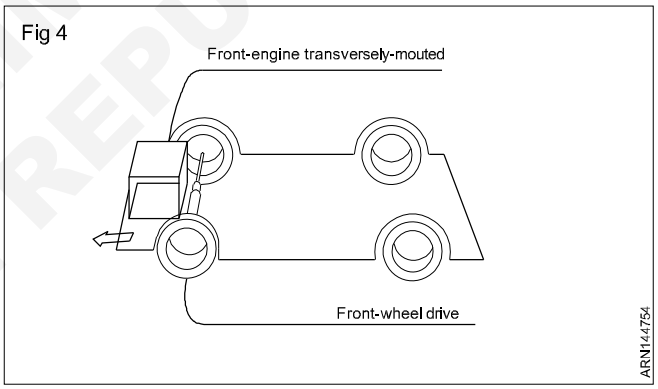


Fig 3



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 axle stand .**

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

Single post hydraulic car hoist

Two post car hoist

Four post car hoist

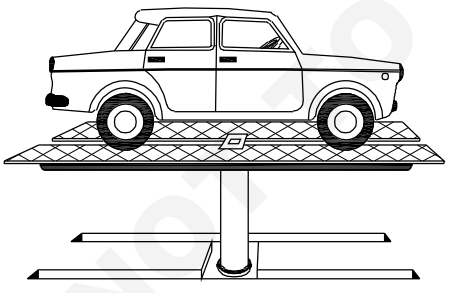
Engine hoist

Jacks

Stands

Single post hydraulic car hoist (Fig 1) : It is facilitate the servicing and reaper works conveniently. It is constructed for dependable, trouble free performance and ensuring smooth and safe operation. The post is made of high grade steel. The car hoists are specially designed for resistant to wear and damage during water wash. Single post type is suitable for vehicle up to 6 tones.

Fig 1



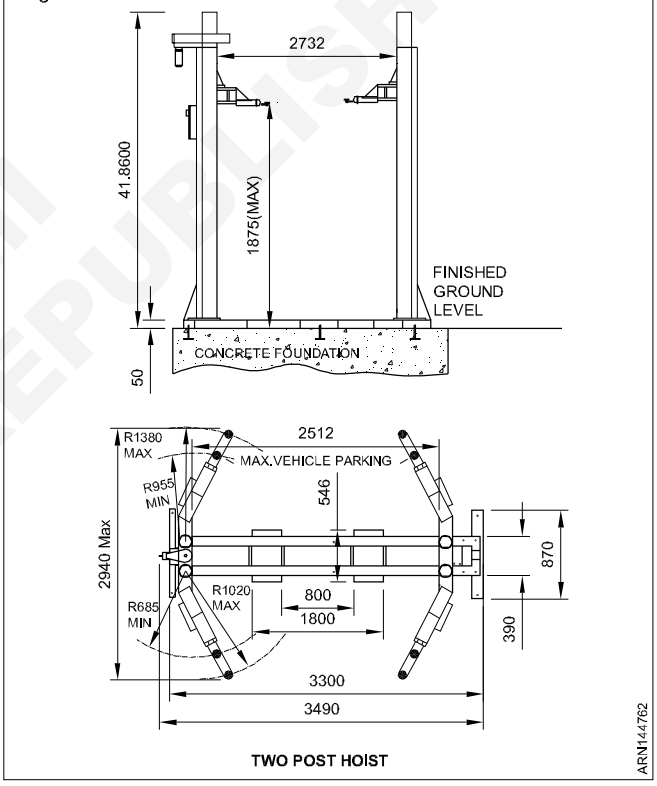
HYDRAULIC CAR HOIST

MDN170411

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

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

Fig 2



TWO POST HOIST

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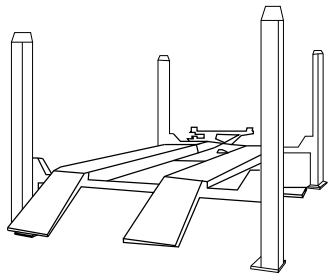
Fig 3



FOUR POST HOIST

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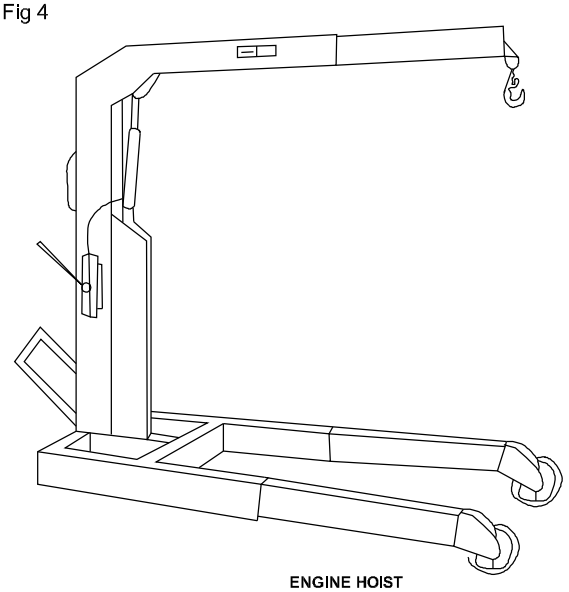
Engine hoist (Fig 4)

The engine hoist helps to lift an engine from a car/truck. The hydraulic pressure converts power to a mechanical advantage and lifts the engine from the car with less effort. When using a block and tackles for lifting an engine, use a lifting plate attached to the intake manifold or use a chain bolted at each end of the block.

Jacks: Jacks are operated by moving the handle up and down. The other type of portable floor jack is the pneumatic jack which uses compressed air to lift a car or truck. It is mostly used in production side.

Fig 4



ENGINE HOIST

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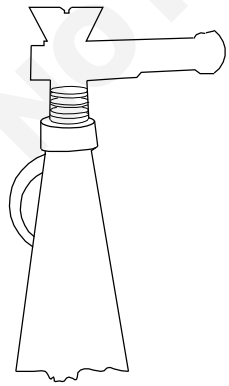
Never work under a car without safety stands or jack stands.

On roads mostly mechanical jacks are used to lift the car/vehicle for small jobs. These jacks work under the principle of screw and nut. Jacks are operated by mechanically and hydraulically, Jack is designed to lift the vehicle and hold the vehicle load during the repair works. Jack is a standard accessory with many vehicles.

Types of jacks

- Light weight screw jack (Fig 5)

Fig 5



MANUAL TYPE LIFTING JACK

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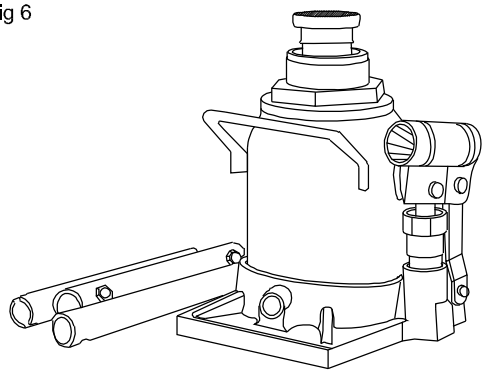
- Heavy duty bottle type hydraulic jack (Fig 6)

Fig 6



HEAVY DUTY BOTTLE TYPE LIFTING JACK

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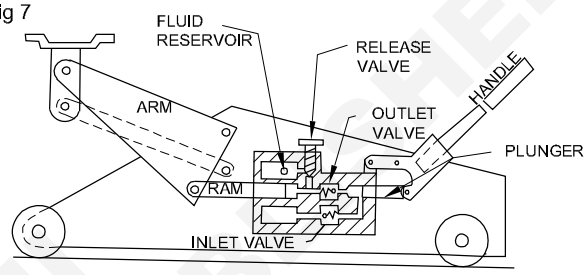
- Trolley types hydraulic jack (Fig 7)

Fig 7



TROLLEY TYPE JACK

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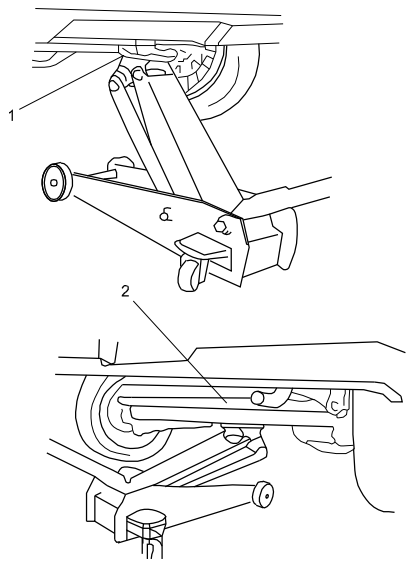
In raising front vehicle end off the floor by jacking , be sure to apply jack against front jacking bracket(1) (Fig 8).

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

Fig 8



FLOOR JACK

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Caution: Never apply jack against suspension parts (i.e., stabilizer, etc.) front bumper or vehicle floor, Otherwise it may get deformed.

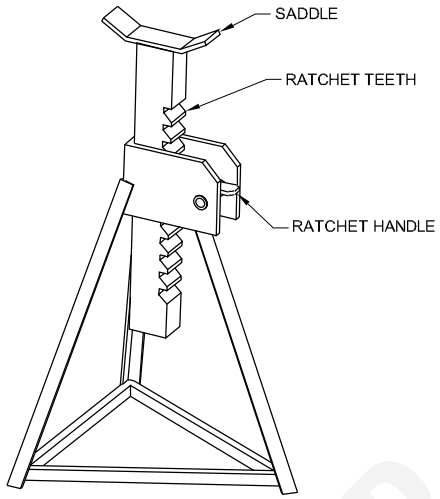
Warning: If the vehicle to be jacked up only at the front or rear end, be sure to block the wheels on ground in order to ensure safety.

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 ensure the safety before starting the work under the lifted vehicle, Jack report is not enough, it could be dangerous. Always use axle stands for safety work. Different size of stands are used depend upon the vehicle load.

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

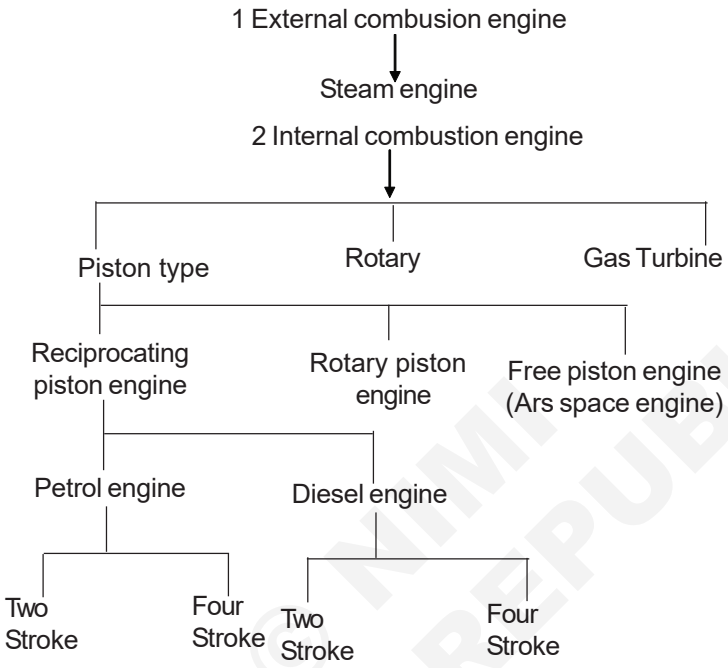


TYPICAL ADJUSTABLE JACK STAND

Internal and external combustion engine

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

Types of heat engines



Internal combustion engine: Internal combustion engines are those heat engine, that burns their fuel and takes combustion inside the cylinder, this definition including the two stroke and four stroke engine, spark ignition and compression ignition engine, austine and jet engines are also internal combustion engine. Ex: Wankel.

External combustion engine: The external combustion engines are those heat engine that burn their fuel outside the engine cylinder. The energy developed during the combustion of fuel is transmitted to steam. This steam acts on the piston inside cylinder example - railway steam engine.

Difference between internal and external combustion engine

Sl.No.	Internal combustion engine	External combustion engine
1	Occupies less space.	Occupies more space.
2	Lighter in weight.	Heavier in weight.
3	High speed engine.	Slow speed engine.
4	Combustion of fuel takes place inside the engine.	Combustion of fuel takes place outside the engine.
5	No fuels used in when engine is not running.	Solid or liquid fuels used to form steam.
6	No loss of fuel when engine is not running.	Fuel has to burn even when the engine is not running for small halts.
7	Could be started or stopped at will.	Cannot be started unless steam is prepared which takes much time.
8	Temperature produced inside the cylinder is too high.	Works at comparatively low temperature.
9	Cooling arrangement necessary.	No cooling of the cylinders required. Rather it is steam jacketed.

10	Single acting.		Mostly double acting.
11	Exhaust gas temperature as high as 300°C.		The temperature of exhaust steam is quite low.
12	Thermal efficiency of diesel engine up to 40%.		Thermal efficiency up to 24% as that of petrol engine.
13	No needs boiler, furnace or condenser.		Boiler, furnace and condenser are must.

Classification of I.C engines

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

Engines are classified according to the following factors.

Number of cylinders

Single cylinder

Multi cylinder

Arrangements of cylinders

In-line engine (Fig 1)

`V' shape engine (Fig 2)

Opposed engine (Fig 3)

Horizontal engine

Radial engine (Fig 4)

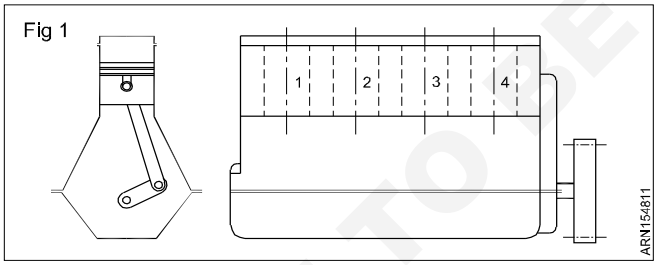
Vertical engine

Types of engines as per cylinder arrangement

In-line engines

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

Fig 1



'V' shape engines

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

Opposed engines

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

Fig 2

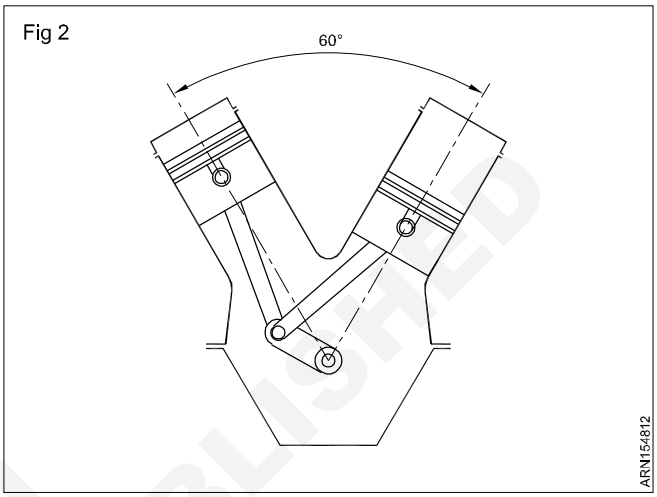
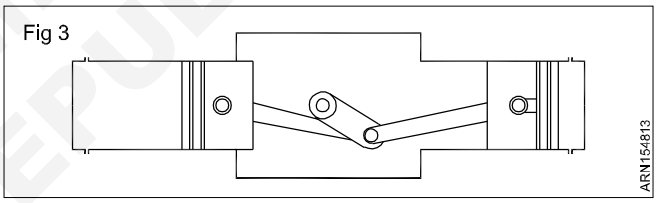


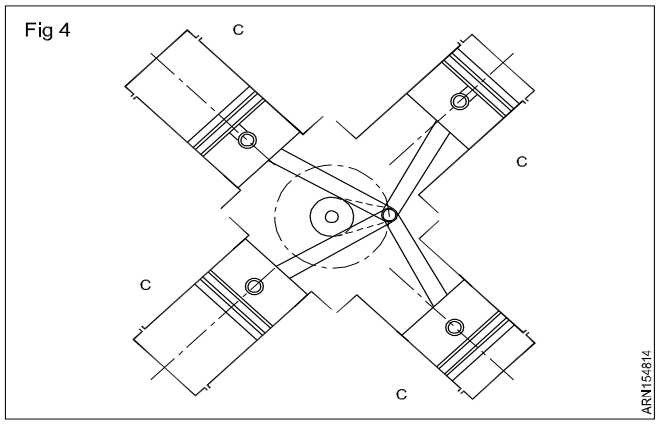
Fig 3



Radial engines

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

Fig 4



Types of engine as per number of cylinders

Single cylinder engines

An engine which has only one cylinder is called a single cylinder engine. Since it is a single cylinder engine it cannot develop more power. It is normally used only in two wheelers like scooters and motor cycles.

Multi cylinder engines

These engines have more than one cylinder. Two-cylinder engines are usually used in tractors. Three or four cylinder engines are used in cars, jeeps and other vehicles. In heavy vehicles six-cylinder engines are used. A greater number of cylinders gives smoother engine operation.

Types of fuel used

Petrol

Diesel

Gas

Types of valve arrangements

`I' head engine

`F' head engine

`L' head engine

`H' head engine

`T' head engine

Application of engine

Constant speed engine

Variable speed engine

Engine Cooling system

Air cooled engine

Water cooled engine

Strokes of engine

Four-stroke engine

Two-stroke engine

Working of diesel engine

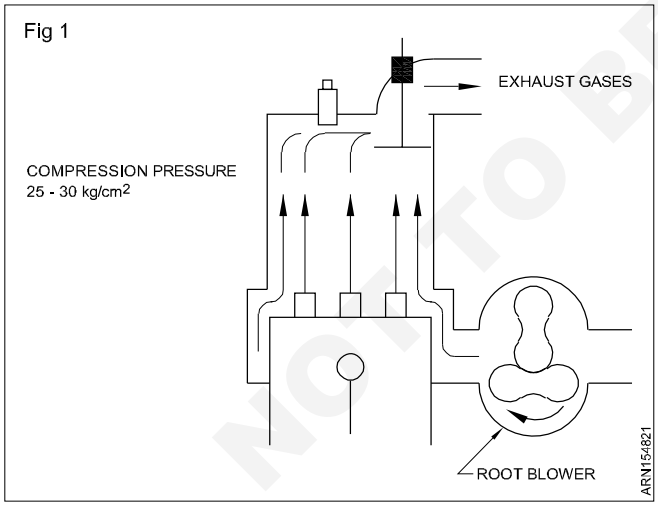
Objectives: At the end of this lesson you shall be able to
- **describe the function of a two-stroke diesel engine**
- **describe the function of a four-stroke diesel engine.**

Two stroke diesel engine

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

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

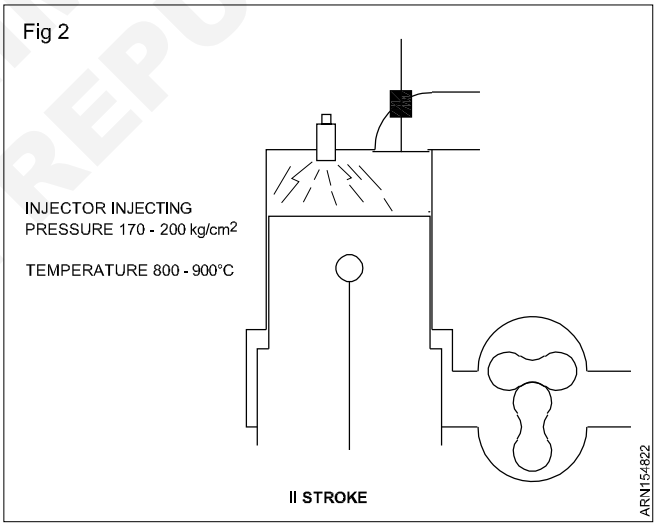
Fig 1



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

Fig 2



centre.

Four-stroke engine

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

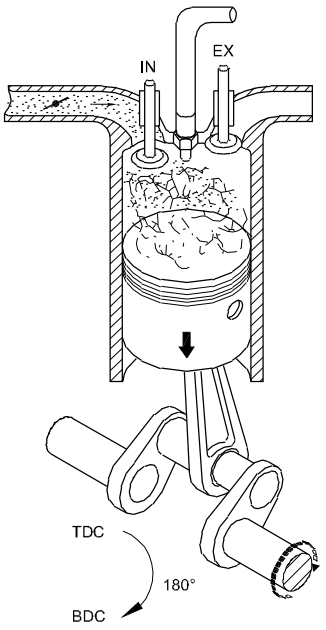
Suction stroke

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

Compression stroke (Fig 4)

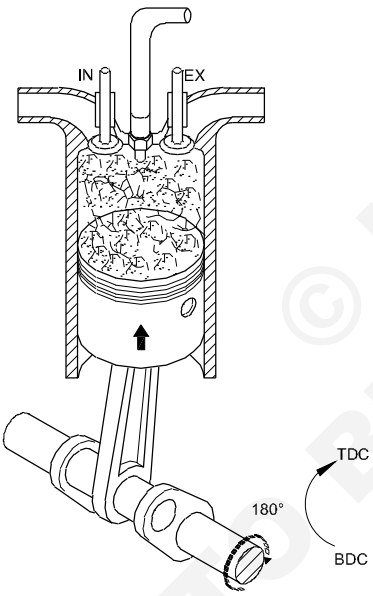
The inlet and exhaust valves are closed. The piston moves from BDC to TDC (Fig.4). The charged air is compressed

Fig 3



SUCTION STROKE

Fig 4



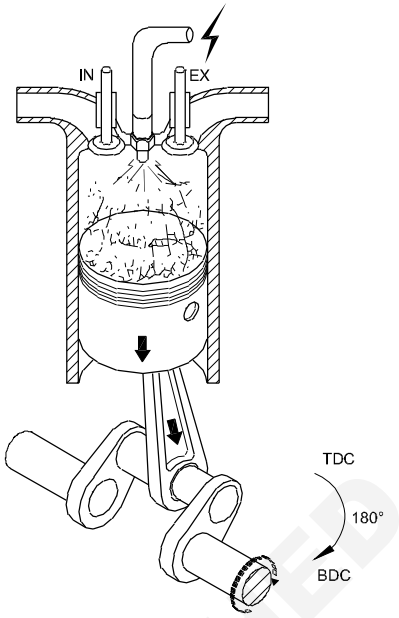
COMPRESSION STROKE

in the cylinder. The compressed air pressure and temperature is increased upto 800°C.

Power stroke

At the end of the compression stroke diesel fuel is injected into the hot compressed air in the combustion chamber; result burning of diesel with an explosion the gas expand and pressure develops inside the cylinder. The piston

Fig 5



POWER STROKE

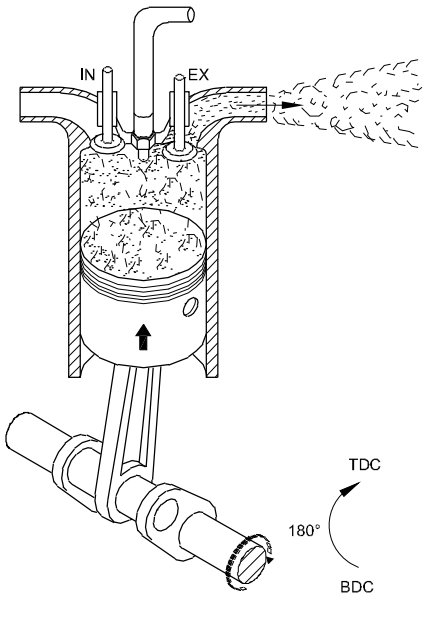
moves from TDC to BDC (Fig 5). Both the valves remain closed. Power is supplied to the fly wheel.

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

Working of spark ignition engine

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

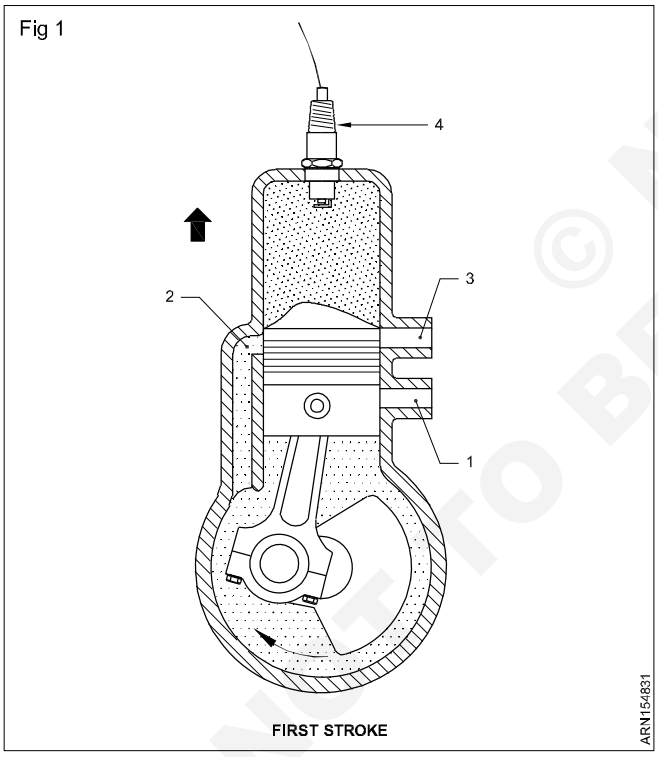
Two-Stroke spark ignition engine

To produce power in two stroke engine the following operations take place in the sequence given below.

First stroke (Suction and compression) (Fig 1)

As the piston moves up from BDC,(Fig 1) it closes the inlet port (1), the exhaust port (3) and the transfer port (2). Further upward movement of the piston results in compressing the mixture in the cylinder and opening of the inlet port (1). The upward motion of the piston creates a partial vacuum inside the crank-case below the piston, and the air/fuel mixture is drawn into the crank-case through the inlet port (I). The exhaust and transfer ports remain closed during the operation of the upward stroke and the charge which reached above the piston during the previous stroke is compressed.

Fig 1



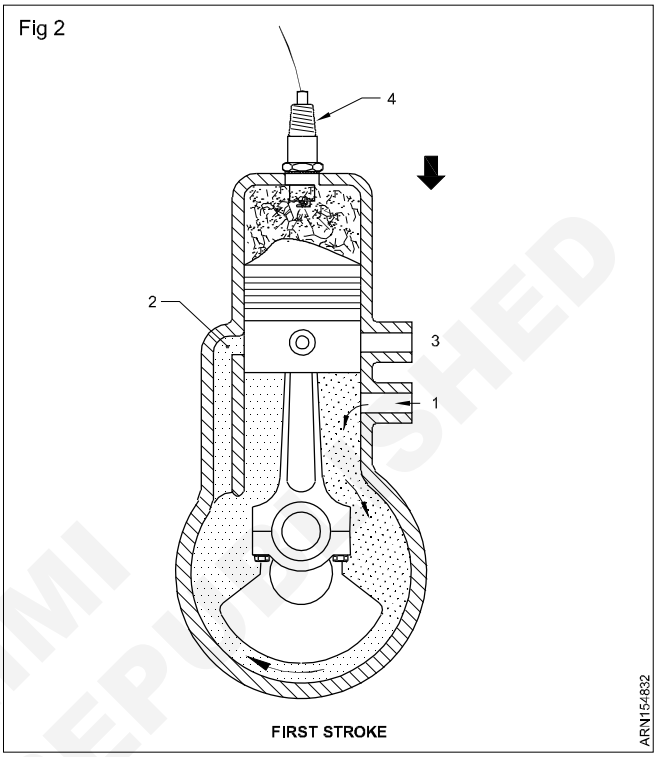
At the end of this stroke the mixture is ignited by an electric spark (4). This causes the pressure to rise.

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.

Fig 2



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)

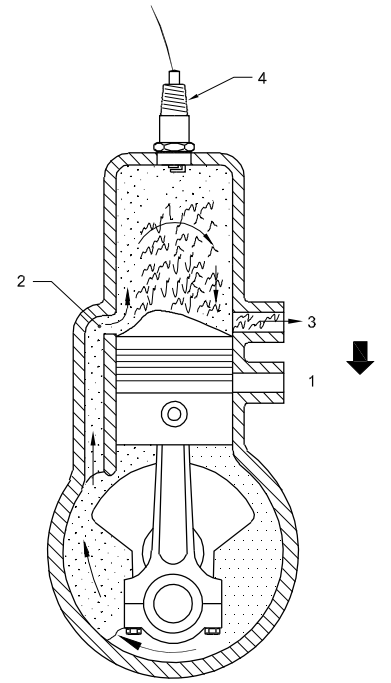
In a spark ignition (SI) engine, petrol is used as fuel. During the suction stroke the air and fuel mixture is sucked into the cylinder. The quantity of the mixture is metered by the carburetor according to the load and speed. The ratio of air/fuel mixture is also metered by the carburetor. During the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

In this type of engine the compression ratio is low.

Four-stroke spark ignition engine

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

Fig 3

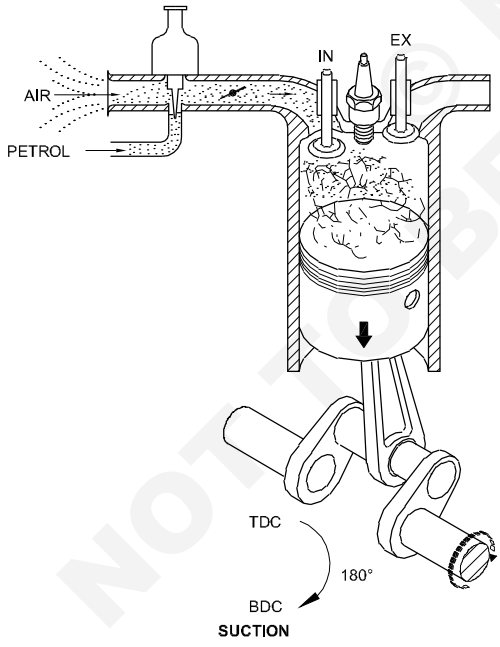


SECOND STROKE

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

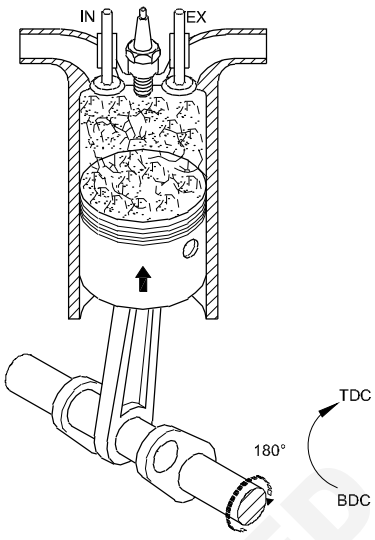


SUCTION STROKE

Compression stroke

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

Fig 5

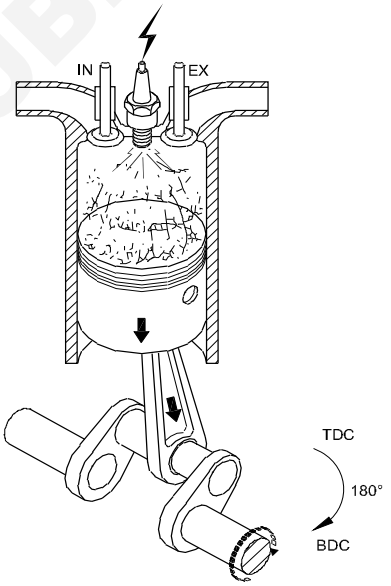


COMPRESSION STROKE

Power stroke

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

Fig 6



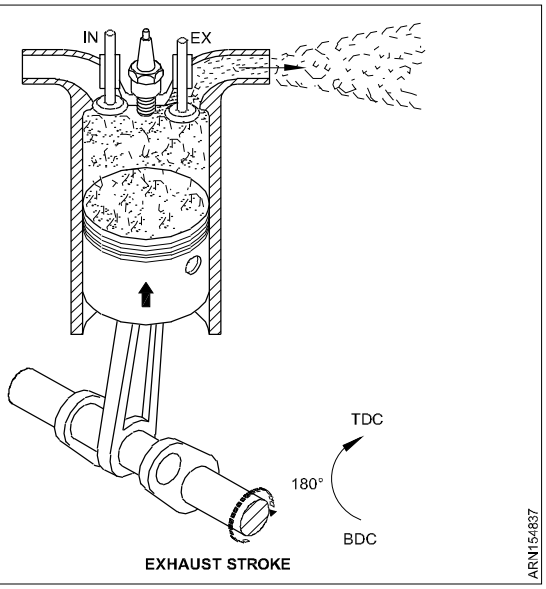
POWER STROKE

Exhaust stroke

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

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



Comparison between four-stroke engine and two-stroke engine

Four-stroke engine	Two-stroke engine
- Four operations (suction, compression, power and exhaust) take place in the four strokes of the piston.	- The four operations take place in two strokes of the piston.
- It gives one power stroke in two revolutions of the crankshaft. As such three strokes are idle strokes.	- The power stroke takes place in every two strokes i.e. one power stroke for one revolution of the crankshaft.
- Due to more idle strokes and non-uniform load on the crankshaft, a heavier flywheel is required.	- The engine has more uniform load as every time the piston comes down it is the power stroke. As such a lighter flywheel is used.
- The engine has more parts such as valves and its operating mechanism. Therefore, the engine is heavier.	- The engine has no valves and valve-operating mechanism therefore it is lighter in weight.
- The engine is costlier as it has more parts.	- The engine is less expensive as it has a lesser number of parts
- The engine efficiency is more as the charge gets completely burnt out. Consequently the fuel efficiency is more.	- The engine efficiency is less. A portion of the charge escapes through the exhaust port, and because of this, the fuel efficiency is less.

Comparison between S.I and C.I. Engine

SI engine	CI engine
Petrol is used as fuel.	Diesel is used as fuel.
During the suction stroke air and fuel mixture is sucked in the engine cylinder	During the suction stroke air alone is sucked in to the cylinder
Compression ratio is low. (Max. 10:1)	Compression ratio is high. (Max. 24:1)
Compression pressure is low. (90 to 150 PSI)	Compression pressure is high. (400 to 550 PSI)
Compression temperature is low.	Compression temperature is high.
It operates under constant volume cycle (otto cycle).	It operates under constant pressure cycle (diesel cycle).
Fuel is ignited by electric spark.	Fuel is ignited due to the heat of the highly compressed air. Combustion takes place at constant pressure.
Spark plug is used	Injector is used.
A carburetor is used to atomize, vaporize and meter the correct amount of fuel according to the requirement.	Fuel injection pumps and atomizers are used to inject metered quantities of fuel at high pressure according to the requirement.
Less vibration, and hence, smooth running.	More vibration, and hence, rough running and more noisy.
Engine weight is less.	Engine weight is more.
It emits carbon monoxide. (CO)	It emits carbon dioxide. (CO_2)

Otto Cycle

1 - 2 - Suction

2 - 3 - Compression

3 - 4 - Heat addition

4 - 5 - Power

5 - 2 - 1 - Exhaust

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

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

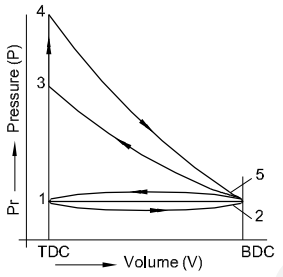
Compression takes place when piston moves from BDC to TDC. (2-3)

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

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

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

Fig 8



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

Diesel Cycle

1 - 2 - Suction

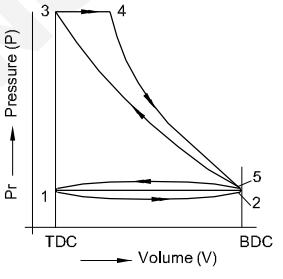
2 - 3 - Compression

3 - 4 - Heat addition

4 - 5 - Power

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

Fig 9



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)

turbocharging or tuning) than direct injection diesels. The increased temperature and pressure on one part of the piston crown causes uneven expansion which can lead to cracking, distortion or other damage due to improper use; use of " starting fluid" (ether) is not recommended in glow plug, indirect injection systems, because explosive knock can occur, causing engine damage.

Basic technical terms used in relation to engines

T.D.C. (Top dead centre)

It is the position of the piston at the top of a cylinder, where the piston changes its direction of motion from the top to the bottom.

B.D.C. (Bottom dead centre)

It is the position of the piston at the bottom of the cylinder where the piston changes its direction of motion from the bottom to the top.

Stroke

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

Cycle

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

Swept volume (VS)

Displacement volume of a piston.

Clearance volume (VC)

Volume of the space above the piston when it is at TDC.

Compression ratio (CR)

Ratio of compression volumes before the stroke and after.

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

where VS = Swept volume

VC = Clearance volume

VS+VC = Total volume at BDC.

Power

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

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

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

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

Brake horsepower (BHP)

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

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

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

Indicated horsepower (IHP)

It is the power developed in the engine cylinder.

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

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

L is length of stroke in metres

A is the area of the piston in cm²

N is the No. of power strokes per minute

K is the No. of cylinders.

Frictional horsepower

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

FHP = IHP - BHP

Mechanical efficiency

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

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

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

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

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

Technical Specification of an engine

Engines are specified as per the following types.

Number of cylinders

Bore diameter

Stroke length

Capacity in cu.cm/cu.inch

Maximum engine output at specified r.p.m.

Maximum torque

Compression ratio

Firing order

Idling speed

Air cleaner (Type)

Oil filter (Type)

Fuel filter

Fuel injection pump

Weight of engine

Cooling system (type)

Type of fuel

Technical specifications of vehicles
LPT - 1210 D

Specifications

Engine	
Model	6692 D.I.
Number of cylinders	6
Bore	92 mm
Stroke	120mm
Capacity	4788 cc
Gross H.P. (S.A.E.)	125 at 2800 R.P.M.
Taxable H.P.	31.5
Maximum Torque	30 mkg at 2000 R.P.M
Compression Ratio	17 : 1
Compression pressure at 150-200 R.P.M.	Minimum 20 kg/cm²
Fuel injection begins	23° before T.D.C.
Firing order	1-5-3-6-2-4
Opening pressure of the injection nozzles	200 + 10kg/cm² Newnozzels Min. 180 kg/cm² Used nozzels
Maximum variation permissible in injection: nozzle pressure	5 kg/cm²
Inlet valve clearance	0.20 mm
Exhaust valve clearance	0.30 mm
Air cleaner	oil bath
Total bearing area per bearing	55 sq.cm
No.of main bearings	7
Fuel injection pump	MICOBOSCH
Weight (Dry)	382 kg
Capacity of cooling system	20 litres
Crankcase oil capacity	Maximum - 14 litres Minimum - 10 litres
Cooling water temperature	75°C - 95°C

Depth max : 223 mm $\left(8\frac{3}{4}"\right)$

Vehicle construction technology

Objectives: At the end of this lesson you shall be able to
- **state the auto body collision repair**
- **state the different type of auto body repair shop**
- **state the vehicle body repair order**
- **state the description of vehicle body and chassis frame.**

Definition of collision repair: In order to repair or replace the damaged sections of an auto body. The major elements of auto body constructions may seam complicated. Without a clear understanding of the basics of vehicle construction and assembly, it would be very difficult to follow correct repair procedures so the technician must begin with a through understanding of how the vehicle is constructed.

The goal of collision repair is to restore the vehicle to its precedent condition. During repairs, you should use repair methods that exactly near to duplicate how the vehicle was manufactured on its assembly line.

Body shop: A body shop, or collision repair facility, has well-trained technicians, specialized tools, and heavy equipment for restoring damaged vehicles to their pre accident condition. There are several ways to classify a body shop. A few of the most common are discussed in the following section.

An independent body shop is owned and operated by a private individual. The shop is not associated with other shops or companies. A franchise body shop is tied to a main headquarters that regulates and aids the operation of the shop. The shop logo, materials used, fees, and so on, are all set by corporate headquarters and the franchise must follow these guidelines.

A **dealership body shop** is owned and managed under the guidance of a new car dealership, such as general motors, Chrysler, Lexus, Toyata, Jaguar, or Ford. This type of shop often concentrates on repairs of the specific make of cars sold by the dealer.

A progression or production shop often has an assembly line organization with specialists in each area of repair. One person might do nothing but heavy frame repair work. Another technician might be good at "building the body", or installing parts and panels. The shop might have a wheel alignment technician, prep people, painter, and cleanup specialists. The vehicle will move from one area and specialist to the next until fully repaired.

A **specialty shop** performs only specific types of repairs. For example, the body shop might send a radiator with a small hole in it to a specialty radiator shop for repair with specialized equipment.

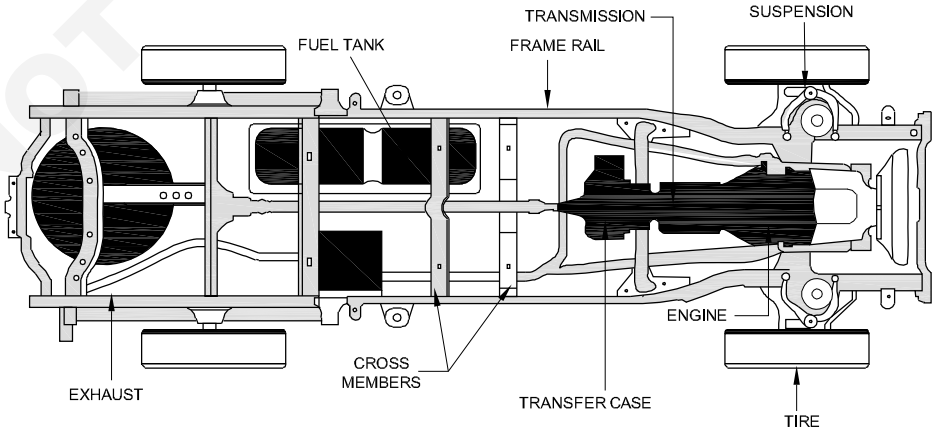
A body shop that provides complete collision services might do wheel alignments, cooling system repairs, electrical system diagnosis and repair, suspension system work, and other parts. Today, more and more collision repair shops are offering complete collision services. They have both a body shop area and a mechanical repair area.

Vehicle repair order: Vehicle repair order is an order for services or work that is done by an outside the vendor and for which the auto body repair estimate stands for remove and replace the damaged parts. Remove and replace the parts occurs when a part is removed from vehicle that cannot be repair. As a result, the removed parts is replaced by new one. Light damaged panel parts are repaired by technician.

Vehicle repair order s guide line to auto body technician to identify and repair the damaged parts systematically.

Auto body and chassis (Fig 1): The major parts of a vehicle can be categorized as parts of the body the chassis or the frame. The vehicle body provides a protective outer hull around the outside of an automobile. The vehicle body can be made from steel, aluminium, fibre glass, plastic or composite. Vehicle body is painted for shiny colour and good appearance.

Fig 1



Chasis or frame includes the engine, suspension system, steering system and other mechanical parts with the body removed. The frames are usually made of steel or aluminum and sometimes composite materials. The frame can be separate from the body.

The body-over-frame has a thick metal box or 'U'-shaped stampings or rails welded and riveted together. The main structural members are two side rails connected by a series of cross members for high load carrying capabilities. The separate frame is made of much heavier gauge steel than the body panels.

A hydro formed frame is manufactured by using water under high pressure to force straight box extruded frame rails into the desired shape. A hydro formed frame is made of a thinner gauge metal than a conventional perimeter frame. Hydro formed frames are lighter a conventional perimeter frame. Hydro formed frames are lighter almost as strong and equally as stiff as conventional heavy gauge steel or aluminum frames.

Unibody construction uses body parts welded or adhesive bonded together to form an integral frame. The body structure is designed to secure other chassis parts. No separate heavy gauge steel frame under the body is needed, unibody construction is very different concept in vehicle design that requires more complex assembly techniques, new materials and a complex different approach to repairs. The unibody designs, heavy gauge cold rolled steel or aluminium alloys. This requires new handling straightening and welding techniques.

Major body sections: The vehicle is commonly divided into three body sections as front, center and rear. The frank section also called the nose section, includes everything between the front bumper and the fire well. The bumper, grille frame rails, front suspension parts, and engine are a few of the items included in the front section of a vehicle. The nick name, front clip or dog house is used to refer to the body section.

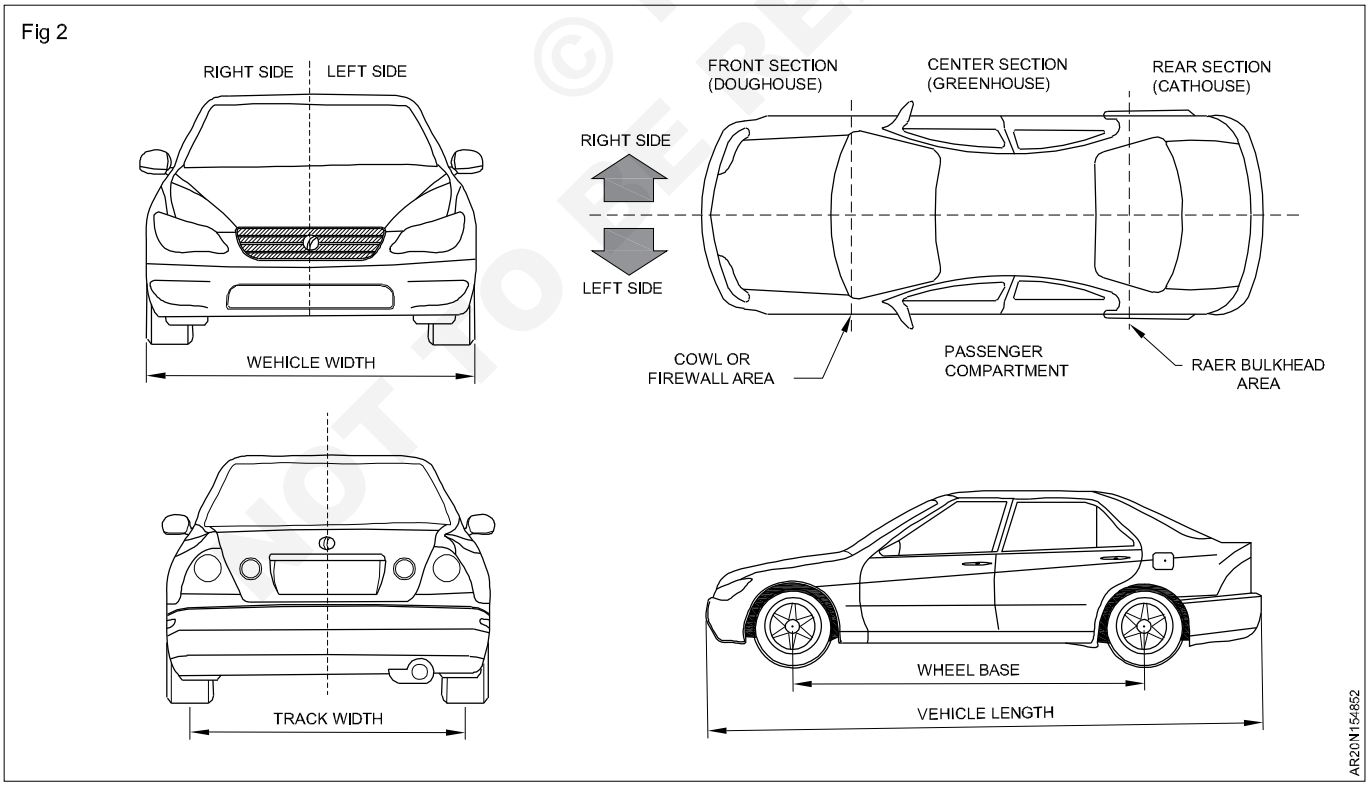
The vehicle center section or mid section, typically included the body parts that form the passenger compartment. A few parts in this section are the floor pan, roof panel. Cowel, doors, door pillars, glass and related parts. The center section is nicknamed the green house because it is surrounded by glass.

The rear section commonly consists of the rear quarter panels, trunk or rear floor pan, rear frame rails, rear bumper also called the cathouse. It is often sectioned of a salvage vehicle to repair severe rear impact damage.

Vehicle left and right sides: The left and right sides of a vehicle is determined by standing behind the vehicle or setting in the drivers seat behind the steering wheel in either position, the vehicle's left side is to your left the right side is to your right panel and parts are often named for the left or right side of the vehicle.

Drive line configuration: It refers to how the engine power is transmitted to the vehicle drive wheels. There are six basic drive train designs; front wheel drive, rear wheel drive, rear engine rear wheel drive, mid-engine rear wheel drive, four-wheel drive and all-wheel drive. (Fig 2)

Fig 2

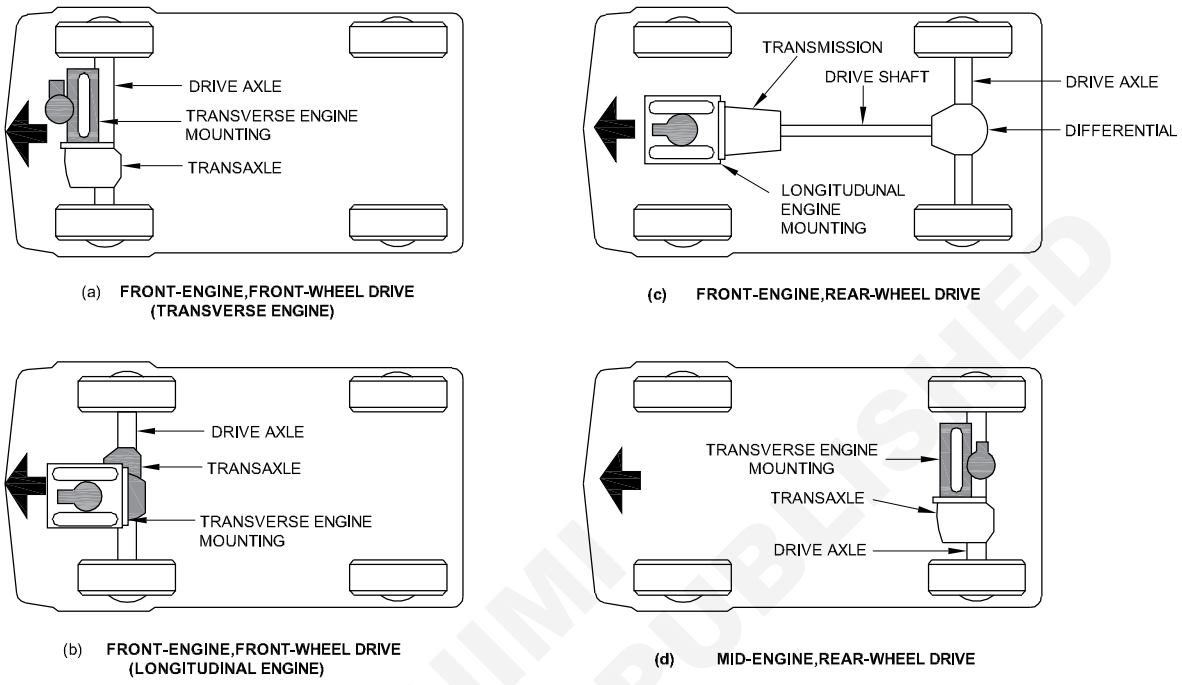


The design of drive line construction is affect the vehicle repair methods.

Transverse engine: The transvers engine mounted on side ways of the engine compartment. The engine's crank shaft center line external toward the right and left of the body. Both rear and front engine vehicles are used this transverse engine configuration.

Longitudinal engine: This engine crankshaft mounts center line front to rear. When viewed from the top. Front engine rear wheel drive vehicles use this type of engine fittings. (Fig 3)

Fig 3



Front engine front wheel drive: Vehicle has to front engine and trans axle in the front of the vehicle. The drive axles extend out from the trans axle to power the front drive wheels it adds the heavy drive train weight to the front drive wheels for good traction on slippery pavement.

Front engine rear wheel drive: This type of vehicle has the engine in the front and drive axle in the rear. The engine power transmission is usually right behind the engine and a drive shaft transfers power back to the rear axle.

Rear engine rear wheel drive: This type of vehicle has the engine in the back and trans axle transfers power to the rear wheels. This engines power drive train is good over the rear drive wheels.

Mid engine rear wheel drive: Mid engine has located in center of vehicle right behind the driver seat. Mid engine helps to plate the center of gravity in the middle of the vehicle. So that the front and rear wheels hold the same amount of load and it helps to improves the cornering ability.

Four wheel drive: Four wheel drive systems use to transfer case to transmit the power to front and rear axle differentials to all wheels. The transfer case can be engaged and disengage to select two or four wheel drive as desired.

Body classification

Objectives: At the end of this lesson you shall be able to
- **state the vehicle body classification**
- **state the vehicle body materials**
- **state the vehicle construction and frame tests**
- **state the vehicle collision repair measurements.**

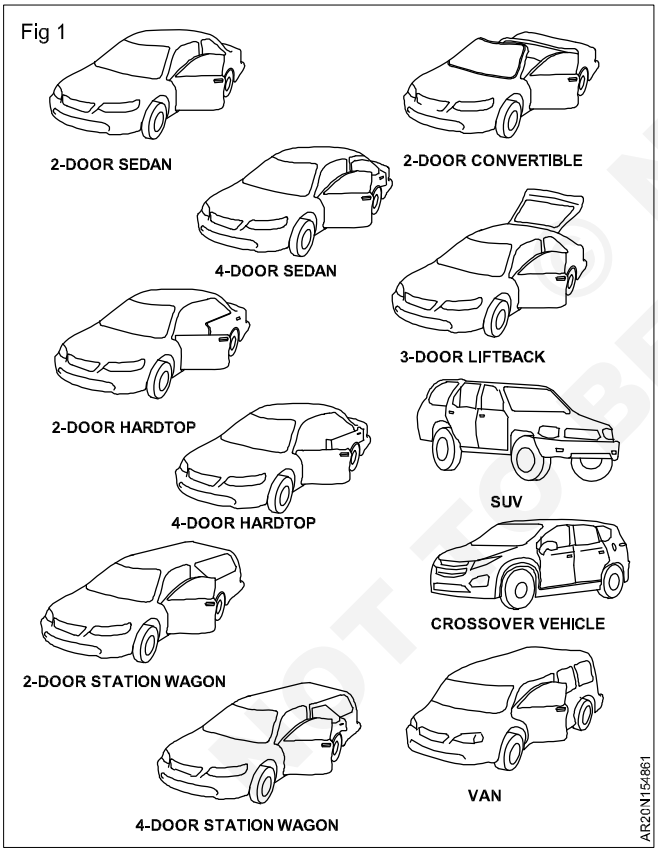
Body classification: Various methods used for classifying the vehicle body. Body classifications most recognised by consumers are car size, body shape, seat arrangement, number of door used in the vehicle and engine type, fuel system type, drive line type.

Car size: There are three type of car size as a compact or economy car, intermediate car and full size car or luxury car small size car uses a three or four cylinder engine and intermediate car uses a four or six cylinder engine and luxury car uses a high performance V8 engine. Full size cars can have either unibody or body over frame construction.

Roof designs: (Fig 1) There are several basic body or roof designs used as follows.

- A sedan refers to a body design with a center pillar that supports the roof.
- A hard top does not have a center pillar to support the roof, so the roof must be reinforced to provide the enough strength of hard top of the car.
- A hatch back roof design has a large third door at the back. The design is commonly found on small compact cars.
- A convertable car roof uses a retractable canvas roof with a steel tube frame work. The top folds down behind the seat. Some convertables uses as a removable hard top.
- A station wagon roof extends straight back to the rear of the body to allow access to the large storage area.
- A van type car has a large box shaped body to increase interior volume or space.
- Sport utility or SUV vehicle body and roof is designed as drilling through snow and mud at all-weather.
- Pick up trucks has a separate cab and bed.

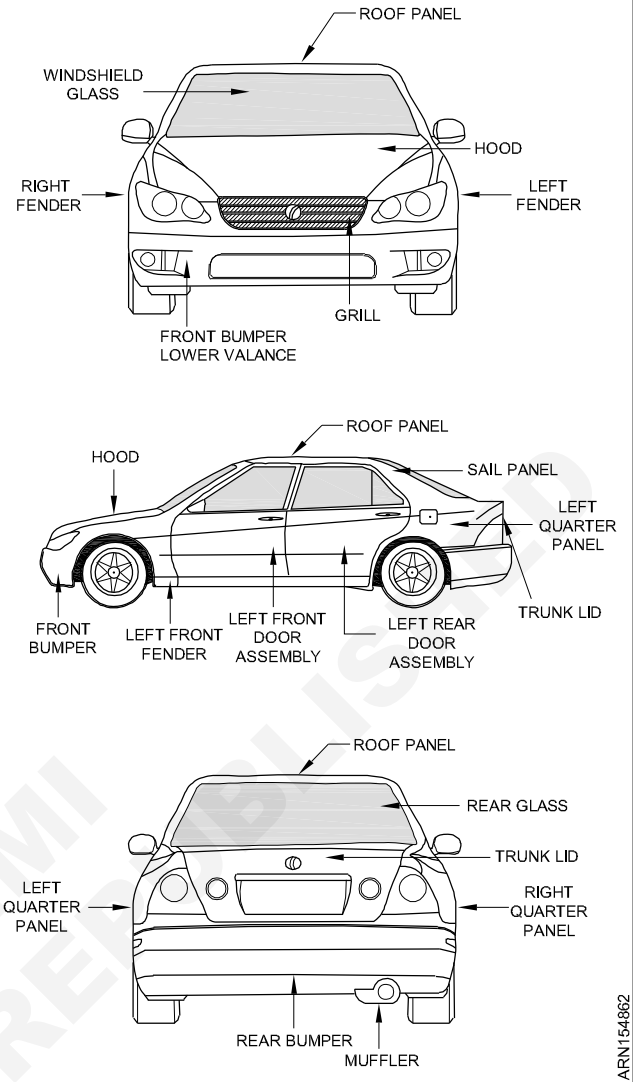
Fig 1



Body panels: (Fig 2) Body panels refers to an individual unit used to build a vehicle. Several parts are fastened together form as vehicle body assembly. A panel is a steel aluminium or plastic sheet stamped or moulded into body part various panels are used in a vehicle as the name of the panel is self-explanatory,

- Hood panel
- Fender panel

Fig 2



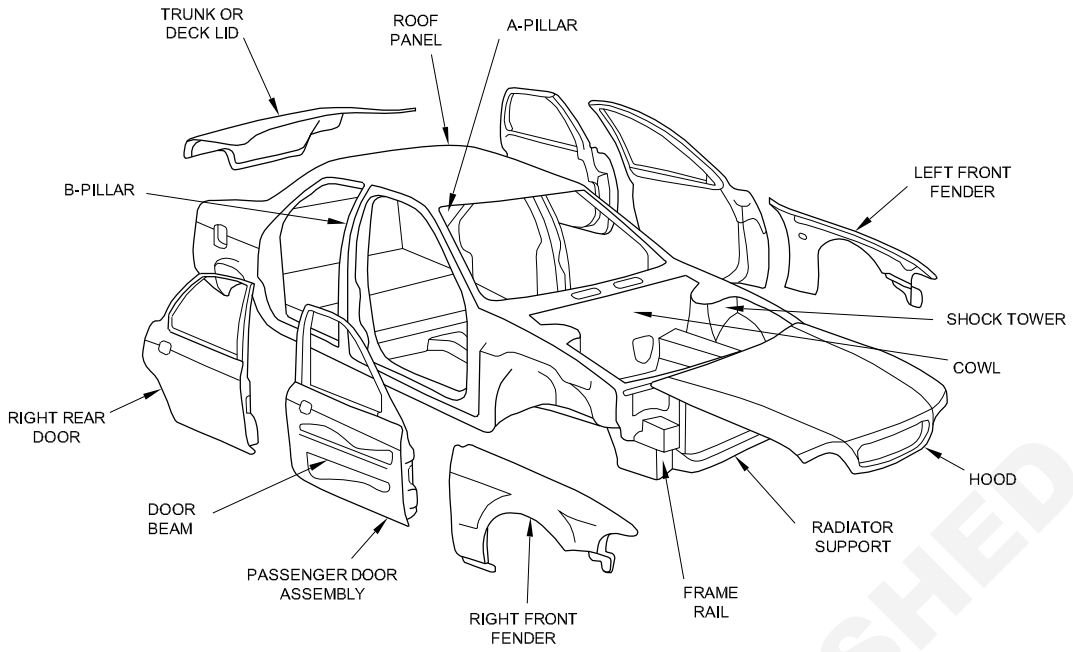
- Trunk lid panel or roof panel

The giant machines are used to crush the thin flat sheet metal in a die machined to match the shape of the desired body shape. Body panels usually have compound curves formed to increase stiffness with unibody construction, panels are welded together to form the unibody frame at the vehicle assembly plant.

Unibody panels and their parts: It is important to know which type of auto body construction is used, while because repair work different for each type of the vehicle construction. The technician must know how to repair both full frame and unibody vehicles with great precision. Some panel parts are same for both unibody and full frame vehicles.

Front section parts: The unibody front section parts of the frame rails are the box members extending out rear the bottom of the front section. They are strongest part of a unibody. Frames or rails are welded to the firewall and to the bottom of the fender aprons. The cowel is the assembly of panels at the rear of the front section right in front of he wind shield. This assembly includes the top cowel panel and side cowel panels. (Fig 3)

Fig 3



The front fender aprons are inner panels that surround the wheels and tyres to keep out road debris. They are bolted or welded to the frame rails and cowel.

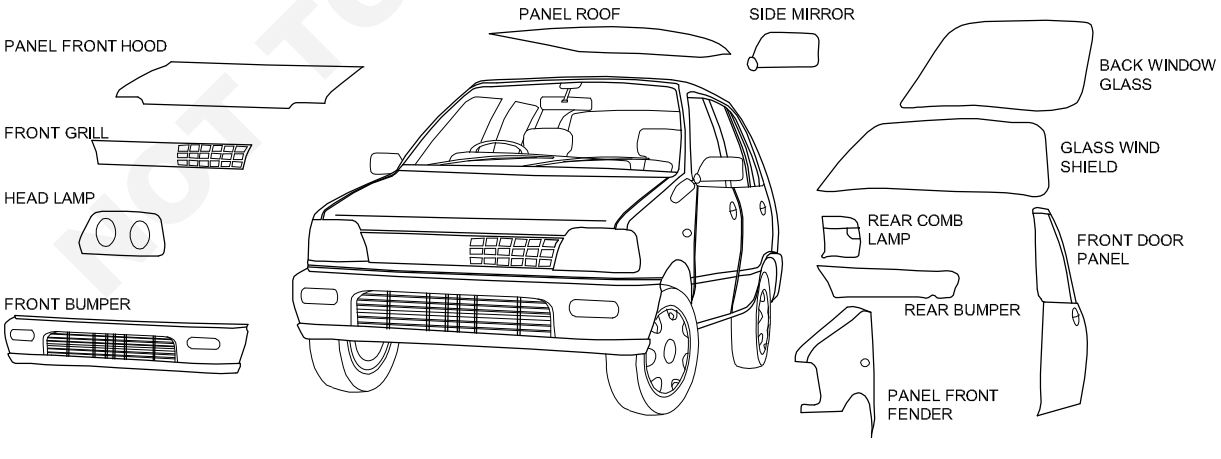
The shock towers or strut towers are reinforced body areas for holding the upper parts of the suspension system. The coil springs and strut or shock absorbers fit up into the shock towers. The radiator core support is the frame work around the front of the body structure for holding the cooling system radiator and other related cooling system parts. These parts are often fastens to the frame rails and inner fender aprons.

The hood is hinged panel for accessing the engine compartment. Hood hinges bolted to the hood and cowel panel, allow the hood to swing open. The hood is made of two or more panels welded or bonded together to prevent flexing and vibrations.

The dash panel or fire wall or bulk head. Panel is dividing the front section and the center passenger compartment section. The dash panel protect the passengers in the event of a fuel leaks and resulting engine fire.

The front fenders covers front suspension and inner aprons. The bumper assembly bolts to the front frame horns to absorb minor impacts. The grille is the center cover over the radiator support it has opening for airflow through the radiator. (Fig 4)

Fig 4



Center section parts: The floor pan is the main structural section in the bottom of the passenger compartments. It is stamped as one large piece of steel.

The unibody pillers are vertical body members that hold the roof panel and protect the passengers in case of a roll over accidents.

There are three types of pillars are used in modern cars. Front pillers extend up next to the edges of the wind shield they are steel box members that extend down from the roof panel to the main body section.

Center pillars are the roof supports between the front and rear doors on four door vehicles, it helps strengthen the roof and provide a mounting point for the rear door hinges.

Rear pillars extend up from the quarter panels to hold the rear of the roof and rear window glass.

Rocker panels or door sills are strong beams that fit at the bottom of the door openings. They are welded to the floor pan and to the pillars. Kick panels or quarter panels. The kick panels are small panels between the front pillars and rocker panels.

The rear shell is a thin panel behind the rear seat and in front of the back glass. The rear bulkhead panel separates the passengers compartment from the rear trunk area.

The doors are made up of outer skin, inner door frame, door panel, window regulator, glass and related parts door hinges are bolted between the pillars and door frame.

The roof panel is a large panel that fits over the passenger compartment. It is normally welded to the pillars. Some vehicles roof panel have a provision to removable top pieces.

The dash panel is the assembly including the soft dash pad, instrument pad, instrument cluster, radio, heater and air conditioning controls vents and similar parts. The dash panel can be damaged in a major collision, when people fail to wear their seat belt as well as by air bag deployment.

Rear section parts: The rear frame rails are strong boxed structures that give strength to the rear of the vehicle. The trunk floor panel is a stamped steel part that forms the bottom of the rear storage compartment.

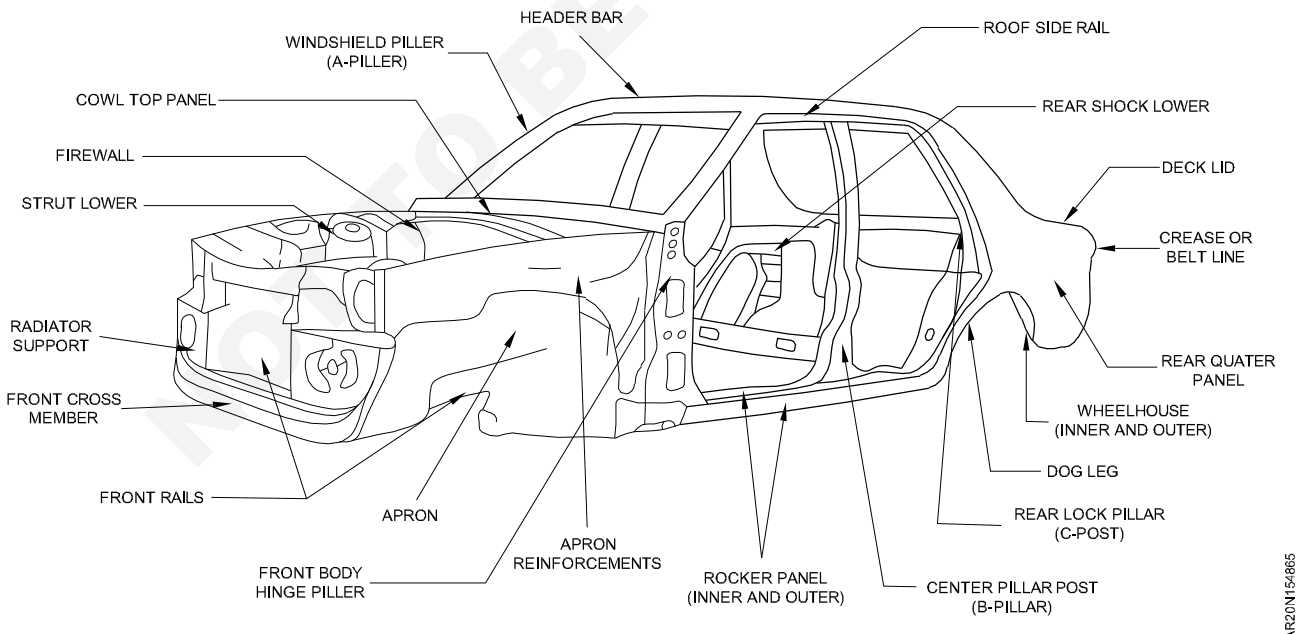
The deck lid is a hinged panel over the rear storage component. A rear hatch is a larger panel and glass assembly hinged for more access to the rear of the vehicle.

The quarter panels are the large side body sections that extend from the side doors back to the rear bumper. They are welded in place and form a vital part of the rear body structure. The rear body panel fits behind the rear bumper and between the quarter panels. The rear shock towers hold the top of the rear suspension. The inner and outer wheel housings surround the rear wheels and weld to the quarter panels. The upper rear panels are the area between the back glass and trunk lid.

Cross members are thick gauge supports that extend across the frame rails of both unitized and full frame vehicles. They provided more strength for holding various parts of the vehicle. Cross members increase the stiffness and strength it may be welded or bolted in place.

Unibody design factors: There are many types of vehicle construction designs are used in modern vehicles that should be understood. The following designs are considered for the unibody vehicles. (Fig 5)

Fig 5



Semi utilized frame body: These type of frame body uses heavier gauge steel stub rails that are bolted to the front and rear of the body structure it secure mechanical chassis parts and also add to the structural integrity of the vehicle during a collision. The design provides the advantages of both unitized and full frame construction on the same vehicle.

Unibody torque boxes: It allows controlled twisting and crushing of the structure during severe collisions. Unibody torque boxes help to secure the passenger compartment to the frame rails by increasing the surface area.

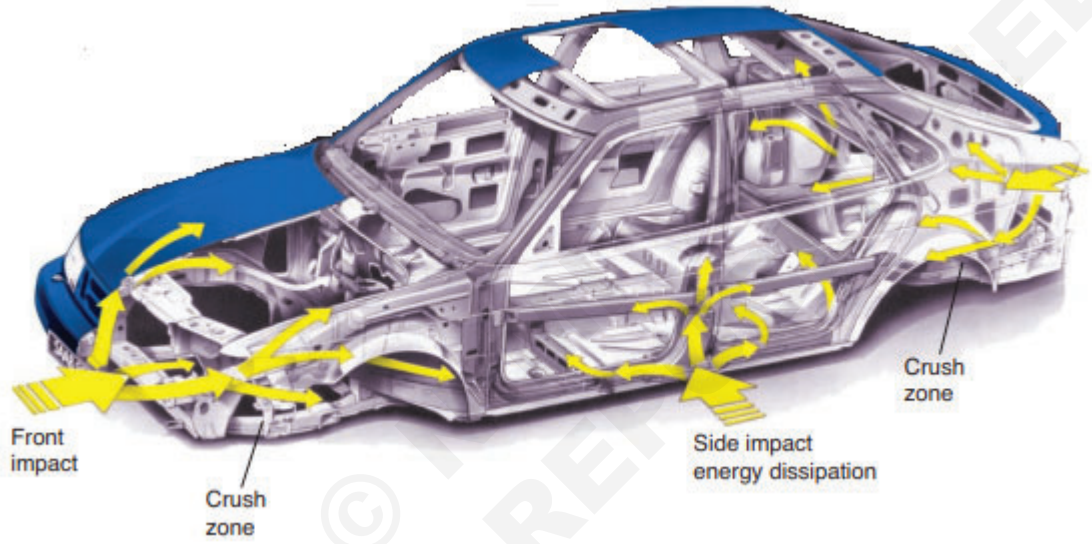
Stress hull design: This type of structure is often compared to an egg shell. This design is used for the bodies of aircraft.

Crush zones: Crush zones are areas in the unibody that are intentionally made weaker in order to collapse during a collisions crush zones provides control of secondary damage and a safer passenger compartment in a unibody structure the front and rear areas will crush, whereas the passenger compartment area tends to stay intact.

Advantages of aerodynamics: Aerodynamics is a measurement of how well a motor vehicle moves without resistance against wind. Vehicle body aerodynamics design helps to increase the vehicle speed against the air resistance and save fuel. A tear drop is the perfect aerodynamic shape or rounded aerodynamic shape for increased fuel economy. Aerodynamic design provide good look to the vehicle.

General unibody characteristics: Vehicle body integrates the frame and body into one assembly is known as a unibody. It has the following characteristics. (Fig 6)

Fig 6



- A unibody structure is made by combining pieces of thin sheet metal pressed to form panels of various shapes and joined into the integrated structure by spot welding. The light weight structure is highly rigid and resistant to bending or twisting.
- The bulk or space taken up by a separate frame can be used to make the car more compact and lighter.
- Vibration and noise from the drivetrain and suspension enter the floor pan are amplified by the body, which acts as an acoustic chamber. This makes it necessary to add extra sound deadening materials to the inside of the body to quiet the passenger compartment.
- Anti corrosion materials are used for prevent rusting of metal parts.
- The stiffer sections used with unibody design even sections that are buckled or torn loose might have pased along heavy force before deforming.
- The unibody underbody includes the floor pan, trunk pan rocker panels cross members, front and rear members and related parts must resist rusting and add strength to the unibody structure.
- There are four basic unibody structures: Front engine, rear drive (FR), front engine front drive (FF), mid engine rear-drive (MR) and rear engine front wheel drive (RR). (Fig 7)
- The transmission and differential are combined and the drive shaft is eliminated, providing a substantial weight reduction.
- Overall noise and vibration are reduced because they are confined to the front of the vehicle.
- The engine and transmission are located in the front, the load on the front suspension and tires is increased.

Plastic parts and panels: (Fig 8) Plastic is a polymer material made from the processing of crude oil. It is a very light, strong, flexible, corrosion resistant material. Plastics parts are being used in the construction of modern new vehicles for various smaller body and trim parts.

Fiber glass is used to strengthen plastic parts, it is a glass filament or fine strands of glass that can be added to plastic to increase its stiffness and strength sheet moulded compound refers to reinforced plastic materials that are formed into body panels. Carbon fiber is a composite of fiberglass cloth reinforced with strands of graphite. Carbon fiber panels are very light and strong.

Fig 7

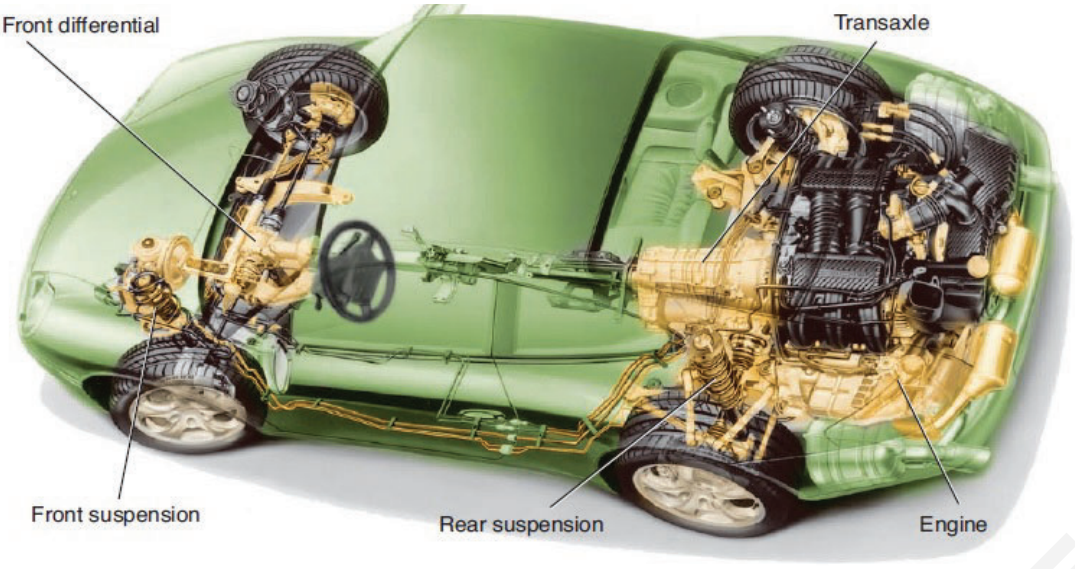
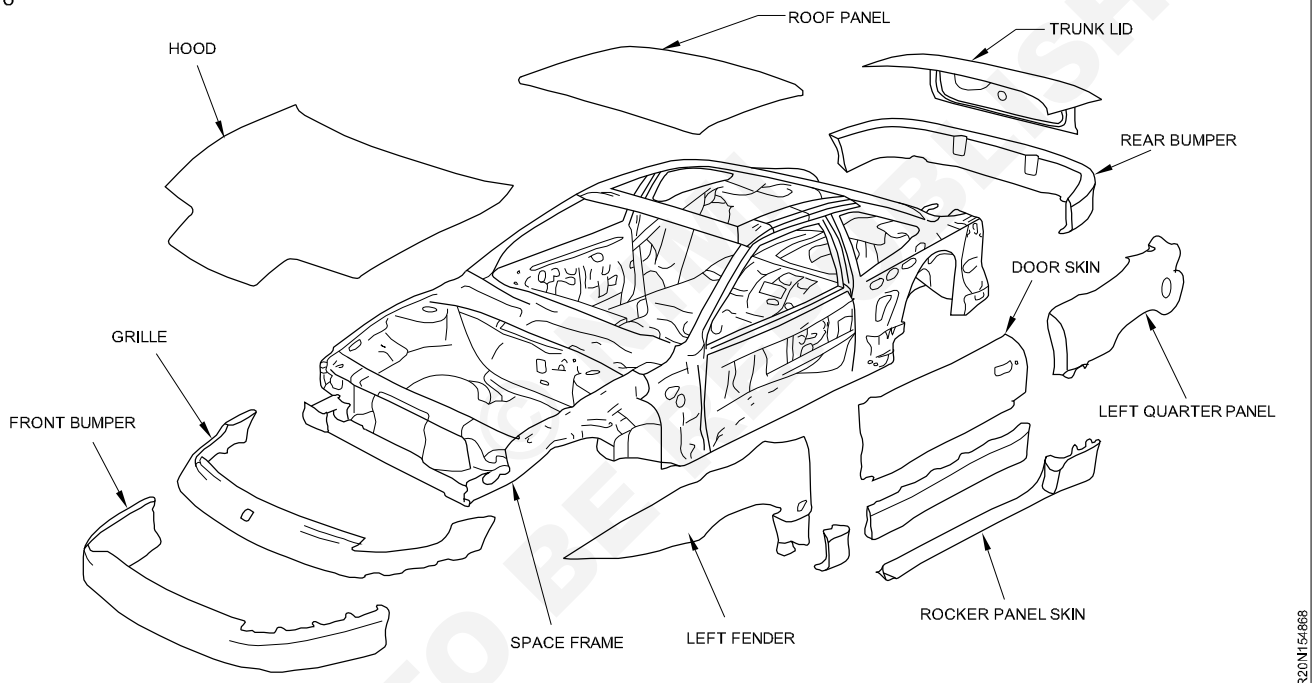


Fig 8



Composite unibody: A composite unibody is made of specially formulated plastics and other materials such as carbon fiber, to form the vehicle many manufacturers are experimenting with composite unibody construction.

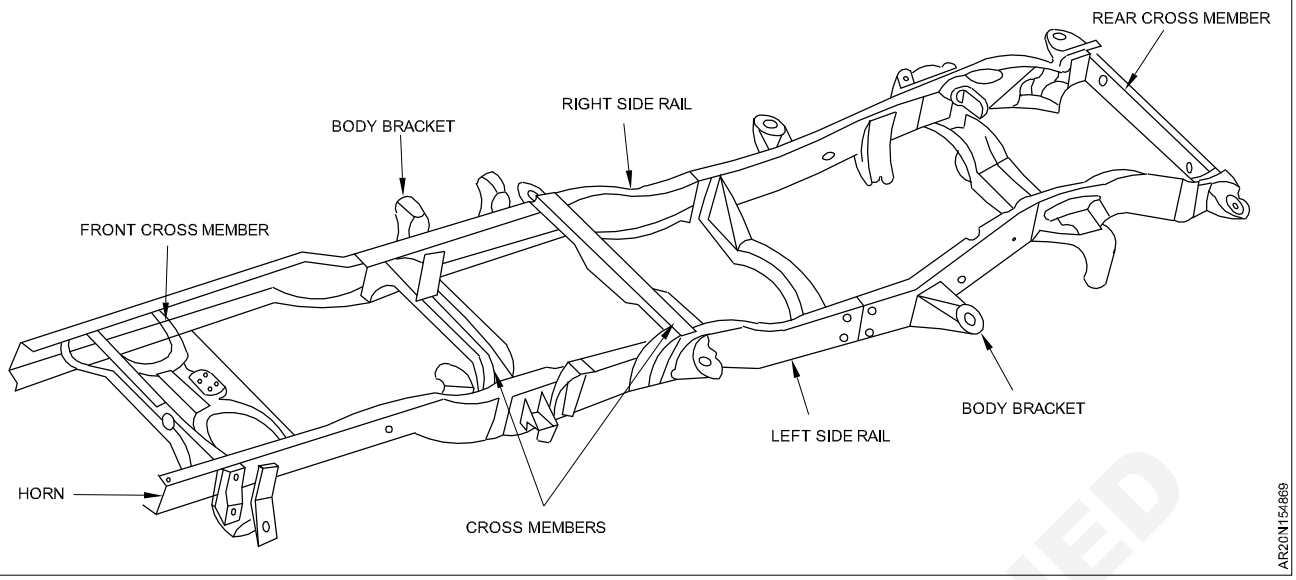
Aluminium vehicle construction: Aluminium is much lighter than steel and can reduce the vehicles curb weight to reduce fuel consumption. Aluminium will also resist rust and corrosion much longer than steel. Aluminium hoods, fenders, roof and other panels are commonly fastened to conventional steel unibody vehicles. Aluminium panels are forced using a super plastic forming process. The aluminium is heated to near its melting point and forced into a complex die using high air pressure. This allows the aluminium to be formed into very complex shapes.

Body-over frame constructions: In this system, the frame is the vehicle's foundation. Vehicle body and all major parts are attached to the frame, it provide the support and strength needed by the assemblies and parts attached to it. The frame is the most important part of the vehicle. (Fig 9)

Characteristics of body over frame vehicles

- Fewer road-induced vibrations are transfered to the body.
- Rubber mountings between the body and frame insulate the body from vibrations and noise, providing a quiet interior.
- High amounts of energy can be absorbed by the frame during some collisions.
- Under surface of the thin body panels are protected over rough roads by the thick frame work.
- Suspension and power train parts can be quickly assembled on the basic frame.

Fig 9



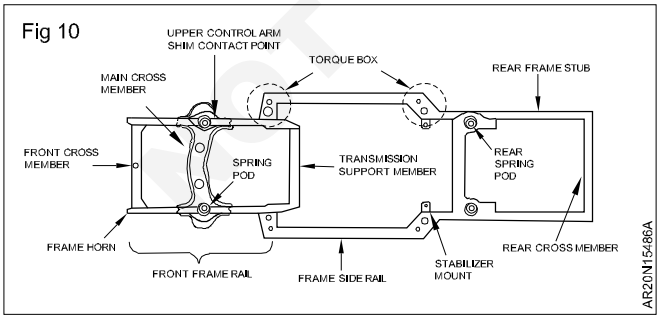
- A heavy frame made of thick sheet metal is approximately $\left(\frac{3}{64}\text{ to }\frac{1}{8}\text{ inch}\right)$ 12 to 3.1 mm thick
- The vehicle ride height is often higher off the ground.
- Total vehicle weight is increased over unibody construction, which lowers fuel economy and handling.
- The load - carrying ability of body-over frame construction is normally higher than for unibody construction.

Full frame designs: There are three types of conventional vehicle frame have been used by the auto industry. They are as follows.

- Ladder frame
- Perimeter frame
- X-frame or backbone frame

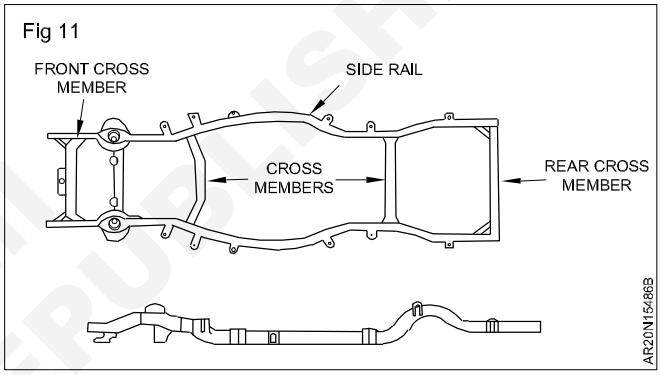
The ladder frame consists of two side rails not necessarily in parallel, connected to each other by a series of cross members like ladder. This type of frame improved to absorb impact energy more efficiently. (Fig 10)

Fig 10



The perimeter frame's full length side rails supports the body at its greatest width, which provides more protection to the passengers in the event of the side impact to the body. The areas behind the front wheels and in front of the rear wheels are stepped to form a torque box structure. (Fig 11)

Fig 11



The 'X' frame narrows in the center giving the vehicle a rigid structure that is designed to with stand a high degree of twist. Heavy front cross members are used to support the upper and lower suspension control arms and coil springs. (Fig 12)

Now a days 'X' frame considered as absolute model.

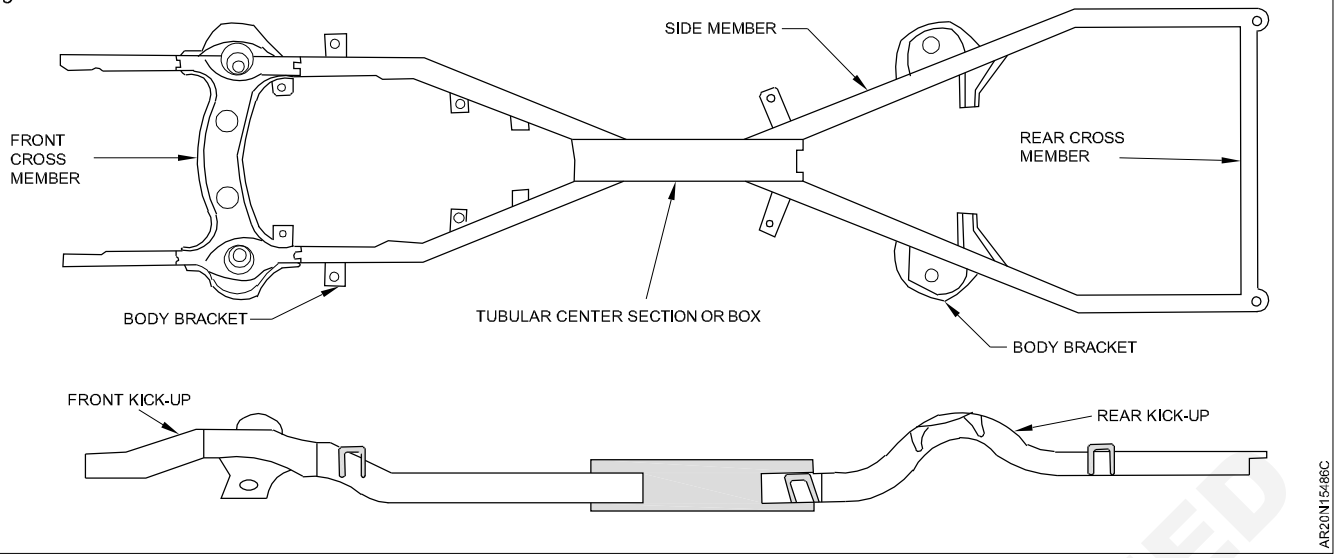
The back bone frame has a single thick beam or box section in the center section it is used some of sports cars.

Crash testing: The computer simulated crash testing helps to determine how will a new vehicle might survive a crash. Computer simulated testing is used before building a prototype or faulty structural areas prior to investing in mass production. Computer readings from the sensors in the crash test dummies give feed back in the form of raw date about each test for body structure and potential injury evaluation.

Types of crash tests: There are many types of crash tests are used to evaluate the vehicle structural integrity and safety.

- Full frontal crash test
- Offset front crash test
- Side impact crash test
- Whiplash testing
- Bumper crash testing

Fig 12



Full fronted crash test pulls the vehicle squarely into a solid in mobile wall at 35 mph (milli per hour). So that the whole front of the vehicle hits the barrier. This type of test measures the effectiveness of the restraint systems used to protect the driver and passengers.

Offset front crash test, the vehicles are pulled at 40 mile per hour into a solid barrier that only impacts the drivers side of the front end. This test is better at evaluating the structural integrity of the vehicle bumper, front frame rail, fender, apron and related parts fitted in front side of the vehicle. This test measure how much damage the front and section can with stand before impact test force enters the passengers compartment of the vehicle.

Side impact crash testing is done by moving a 3000 pound sled into the side of the vehicle at 38.5 mile per hour speed side impact crash test are done on the drivers side only done. This test measured how well the doors, pillars, rocker panels and other structured panels protect the passengers compartment. This test also measured the effectiveness of the side air bags and shoulder hardness.

Whiplash testing is done determine injury from rear-end collisions. The test vehicle is hit from the rear with a sled. This test evaluates the seat head rests a good, acceptable, marginal in terms of protection from neck injuries.

Bumper crash testing involves a 5 mile per hour speed impact to determine the amount of damage to the front and rear ends of the vehicle.

Service information

Objectives: At the end of this lesson you shall be able to
- **achieve the vehicle service information**
- **state the vehicle specifications and measurements.**

Introduction to vehicle service information: Now a days motor vehicles are built to exacting standards using various manufacturing methods, Which results in different method repair. Because it is impossible to memorize all of the service details needed to rebuild the damaged vehicles. The service information of vehicle gives a vehicle manufacturing year, make and model efficiently. Vehicle service information data sheet gives the details of vehicle service charts, symbols, abbreviations and technical illustrations.

The measurements are number valves that help control repair process in collision repair. Measurements are needed to measure the structural damage, straighten frame damage, mix paint, adjust spray gun pressure, do a wheel alignment, torque a bolt and numerous other repair tasks vehicle manufacturers give specifications for numerous repair procedures, body straightening dimensions, bolt or nut torque valves, material thickness, electrical values and other critical information. Vehicle specifications helps to refer and to a competent vehicle body repairs.

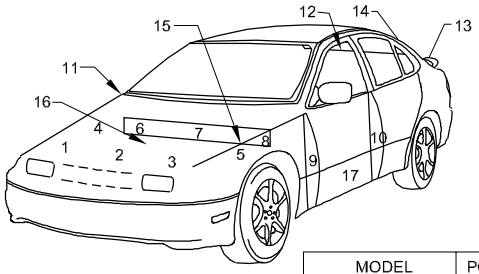
Service information: Vehicle service information includes written instructions and technical information, it helps to properly repair a damaged vehicle parts. It is published by vehicle manufacturers. There are different type of serve information provided by vehicle manufacturers (1) Printed service information (2) Computer based service information (3) Shop publications. All automobile companies publish yearly service manuals that describe the construction and repair of their vehicles.

The contents pages of a service manual list the broad categories in manual and gives page numbers. Each service manual section concentrates on describing one area of repair, body parts, interior parts, suspension system, brakes and other system parts technical specification and repair methods.

Basic steps to using refinishing materials information: Refinishing materials information will help allocate the right amounts for refinishing materials and calculate their cost for each job. The refinishing guides explain paint codes, type of paints and how to apply and buff paints and also describe other paint related information. Refinishing guides and software include information on the following.

- Paint code locations (Fg 1)
- Paint code explanations
- Body work materials
- Plastic and fiber glass materials
- Sanding and buffing materials
- Blending paints
- Low volatile organic compound information

Fig 1



MODEL	POSITION
ACURA	9
ALFA ROMEO	4,13
AMC	9,10
AUDI	12,13
AUSTION ROVER	17

MODEL	POSITION
COLT VISTA	16
CONQUEST	7
DAIHATSU	1,6,7
DATSUN	2
DODGE D50	3
FORD	10
FORD MOTOR CO	10
GENERAL MOTORS	
A,J AND L BODIES	14
E AND L BODIES	12
B,C,H AND N BODIES	13
GM IMPORTS	2,12,13,14
HONDA	8,10
HYUNDAI	6,7
ISUZU	2,10
LEUZU	7,8
MAZDA	1,2,3,4,6,8
MERCEDES	2,7,9

MODEL	POSITION
MITSUBISHI	7
MONTERO/PICKUP	3
CORDIA/TREDIA	4
OTHERS	1,2,3
NISSAN	1,3,4,6,8,15
PEUGEOT	2,3,4,5,8
PORSCHE	9
RENAULT	1,3,4,5,8
REVER	1,3,4,5
SAAB	5,6,8
SUBARU	2
SUZUKI	7,11
TOYOTA PASSENGER	7,8,14
TRUCK	4
VOLKSWAGEN	2,11
VOLVO	6,7,8
YUGO	

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Steps to using refinishing materials information

1 Look up the paint code tag location

2 Find the paint code/colour page information in the reference material for the vehicle being required.

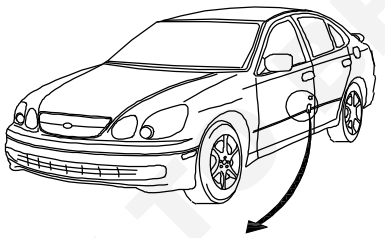
3 Study the cost information for the specific vehicle being required including single stage colour, colour coat, clear coat and three stage finishes.

4 Refer to the additional information for refinish time two-tone paint and so on.

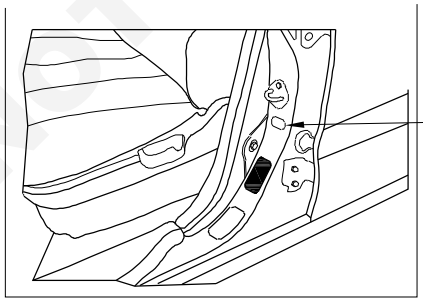
5 Follow the vehicle manufacturers make and particular specific instructions.

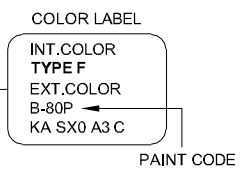
Vehicle paint code: The paint code is an alpha numeric code that states the type and colour of paint was used during vehicle manufacturing. The body ID number or service part label given information about the finish paint and trim are used on a specific vehicle. The vehicle body identification number will be on the body ID plate in various locations on the vehicle. (Fig 2)

Fig 2



VEHICLE IDENTIFICATION NUMBER AND FEDERAL MOTOR VEHICLE SAFETY STANDARD CERTIFICATION





PAINT CODE	COLOR
B-80P	MYSTIC BLUE PEARL
B-91M	CRYSTAL BLUE METALLIC
G-83P	EUCALYPTUS GREEN PEARL
NH-578	TAFFETA WHITE
RP-25P	DARK CURRANT PEARL
YR-508M	HEATHER MIST METALLIC

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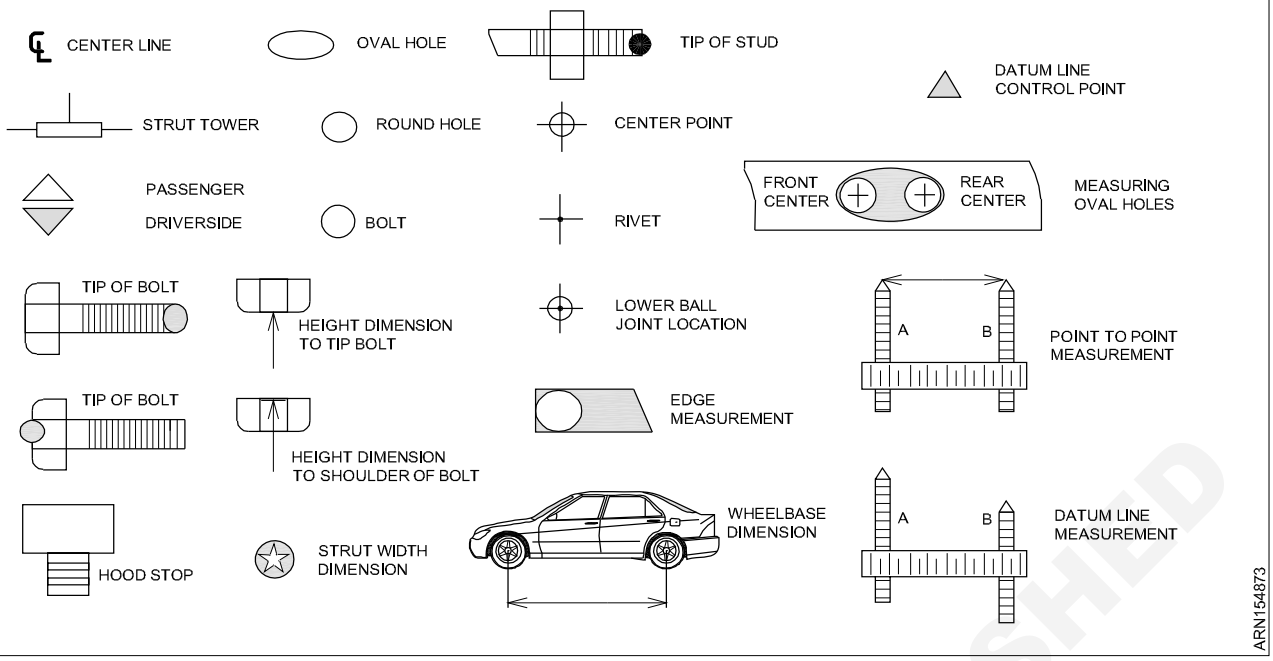
Service Abbreviations: Service abbreviations are a short series of letters that represent technical terms or words. Each manufacturers uses slightly different abbreviations.

Service symbols: Service symbols are small pictures that represent a location, part, procedures safety warning, measurements point or other aspect of repair. Symbols use varies from publication to manufacturers publishers. (Fig 3)

Fig 3



Service charts: Repair charts give diagram give diagrams that guide through logical steps for making vehicle repairs. Through they vary in content and design, most use arrows and icons (graphic symbols to represent repair steps).

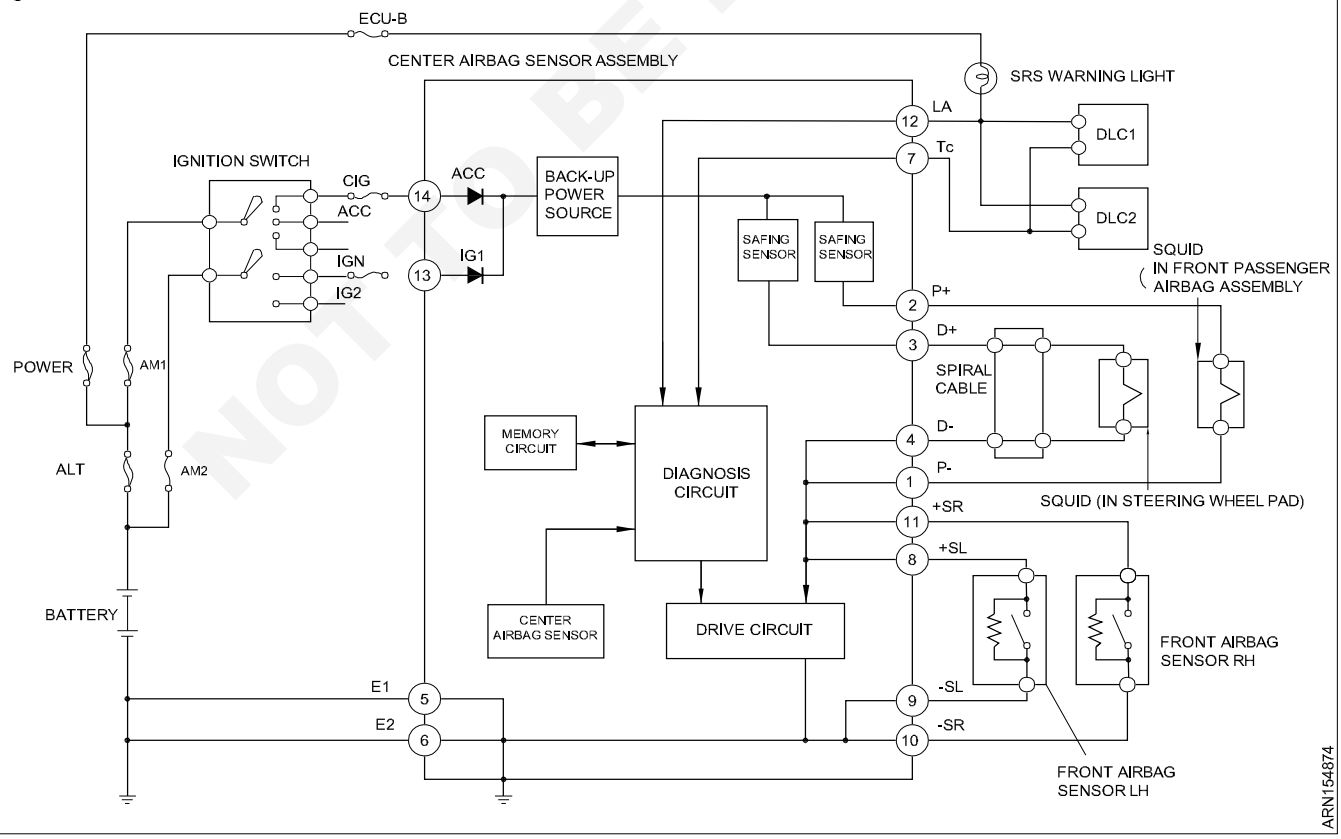
The diagnosis charts given logical steps for finding the source of problems, mechanical, body, electrical and other types of trouble shooting charts are provided in service manuals and computer based service information. These trouble shooting charts gives the common source of problems for the symptoms.

Paint reference charts list comparable paints manufactured by different companies. This will help to match the colour of the paint to be used during refinishing with the paint already on the vehicle.

Wiring diagrams (Fig 4)

Wiring diagrams are drawings that show the location of electrical components. They show how wires are routed to electronic parts, fuses, circuit breakers, electronic control unit and other electrical components. During major collision

Fig 4

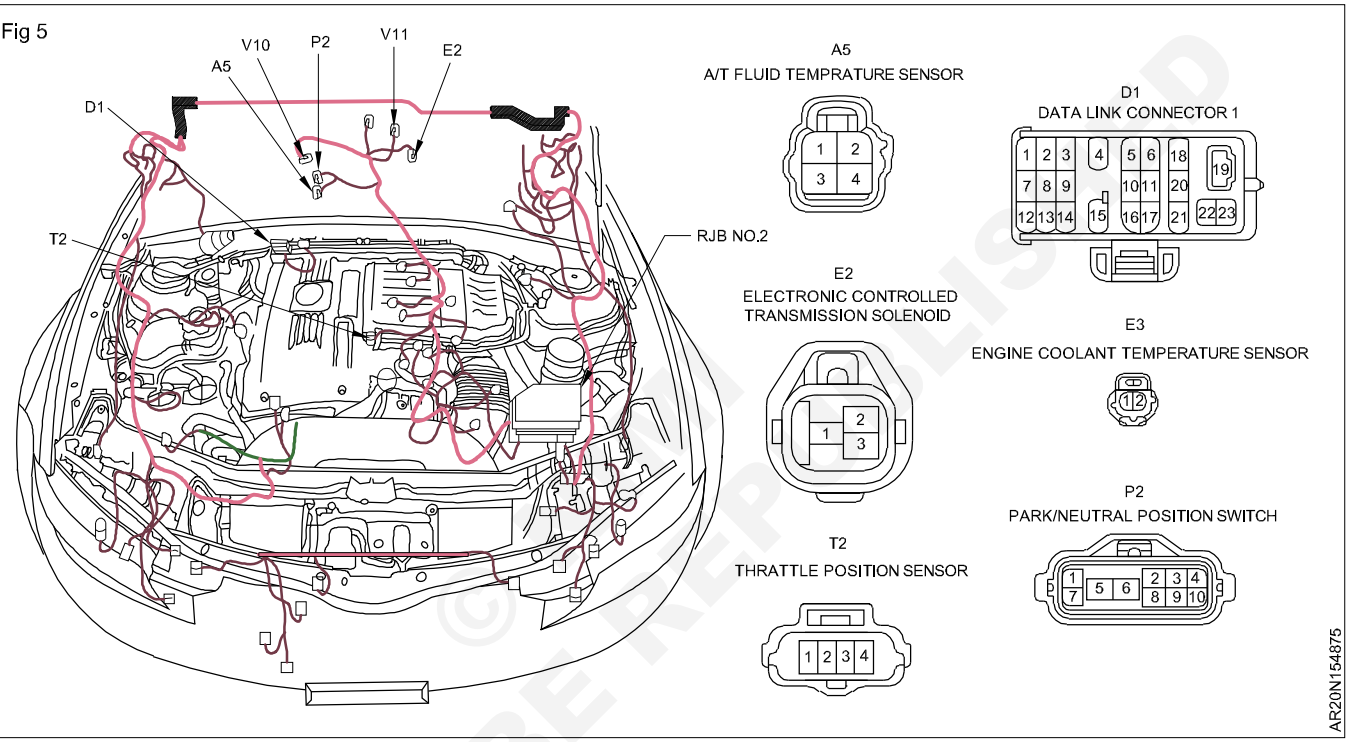


of the vehicle the wire and electronic parts can be cut and damaged. That time it require replacement with help of wiring diagrams. Vehicle wiring diagram give service information for all major electrical systems as follows. (Fig 4)

- Starting and charging systems
- Car A/C system
- ABS brake system
- Cruise control system
- Power window and door locks
- Interior and exterior lights
- Lighting systems
- Computer data lines
- Audio and videos systems

Collision repair measurements: (Fig 5) Most of the vehicle assembly at the factory uses automated conveyors and robotics, which results in motor vehicles that are built to closer tolerances than over before. This requires auto body repair mechanic to measure accurately and repair vehicles precisely. The accurate measurement is one of the most important aspects of todays collision repair industry. English and metric system is used for measuring auto body collision repair.

Fig 5



AAM	All Active Module
AAS	Automatic Adjusting Suspension
ABS	Antilock Braking System
ACE	Active Cornering Enhancement
A/C	Air Injection Reactor
AIR	Air Injection Reactor
Add'l	Additional
Adj	Adjus/Adjuslable
ADS	Adapt ive Damping System
Alum	Aluminium
Alt	Alernator
AOT	Automat ic Overdrive Trans
ASC	Auto Stability Control
ASC&T	Auto Stability Control Plus Tranction Control
ASD	Auto Locking Differential
ASR	Automatic Slip Control
Assy	Assembly

ATC	Automatic Temp Control
Attach	Attachments
Aux	Auxiliary
AWD	All Wheel Drive
BAS	Brake Assist System
Batt	Battery
BPMV	Brake Pressure Modulator Valve
BPT	Back Pressure Transducer
Brg	Bearing
BSC	Battery Safety Clamp
Bush	Bushing
"C"	Cleveland Eng
CB	Citizens Band Radio
CC	Cubic Centimeters
CCC	Computer Command Control
CCT	computer Controlled Timing
Ch	Chassis
CNG	Compressed Natural Gas

Comb	Combination
Comm	Communication
Comp	Compression. Compressor
Compt	Compartment
Cond	Condenser or Conditioning
Cont	Control
Conv	Convertor or Convertible
CPI	Central Port Injection
Cr/Cont	Cruise Control
Ctr	Center
CV	Constant Velocity
D	Discontinued
D&A	Disassemble & Assemble
D & C	Dissconnect & Connect
DEFI	Digital Electronic Fuel Injection
Defi	Deflector
DERM	Diagnostic Energy Reserve Module
Diaph	Diaphragm
Diff'I	Differential
DME	Digital Motor Electronics
DOHC	Dual Over Head Cam
DPMS	Driving Position Memory system
DRL	Daytime Running Lights
DSTC	Dynamic Stability Traction Control
Eatx	Electronic Automatic Transmission Control
EBCM	Electronic Automatic Transmission Control
EBCM	Electronic Brake Control Module
EBTC	Electronic Brake and Traction Control
ECM	Electronic Control Module
ECS	Emission Control System and Electronic Crash Sensor
EEC	Electronic Engine Control
EFC	Electronic Fuel Control
EFE	Early Fuel Control
EFI	Electronic Fuel Injection
EGR	Exhaust Gas Recirculation
EGS	Elect Trans Gear System
Elec	Electric
Elect	Electronic
ER	Evaporator Pressure Regulator
EPS	Electrical Power Steering
Equip	Equipment
ESP	Electronic Stability Program
EST	lectronic Spark Timing
ETR	Emergency/Energy Tension Reactor
ETS	Electronic Traction System
Evap	Evaporator

Ev-Em	Evaporative Emission Control
Ech	Exhaust
Ext	Extended or Extension
Frt	Fuel Injection
Frt	Front
Fwd	Forward
FWD	Front Wheel Drive
Gal	Garage door opener
GDO	Garage Door Opener
Gskt	Gasket
GVW	Gross Vehicle Weight
HCU	Hydraulic Control Unit
HD	Heavy Duty
HHEI	High Energy Ignition
HFM	Hot Film Management
HICAS	High Capacity Suspension
HID	High Intensity Discharge
H/lamp	Headlamp
HO	High Output
HP	Horsepower
Hsg	Housing
HSLA	High Strength Low Alloy Steel
HUD	Head Up Display
HV	High Voltage
HVAC	Heater Ventilation Air Conditioning
Hvy	Heavy
Hyd	Hydraulic
ID	Identification or Inside Diameter
Ign	Ignition
Ilium	Illuminated
IMA	Integrated Motor Assisted
Inr	Inner
Inst	Instrument
IVD	Interactive Vehicle Dynamics
Inter	Intermediate
IOH	Included in Overhaul
ITS	Inflatable Tubular Structure
Km	Klometer
KPH	Kilometer Per Hour
L	Liitre or Left
Lb	Pound
Lic	License
LSD	Limited Slip Differential
Lwr	Lower
"M"	Modified Eng
Man	Manual
Map	Manifold Absolute Pressure
M.D	Medium Duty

MDM	Motor Drive Module
Med	Medium
MFI	Multi-Point Fuel Injection
Mtd	Mounted
Mtg	Mounting
N.A	Not Available
Nav	Navigation
NOx	Nitrogen Oxide Emission Control
NP	New Process
OBD	On-Board Diagnostic
OD	Outside Diameter
O/D	Overdrive
O/H	Overhaul
OHC-	Over Head Cam
OHV	Over Head Valve
OPDS	Occupant Position Detector Sensor
ORVR	On Board Refueling Vapor Recovery
Otr	Outer
Opng	Opening
PAIR	Pulse Air Injection Reactor
PCM	Powertrain Control Module
Pass	Passenger or Passive
Pert	Performance
Pnl	Panel
Pos	Positive
PPD	Passenger Presence Detection
Press	Pressure
PTO	Power Take Off
Pwr	Power
Qtr	Quarter
R	Right
R	Radiator
Rect	Rectangular
Refrig	Refrigeration
Reg	Regulator or Regular
Reinf	Reinforcement
Resv	Reservior
R & I	Remove & Install
R & R	Remove & Replace
RPO	Regular Production Option
RWD	Rear Wheel Drive
SAM	Signal Acquisition Module
ABEC	Signal board engine control
SDM	Sensing & Diagnostic Module
Sect	Section
Sed	Sedan
SEFI	Sequential Electronic Fuel Injection

Sgl	Single
SIPS	Side Impact protect system
SIR	Supplement Inflatable Restraint
SISM	Side Impact Protect System
SIR	Supplemental Inflatable Restraint
SISM	Side Impact Sensing Module
SLS	Self levelling Suspension
SOHC	Single Over Head Cam
Speedo	Speedometer
SRS	Supplemental Restraint System
Stab	Stabilizer
Std	Standard
Stpd	Stamped
Strg	Steering
Supt	Support
Susp	Suspension System
Tach	Tachometer
TBI	Tgrottle Body Injection
TCS	Traction Control System
TDC	Top Dead Center
TDI	Turbo Direct Injection
Temp	Temperature
TEMS	Toyota Electronic Modulated Suspension
T/Gate	Tailgate
TH	Turbo Hydra-Matic
TLEV	Transitional Low Emission Vehicle
Trans	Transmission
Transf	Transfer
Upr	Upper
Vac	Vacuum
VIN	Vehicle Identification Number
VIR	Valve in Receiver
VSC	Vehicle Skid Control
VTEC	Valve Timing Electronic Control
“W”	Windsor Eng
Warn	Warning
Whlhse	Wheelhouse
W/S	Windshield
W/Strip	Weatherstrip
X-Cool	Extra Cooling
Xmbar	Crossmember
	- MISC:-
4x2, 2WD	2- Wheel Drive
4x4, 4 WD	4-Wheel Drive
2 WS	2- Wheel Steering
4 WS	4 – Wheel Steering

Compressor air system

Objectives: At the end of this lesson you shall be able to
- **state the types of compressor**
- **different types of air purification method.**

Basic requirement for compressed air systems: Air compressor is designed to compress air to higher pressured and harness this potential energy source. Compressed air power many different kinds of devices., it can be used to push a piston, as in a jack hammer, it can go through air turbine to a shaft, as in a dental drift or it can be expanded through compressed air provides torque and rotation power for pneumatic tools, such as drills, brushes, nut turners, riveting guns and screw driver. Such tools are generally powered by some form of rotary air motor such as the vane of tube type or by an air turbine.

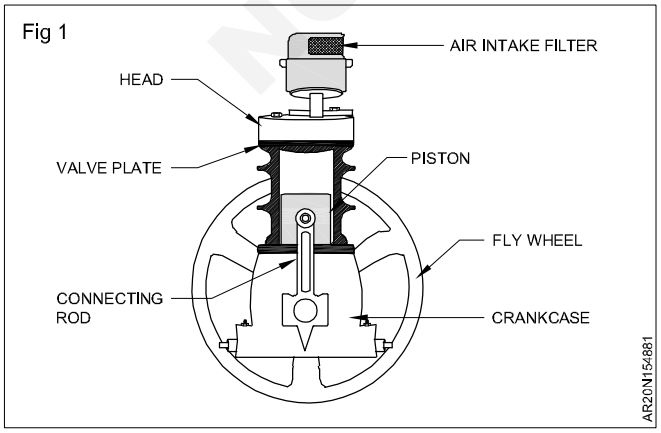
Common applications in industrial plants and on construction site are air powered nail guns, stephers, torque wrenches, screw drivers. Paint spraying and conveying of material. In paint spraying and in air conveying the dynamic pressure of the air imparts motion.

Types of compressors: Air compressors in sizes 30 horsepower and below include both reciprocating and rotary compressors, which compress air in different ways. Major types of reciprocating compressors include reciprocating single acting, reciprocating diaphragm and reciprocating rocking piston type. Major types of rotary air compressor include rotar sliding vane, rotary helical screw and rotary scroll air compressors.

Reciprocating single acting compressors: Reciprocating single acting compressors, are generally one-stage or two-stage. Compressors can be of a lubricant, non-lubricant or oil-less design.

In the single-stage compressor, air is drawn in from the atmosphere and compressed to final pressure in a single stroke.The single-stage reciprocating compressor is illustrated in Fig 1. Single-stage compressors are generally used for pressures of 70 psi (pounds per square inch) to 135 psi.

Fig 1



The two-stage compressor, air is drawn in from the atmosphere and compressed to an intermediate pressure in the first stage. Most of the heat of compression is removed as the second stage, where it is compressed to final pressure. Two-stage compressors can include two cylinder designs. The two-stage reciprocating compressor is illustrated in figs 2 & 3.

Fig 2

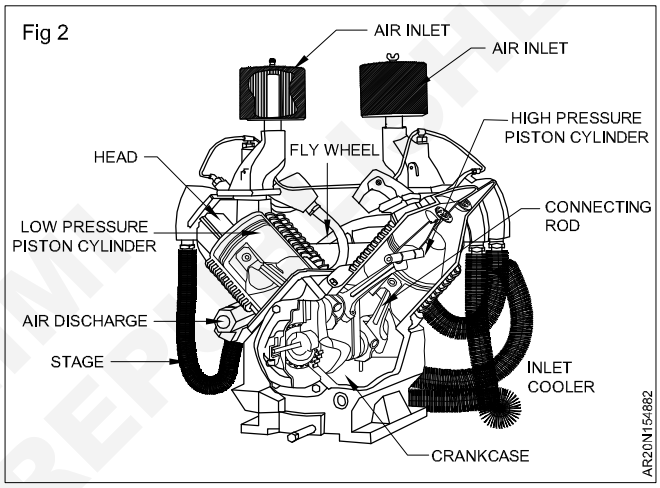
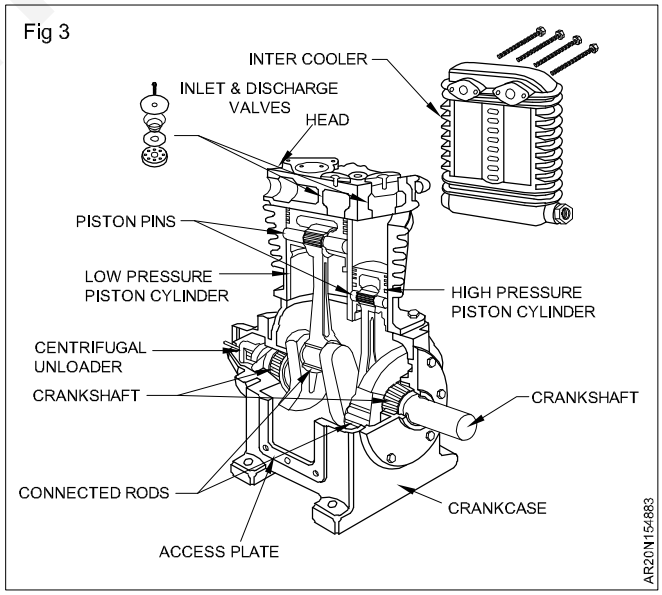
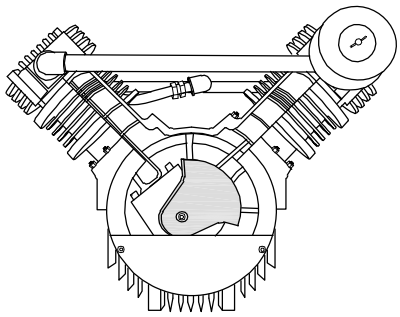


Fig 3



Single and two-stage reciprocating compressors are frequently used in auto and truck repair shops, body shops, service business and industrial plants. Although this type of compressor is usually oil lubricated, hospitals and laboratories can purchase oil-less versions of the compressors as illustrated in Fig 4.

Fig 4



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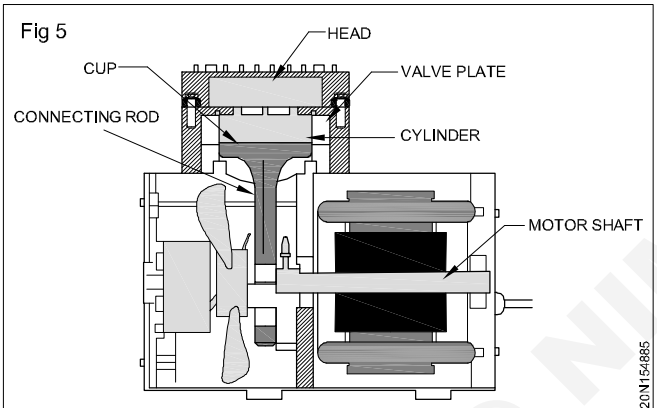
Rocking piston type: Rocking piston compressors are variations of reciprocating piston type compressors. (Fig 5). This type of compressor develops pressure through a reciprocating action of a one-piece connecting rod and piston. The piston head rocks as it reciprocates. These compressors utilize non-metallic low friction rings and do not require lubrication. The rocking piston type compressors are generally of a smaller size and lower pressure capability.

Fig 5



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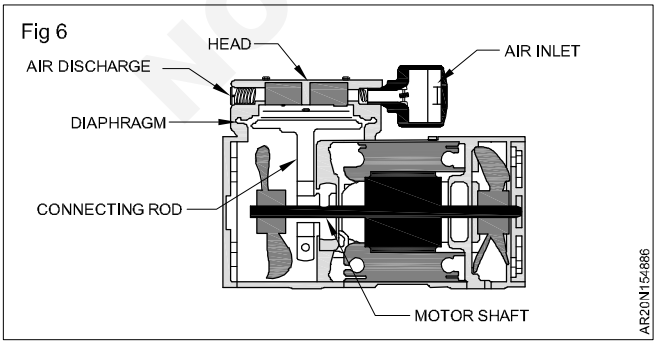
Diaphragm type

Diaphragm compressors (Fig 6) are a variation of reciprocating compressors. The diaphragm compressor develops pressure through a reciprocating of oscillating action of a flexible disc actuated by an eccentric. Since a sliding seal is not required between moving parts, this design is not lubricated. Diaphragm compressors are often selected when to contamination is allowed in the output air or atmosphere, such as hospital and laboratory applications. Diaphragm compressors are limited in output and pressure and they are used most often for light-duty applications.

Fig 6



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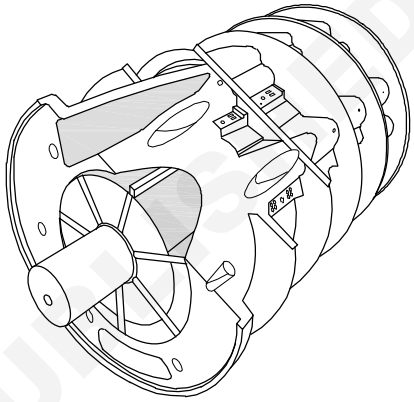
Rotary sliding vane type: The rotary vane compressor consists of rotor mounted eccentrically in a housing (Fig 7). As the rotor turns, the vanes slide out by centrifugal force until they seal against a thin film of lubricant coating the stator wall. There is no metal-to-metal contact as the blade tip glides on the surface of the lubricant. Air compression occurs when the volume of the spaces between the sliding vanes is reduced as the rotor turns in the eccentric cylinder. Single-stage rotary vanes are oil injected and are most common in industrial applications ranging in pressure from 60 psi to 200 psi, use flow-through lubrication that "consumes" lubricant and are most typically used in moving bulk material i.e. concrete. While there are oil-free rotary vane blowers and vaccum pumps, rotary vane compressors are not oil free.

Fig 7



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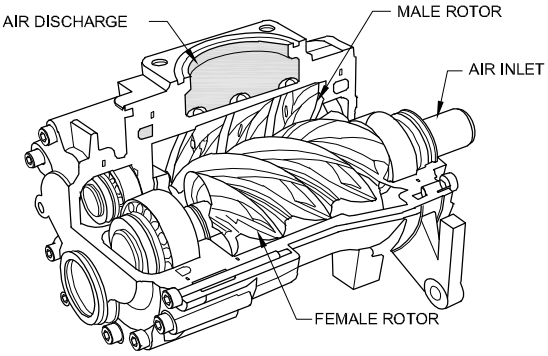
Rotary helical screw type: Rotary helical screw compressors (Fig 8) utilize two intermeshing helical rotors in a twin-bore case. In a single-stage design, the air inlet is usually located at the top of the cylinder near the drive shaft end. The discharge port is located at the opposite end of the cylinder. As the rotors unmesh at the air inlet end of the cylinder, air is drawn into the cavity between the main rotor lobes and the secondary rotor grooves. As rotation continues, the rotor tips pass the edges of the inlet posts, trapping air in a cell formed by the rotor cavities and the cylinder wall. Compression begin as further rotation causes the main rotor lobes to roll into the secondary rotor groove, reducing the volume and raising cell pressure.

Fig 8



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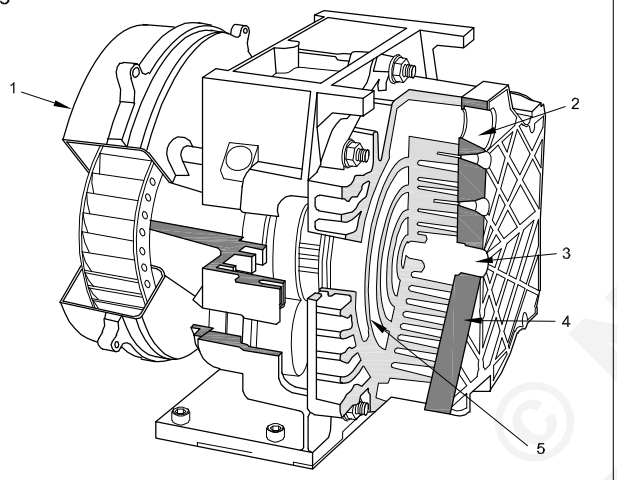
Oil is injected after cell closing to seal clearance and remove heat of compression. Compression continues until the rotor tips pass the discharge porting and release of the compressed air and oil mixture is obtained. Single or multi-stage version are available. This type of compressor can be oil lubricated, water lubricated or oil-free. Some advantage of the rotary helical screw compressors are smooth and pulse-free air output, compact size, high output volume, low vibrations, prolonged service intervals and long life.

Rotary scroll type: Air compression within a scroll in accomplished by the interaction of a fixed and an orbiting helical element that progressively compresses inlet air (Fig 9). This process is continuously repeated, resulting in the delivery of pulsation-free compressed air. With fewer moving parts, reduced maintenance becomes an operating advantage. Scroll compressors can be of lubricated or oil-free design.

Fig 9



1 COOLING FAN WITH INTEGRAL
2 AFTER-COOLER
3 AIR INTAKE
4 AIR DISCHARGE
5 FIXED SCROLL
6 ORBIT SCROLL

Types of controls: Controls are required for all compressors in order to regulate their operation. In accordance with compressed air demand. Different controls should be chosen for different type of compressor applications and requirements.

For continuous operation, when all or most of the requirements are of a steady nature, constant speed controls are required. Use constant speed controls whenever the air requirement is 5 percent or more of the free air delivery of the air compressor or when motor starts per hour exceed motor manufacturer recommendations. Constant speed controls include load/unload control for all types of compressors and inlet valve modulation for rotary compressors.

Start-stop controls are recommended for a compressor when adequate air storage is provided and air requirement is less than 75 percent of the compressor free air delivery.

Variable speed controls are utilized when energy efficiency is an important criteria in selecting an air compressor. This type of control is most commonly found in rotary screw and rotary vane compressor packages. A variable speed drive will control the speed of the motor and dynamically adjust the speed (increase or decrease) in order to meet the air demand required by the application.

Dual controls allow for switching between constant speed and start-stop operation by setting a switch. With dual controls, the operator can select a different type of control to suit his or her specific are requirements each time the compressor is used. Dual controls are helpful when a compressor is used for a variety of applications that vary between intermittent and continuous-duty.

Sequencing controls provide alternate operation of each compressor at each operating cycle and dual operation during peak demands. Sequencing controls are ideal for operating duplex air compressors or a group of compressors at peak efficiency levels or when 100 percent back-up air might be required for critical applications.

Types of drives

Most compressors are driven by electric motors, internal combustion engines or engine power takeoffs. Typically, power is transmitted by one of these sources with V-Belt,gear or direct drive configurations. Alternatively, a compressor can have an engine drive. However, an engine drive must use one of the traditional drive types to transmit power. Three common type of drives are used with these power sources.

V-Belt drives are most commonly used with electric motors and internal combustion engines. V-Belt drives provide great flexibility in matching compressor load to power source load and speed at minimum cost. Belts must be properly shielded for safety.

Gear drives are commonly used with electric motors and provide a reduction of the axial load on the compressed air producing element, extending the operational lifetime. More working points in the optimal working range provide a reduction in shear force.

Direct drives provide compactness and minimum drive maintenance. Compressors can be flange-mounted or direct-coupled to the power source. Couplings must be properly shielded for safety. Lower horsepower compressors also are built as integral assembles with electric motors.

Engine drives gasoline or diesel engine or power takeoff drives are used primarily for portability reasons. A gear box, V-belt or direct drive is used to transmit power from the source to the compressor.

Air compressor performance

Delivery (ACFM/SCFM)

The volume of compressed air delivered by an air compressor at its discharge pressure normally is stated in terms of prevailing atmospheric inlet conditions. (acfm) The corresponding flow rate in Standard cubit feet per minute (scfm) is measured at 14.5 psi (1 bar) 68°F (20°C) and 0% relative humidity.

Varying flow rates for more than one discharge pressure simply reflect the reduction in compressor volumetric, efficiency that occurs with increased system pressure (psig) for this reason, of a compressor the maximum operating pressure of a compressor should be chosen carefully.

Displacement

For a reciprocating (piston) compressor displacement (cfm) is defined as the volume of the first stage cylinder(s) of a compressor multiplied by the revolutions of the compressor in one minute. For a rotary screw compressor, displacement (cfm) is the volume at suction per thread times the number of lobes on the driving rotor.

Accessories

Standard accessories are available to help ensure reliable and trouble-free compressor operation. Some special purpose devices disc are available to meet unusual requirements. Below is a list of commonly used accessories.

Air receiver

A receiver tank is used as a storage reservoir for compressed air. The reservoir prevents the compressor from operating in a continuous run cycle. The receiver allows the compressed air an opportunity to cool. The receiver can be a separate item or can be integrated as part of the compressor package.

Air treatment products

Compressed air treatment products are designed to remove oil and water in a liquid or gaseous state from the compressed at stream. These products include but are not limited to moisture separators, air drivers, air filters and oil/water separators. The use and implementation of these products are highly dependent on the specific process and application. Further details can be found in the Air Compressor System section of this document.

A compressed air expert should be contacted or consulted when working through any compressed air system requirements.

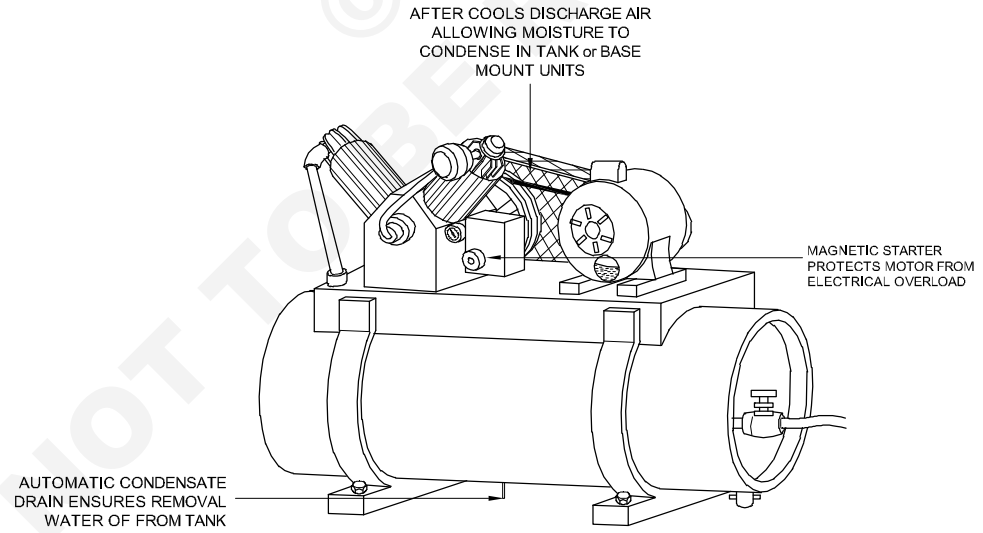
Belt Guard

A belt guard's primary function is safety and it is only utilized on belt drive machines. The belt guard prevents access to fast moving and potentially dangerous components on the compression from both sides of the drive. The belt guard is a mandatory feature for all v-belt driven compressor units where flywheel, motor pulley and belts are used. Compressors 30 horse power and below are available as direct or gear drive and do not require belts or belt guards.

Diagnostic controls

Protective devices are designed to shut down a compressor in the event of malfunction. Devices may include high at temperature shut down, preventive maintenance shut down, etc. These protective devices may be individual sensors or may be monitored by a compressor controller depending on male and model of compressor. (Fig 10)

Fig 10



AIR COMPRESSOR

Intake filter

The intake filter eliminates foreign particulate matter from the ambient air at the intake suction of the air compressor system.

Magnetic motor starters: Magnetic starters provide thermal over-load protection for motors and are recommended for integral horsepower and all three-phase motors. Many compressors come standard with starters, however, when a starter is purchased separately from the compressor, local electrical codes should be checked prior to installation.

Duplex tank mounted compressor with alternator panel

Starters can be configured as full-voltage or reduced voltage. A common type of reduced voltage starter is a wye-delta. A wye-delta starter will reduce the amount of in-rush current to the motor upon initial turn on a compared to a full-voltage starter. A wye-delta starter is also commonly referred to a star-delta configuration. As a note, the motor must be wired to support a wye-delta starter, not all motors support this type of starter configuration.

Variable speed drives: This type of drive is most commonly found in rotary scew and rotary vane compressor packages. A variable speed drive will control the speed of the motor and dynamically adjust the speed (increase or decrease) in order to meet the air demand required by the application. In addition, this type of drive reduces in-rush currents upon initial start-up below that of full-voltage or wye-delta starters.

Air compressor installation

Location

The air compressor location should be a close as possible to the point when the compressed air is to be used. It is also important to locate the compressor in a dry clean, cool and well-ventilated area. Keep it away from dirt, vapour and volatile fumes that may dog the intake filter and valves. If a dry, clean space is unavailable a remote air intake is recommended.

On reciprocating type compressors the fly wheel side of the unit should be placed toward the wall and protected with a totally enclosed belt guard, but it no case should the fly wheel be closer than 12 inches to the wall. Allow space on all sides for air circulation and for ease of maintenance.

Rotary type compressor installations should follow the manufacture's installation requirements, which are typically supplied with the compressor in an installation drawing. Be sure to verify that there is enough space in the room or area where the compressor is to be installed to allow for air flow and compressor maintenance. The inlet grids in the room or area where the compressor maintenance. The inlet grids and ventilation fan should be installed in such a way that any recirculation of cooling air to the compressor is avoided. A proper condensate drain system is essential. Also be aware of the maximum air temperature at the compressor intake, as this can effect compressor operation and life.

Always refer to the manufacturer operational and user's manual for installation guidelines. Make sure that the unit is mounted level, on a solid foundation, so that there is no strain on the supporting or lagging down the unit, be careful not to over-tighten and impose strain.

Ambient temperature conditions can vary by manufacturer and should be reviewed prior to purchasing a compressor. Typical ambient conditions can range from 32°F ti 115°F. Special precautions are usually required when operating outside this range and manufacturer of the equipment should be consulted.

Operation at altitudes above 4000 feet may also require special consideration. Consult the manufacturer when operating a unit at a higher altitude to ensure proper operation can be achieved.

Air consumption chart for automotive service shops

Equip. Air pressure range in psi	Portable tools	Compressor (cfm) required per unit
70-100	**Air filter cleaner	3.0
70-100	**Body polisher	20.0
70-100	**Body sander (Orbital)	10.0
70-100	Brake tester	4.0
70-100	**Carbon remover	3.0
90-100	Dusting gun (Blow gun)	2.5
70-100	Panel cutter	4.0
70-90	**Drill 1/16* to 3/8*	4.0
70-90	**Impact wrench 3/8* sq.dr.	3.0
70-90	**Impact wrench 1/2* sq.dr.	4.0
70-90	**Impact wrench 5/8* sq.dr.	5.0
70-90	**Impact wrench 3/4* sq.dr.	8.0
70-90	**Impact wrench 1* sq.dr.	12.0

Cubic feet per minute required to operate various pneumatic equipment at pressure range 70-90 psig

- This is for 8,000 ibs capacity. Add cfm for each 1,000 lbs, capacity over 2,000 lbs.
- These devices are rated based upon typical "on-load" performance characteristics.

Always check with tool manufactures for actual consumption of tools being used. The above is based on averages and should not be considered accurate for any particular make of tool.

Selecting the Proper Air Compressor to use with an Air Cylinder

Equip. Air pressure range in psi	Portable tools	Compressor (cfm) required per unit
70-90	Die grinder	5.0
90-100	*Vertical disc sanders	20.0
90-100	**Filing and sawing machine, (small)	3.0
90-100	**Filing and sawing machine, (Large)	5.0
90-100	**Burring tool	5.0
Tire tools		
125-150	Rim stripper	6.0
125-150	Tire changer	1.0
125-150	Tire inflation line	2.0
125-150	Tire spreader	1.0
125-150	“Vaccum cleaner”	7.0

Equip. Air pressure range in psi	Portable tools	Compressor (cfm) required per unit
Hammers		
90-100	**Air hammer	4.0
90-100	Tire hammer	12.0
125-150	Beak breaker	12.0
90-100	Spring dier	4.0
Spray guns		
90-100	**Engine cleaner	5.0
90-100	**Paint spray gun (production)	8.0
90-100	**Paint spray gun (touch up)	4.0
90-100	**Paint spray gun (undercoat)	19.0
Other equipment		
120-150	**Grease gun	3.0
145-175	Car LIft* (air compressed hydraulic)	6.0
120-150	Floor jacks (air compressed hydraulic)	6.0
120-150	Pneumatic garage door	3.0
90-100	Radiatar tester	1.0
90-100	Spark plug cleaner	5.0
90-100	Spark plug tester	5
70-100	Transmission and differential flusher	3.0
70-100	**Fender hammer	9.0
70-100	**Car washer	9.0
70-100	**6* Medium duty sander	4.0

Chart A cylinder diameter required to develop power to overcome the load indicated

Thrust load in pounds	Pressure in cylinder-psi														
	70	80	90	100	110	120	125	130	140	150	160	170	175	180	190	200
500	3 1/8	2 7/8	2 3/4	2 1/2	2 1/2	2 3/8	2 3/8	2 1/4	2 1/4	2 1/8	2	2	2	2	1 7/8	1 7/8
1000	4 3/8	4	3 7/8	3 5/8	3 1/2	3 3/8	3 1/4	3 1/4	3 1/8	3	2 7/8	2 3/4	2 3/4	2 3/4	2 5/8	2 5/8
1500	5 1/4	5	4 5/8	4 3/8	4 1/4	4	4	3 7/8	3 3/4	3 5/8	3 1/2	3 3/8	3 3/8	3 3/8	3 1/4	3 1/8
2000	6 1/8	5 3/4	5 3/8	5 1/8	4 7/8	4 5/8	4 5/8	4 1/2	4 3/8	4 1/8	4	3 7/8	3 1/8	3 7/8	3 3/4	3 5/8
2500	6 7/8	6 3/8	6	5 3/4	5 1/2	5 1/8	5 1/8	5	4 7/8	4 5/8	4 1/2	4 3/8	4 3/8	4 1/4	4 1/8	4
3000	7 1/2	7	6 5/8	6 1/4	6	5 3/4	5 5/8	5 1/2	5 1/4	5 1/8	5	4 3/4	4 3/4	4 5/8	4 1/2	4 3/8

Air Cylinders use compressed air to produce force. The Compressed air is directed into a cylinder chamber and it forces a piston to move in a linear direction. The distance the piston travels is called the length of stroke. A piston rod attached to the piston exerts a force in pounds to produce work or motion to a mechanism at a rate of so many strokes per minute.

In commercial and industrial uses, a piece of equipment using an air cylinder of a given diameter will be rated as to force (thrust load) in pounds, length of stroke and the number of strokes per minute.

Using the thrust load and cylinder diameter figures, make your choice of a compressor and determine the pressure needed from chart "A".

Determine the cfm of free air needed by the air cylinder from chart "B" by using the factor shown opposite your cylinder diameter and pressure requirement (see example for explanation of how to determine factors not shown). Multiply this factor by the number of inches of stroke and the number of strokes per minute to determine the cfm requirement.

Air Flow Chart: Another industrial use for compressed air is using a blast of compressed air, released at the proper moment, to blow away small parts from a punch after forming and blanking.

An automatic valve allows air to flow from a properly positioned and aimed nozzle against the work pieces. The pressure employed and the diameter of the passage through the nozzle determine the volume of free air which will flow through the nozzle.

The chart below indicates the rate of flow (volume) per minute, through various sizes of orifices at definite pressures.

Flow is expressed in cubic feet per minute (cfm) and is assumed to take place from a receiver or other vessel, in which air is contained under pressure, into the atmosphere at sea level. Temperature of air in receiver is assumed at 60 deg.F. This table is only correct for orifices with narrow edges; flow through even a short length of pipe would be less than that given below.

The capacity of an air compressor cannot be checked accurately by use of this table and a narrow edge orifice. Specialized equipment is necessary to check compressor capacity.

Example: An air ejector is being used on a punch press. It is connected to an air line with pressure at 120 - 150 psi. It has a nozzle orifice 3/32 in. in diameter and, through use of a stop watch, it delivers compressed air for a total of 30 seconds out of each one minute of operation.

Useful Formulae

$$1\ \text{Comp.RPM} = \frac{\text{motor pulley dia.} \times \text{motor rpm}}{\text{comp. pulley dia.}}$$

Chart B Cubic feet of air required for single acting air cylinder

Piston Dia. (in.)	90 psi	125 psi
1 3/4	.0102	.0131
1 7/8	.0115	.0149
2	.0133	.0172
2 1/8	.0150	.0194
2 1/4	.0168	.0127
2 3/8	.0187	.0242
2 1/2	.0207	.0268
2 5/8	.0228	.0268
2 3/4	0.250	.0324
2 7/8	.0275	.0355
3	.0299	.0386
3 1/8	.0323	.0418
3 1/4	.0350	.0454
3 3/8	.0378	.0489
3 1/2	.0405	.0524
3 5/8	.0434	.0562
3 3/4	.0467	.0605
3 7/8	.0496	.0642
4	.0530	.0685
4 1/8	.0564	.0730
4 1/4	.0599	.0775
4 3/8	.0635	.0822
4 1/2	.0672	.0870
4 5/8	.0708	.0915
4 3/4	.0748	.0970
4 7/8	.0789	.1020
5	.0832	.1076
5 1/8	.0872	.1127
5 1/4	.0913	.1180
5 3/8	.0957	.1237
5 1/2	.1004	.1299
5 5/8	.1050	.1361
5 3/4	.1096	.1416
5 7/8	.1146	.1482
6	.1200	.1550
6 1/8	.1250	.1623
6 1/4	.1300	.1681
6 3/8	.1346	.1742
6 1/2	.1402	.1813
6 5/8	.1460	.1888
6 3/4	.1510	.1955
6 7/8	.1570	.2080
7	.1630	.2105
7 1/8	.1684	.2181
7 1/4	.1746	.2257
7 3/8	.1802	.2332
7 1/2	.1870	.2419

2 Motor Pulley pd = $\frac{\text{comp. pulley dia.} \times \text{comp rpm}}{\text{motor rpm}}$

3 Comp. pulley pd = $\frac{\text{motor pulley dia.} \times \text{motor rpm}}{\text{comp. rpm}}$

4 Motor RPM = $\frac{\text{comp. pulley dia.} \times \text{comp rpm}}{\text{motor pulley pd}}$

5 Free Air = piston displacement x volumetric eff. (%)

6 Required Piston Displacement = $\frac{\text{free air}}{\text{vol.eff.}}$

7 Piston Displacement in Cu. Ft. per Min.* = $\frac{\text{Cyl. bore in In. x Cyl. bore x stroke in In. x rpm}}{2200}$

8 Cu. Ft. Compressed Air = $\frac{\text{cu.ft.free air x 14.7}}{(\text{psig} + 14.7)}$

9 Cu. Ft. Free Air = $\frac{\text{cu.ft.compressed air x (psig} + 14.7)}{14.7}$

10 Cu. Ft. Free Air Req'd to Raise Rec. From 0 Gage to final Pressure = $\frac{\text{vol.of rec. in cu. ft. x psig}}{(\text{atmospheric pressure})\,\text{psia}}$

11 Cu. Ft. Free Air Req'd to Raise Rec. From Some Press. Greater Than 0 Gage To A Final High Higher Pressure =

vol. of rec.in cu.ft. x $\frac{(\text{final psig} - \text{initial psig})}{(\text{atmospheric pressure})\,\text{psia}}$

12 Piston Speed in Ft. Per Min. = $\frac{2 \times \text{stroke (in inches)} \times \text{rpm}}{12}$

13 Gallons = $\frac{\text{cu.ft.}}{0.134}$

14 Cu. Ft. = gallons x 0.134

15 Total Force in lbs. of Air Cylinder = (Area of the Cylinder Dia.in sq.inches) x (psig of air press.used)

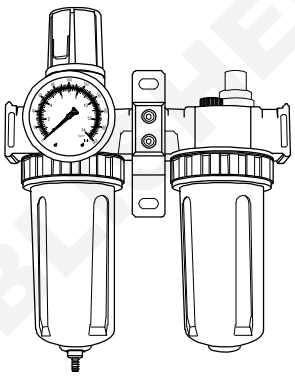
16 CFM of Free Air req'd to Operate Air Cylinder (Single Acting) = (Vol. of Cyl. In cu.ft.) x (Cycles Per Min.) x $\frac{(\text{Gage Press psig} + 14.7)}{14.7}$

17 Pump Up Time (Min) = $\frac{\text{V (tank size in gal.)} \times (\text{final tank press.} - \text{initial tank press.})}{7.48 \times \text{atmos.press.(psia)} \times \text{pump delivery (cfm.)}}$

* Piston displacement for multi – stage compressors – only the low pressure cylinders are considered.

Air Transformer A transformer (Fig 11) is a device that condenses air, oil, and moisture; regulates and strains the air; and provides outlets to which spray guns, dusters, and the like, can be connected. The transformer separates the oil and moisture by mechanical means and air expansion, allowing only clean, dry air to reach the spray gun. If any moisture or oil passes through the spray gun onto the freshly painted surface, it will ruin the paint finish. Therefore, a transformer is required in the refinishing field.

Fig 11



A transformer regulator controls pressure at the gun to give the desired atomization. The transformer regulator has a gauge that shows main line pressure and a gauge for working pressure. It also has outlets for main line pressure and outlets for working pressure, such as used when painting a vehicle. The regulator knob adjusts the working air pressure, and a drain is attached to the bottom of the cylinder. Transformers are usually hooked up off the main line at least 25 ft or 7.75 m from the compressor. The workings of a transformer are relatively simple. The air enters at the back of the transformer main pressure line.By adjusting the pressure regulator knob until the desired pressure is reached, a diaphragm opens that allows air to pass through a metal filter. Water separators and baffle condensers clean the air of its impurities and then it passes out through the regulated side to the spray gun. Drain the transformer daily if necessary.

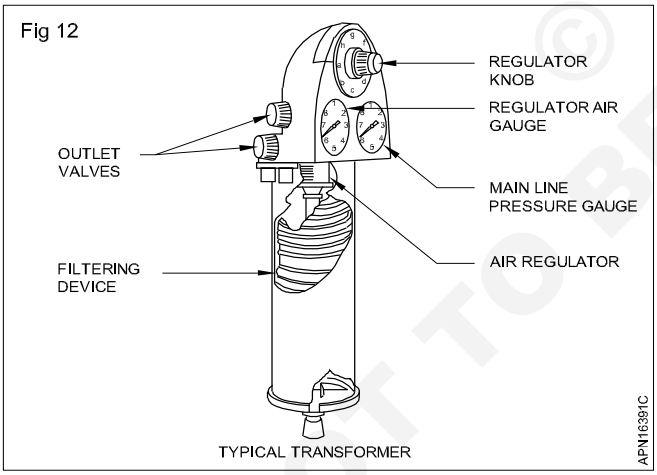
If the transformer cannot stop all the oil in the air line, it is necessary to install a filter such as in Fig 11, which uses a roll of double toilet paper as a medium to remove oil from the air. Filters must be checked regularly, and when a bit of oil is present on the intake side, the element should be changed.

Coalescing oil removal filters are available to remove oil and water vapors and dirt particles from the compressed air. Some of these filters are available as submicron filters, which coalesce oil aerosols and remove them from the lines. The filtered air will contain less than 0.1 ppm of oil by weight. The life of the filter cartridge is exceptionally long when removing aerosols and is designed for 99.999% efficiency. A filter designed to remove any remaining oil vapour and its taste and odour must be used when the air is to be used for breathing purposes. To remove carbon monoxide from compressed air, there are units available on the market that will clean the air for breathing purposes.

Installation of Air Transformers (Fig 12)

The air transformer should be bolted securely to the spray booth or to some similar sturdy object near the operator for convenience in reading the gauges and operating the valves. It should be installed at least 25 ft or 7.75 m from the compressor and the take - off should always be from the top of the air line. Piping should slope toward the compressor air receiver or a drain leg installed at the end of the air line or at the end of each branch to provide for drainage of moisture from the air line. The reason the air line is sloped is to control the water in the air line. Humid air condenses to water when the air is compressed. If some of the water is allowed to get through the system and on a paint job, it will ruin it. Therefore, it is necessary to drain the compressor, receiver, drain leg, and transformer as often as required. Use piping of sufficient size for the volume of air passed and the length of pipe used. The pipe must always be of the recommended size or larger. Otherwise, excessive pressure drop will occur.

Fig 12



TYPICAL TRANSFORMER

Different type of air purification methods:

The function of air quality management is checking of emission in the air and purified the with following systems:

— Sedimentation chamber (gravity separator)

— Cyclone separator

— Rotating scrubber

— Ventura scrubber

— Spray chamber

— Dry electro filter

— Wet electro filter

— Cloth filter

— Ceramic filter

— Absolute filter

— Demister

Gas Purification Techniques:

There are four commonly used technologies for gaseous pollutants, absorption adsorption, condensation and combustion. These systems are recovery techniques, where as combustion implies the destruction of the pollutant. The following techniques apply at purifying pollutants from the air flow.

- Condensation
- Cryo condensation
- Regenerative adsorption
- Dry and semi dry line absorption
- Gas scrubbing
- Thermic combustion
- Catalytic combustion
- Flaring
- Foliate-oxidation
- Ironization
- Selective non catalytic reduction
- Selective catalytic reduction

Compressor air hoses

There are two types of air hoses used in air compressor air layout system they are as follows:

- Durability and flexibly

Hose Size

The external diameter of air hoses will vary widely depending on the quality of the hose and the material, it is made from, common internal sizes of air hose are 6 mm, 8 mm and 10 mm internal diameter.

Weight

Very light and easy to transport

Application:

Medium duty usage in many situations

Cold Weather

Poor cold weather performance

Durability & Flexibility: Tends to coil and kink (materials used for durability is PVC, Rubber and Polyurethane)

Recommended hose size: Table 1 Table 2

Gage pres. in receiver (ins)	Flow of Air (cfm) through orifices of various diameters							
	1/64”	1/32”	3/64”	1/16”	3/32”	1/8”	3/16”	1/4”
1	.027	.107	.242	.430	.97	1.72	3.86	6.85
2	.038	.153	.342	.607	1.36	2.43	5.42	9.74
3	.046	.188	.471	.750	1.68	2.98	6.71	11.9
5	.059	.242	.545	.965	2.18	3.86	8.71	15.4
10	.084	.342	.77	1.36	3.08	5.45	12.3	21.8
15	.103	.418	.94	1.67	3.75	6.65	15.0	26.7
20	.119	.485	1.07	1.93	4.25	7.7	17.1	30.8
25	.133	.54	1.21	2.16	4.75	8.6	19.4	34.5
30	.156	.632	1.40	2.52	5.6	10.	22.5	40.0
35	.173	.71	1.56	2.80	6.2	11.2	25.0	44.7
40	.19	.77	1.71	3.07	6.8	12.3	27.5	49.1
45	.208	.843	1.9	3.36	7.6	13.4	30.3	53.8
50	.225	.914	2.05	3.64	8.2	14.5	32.8	58.2
60	.26	1.05	2.35	4.2	9.4	16.8	37.5	67
70	.295	1.19	2.68	4.76	10.7	19.0	43.0	76
80	.33	1.33	2.97	5.32	11.9	21.2	47.5	85
90	.364	1.47	3.28	5.87	13.1	23.5	52.5	94
100	.40	1.61	3.66	6.45	14.5	25.8	58.3	103
110	.43	1.76	3.95	7.00	15.7	28.0	63	112
120	.47	1.90	4.27	7.58	17.0	30.2	68	121
130	.50	2.04	4.57	8.13	18.2	32.4	73	130
140	.54	2.17	4.87	8.68	19.5	34.5	78	138
150	.57	2.33	5.20	9.20	20.7	36.7	83	147
175	.66	2.65	5.94	10.6	23.8	42.1	95	169
200	.76	3.07	6.90	12.2	27.5	48.7	110	195

TABLE 1

Minimum pipe size recommendations (English units)

Compressing		Main air outfit line	
Size (hp)	**Capacity (cfm)**	**Length (ft)**	**Size (in.)**
1 ½ and 2	6 - 9	Over 50	¾
3 and 5	12 - 20	Up to 200	¾
		Over 200	1
5 -10	20 - 40	Up to 100	¾
		Over 100 to 200	1
		Over 200	1 ¾
10 -15	40 - 60	Up to 100	1
		Over 100 to 200	1¾
		Over 200	1½

Source: Courtesy of DeVilbiss Canada Ltd.

TABLE 2

Minimum pipe size recommendations (Metric units)

Compressing unit		Main air line	
Size (watts)	**Capacity (litres/min)**	**Length (m)**	**Size (mn)**
1120 and 1492	170-255	Over 15	190.6
2238 and 3730	340-566	Upto 61	190.6
		Over 61	254
3730-7460	566-1130	Upto 30.5	190.6
		Over 30.5 to 61	254
		Ovet 61	318
7460-11.190	1130-1700	Upto 30.5	254
		Over 30.5 to 61	318
		Ovet 61	382

Maintenance of compressor air hose

Air hoses mostly made by PVC, rubber and polyurethane materials. So it is need daily maintenance

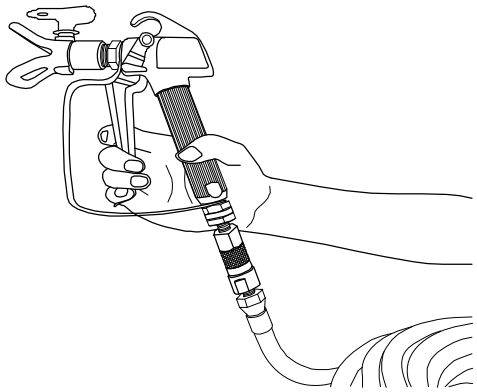
- Daily dry clean the hoses
- Check hose connection
- Check the air leaks from the coupler connection
- Check crack on the hose
- Check weather damage in the air hose

Air hose connectors (Fig 13): Air hose connectors are used to connect the two pieces like air hose connect with adaptors and couplings.

Fig 13

Adaptors and coupling (Fig 14): Air hose adaptors and couplings are used to connect the paint spray gun, air blast sander, pneumatic tools.

Fig 14



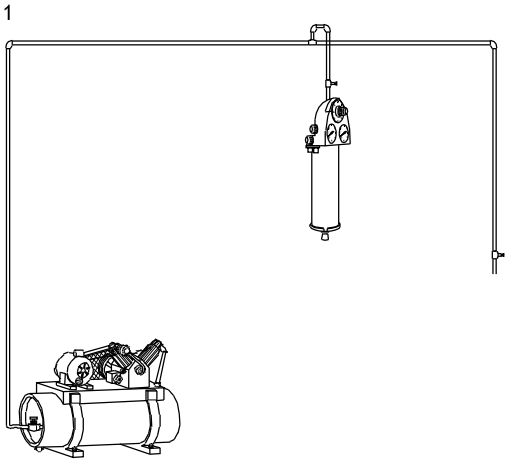
Air system maintenance

Objectives: At the end of this lesson you shall be able to
- state the typical piping arrangement in the in paint shop
- state the colour coding of air line, water line and fuel line.

Typical piping arrangement of air compressor

A stationary air compressor is usually used in the paint shop therefore, the unit should be bolted at its proper location to prevent it from moving then the air line from the shop should connected to the receiver. The compressor should be installed in a cool, clean area that has access room for maintenance or repair. There are two type of piping and hoses are available in paint shop, an air hose and a fluid hose (Fig 1)

Fig 1



PIPING OF SUFFICIENT SIZE MUST BE USED

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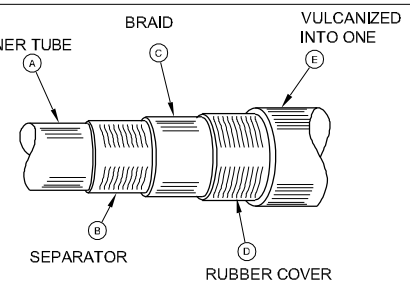
Colour code of the hoses (Fig 2)

A fluid hose is always black in colour with a special solvent resisting liner that is almost improvious to all common solvents in paints.

Fig 2



FLUID HOSE TWO - BRAID CONSTRUCTION

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Air hoses are constructed similarly to fluid hoses except inner liner is a different material such as nitrile rubber air hose outer cover is usually red and can be smooth corrugated. Some hoses are built with the special static wire between the outer cover and the braid. (Fig 3)

Colour code of water line

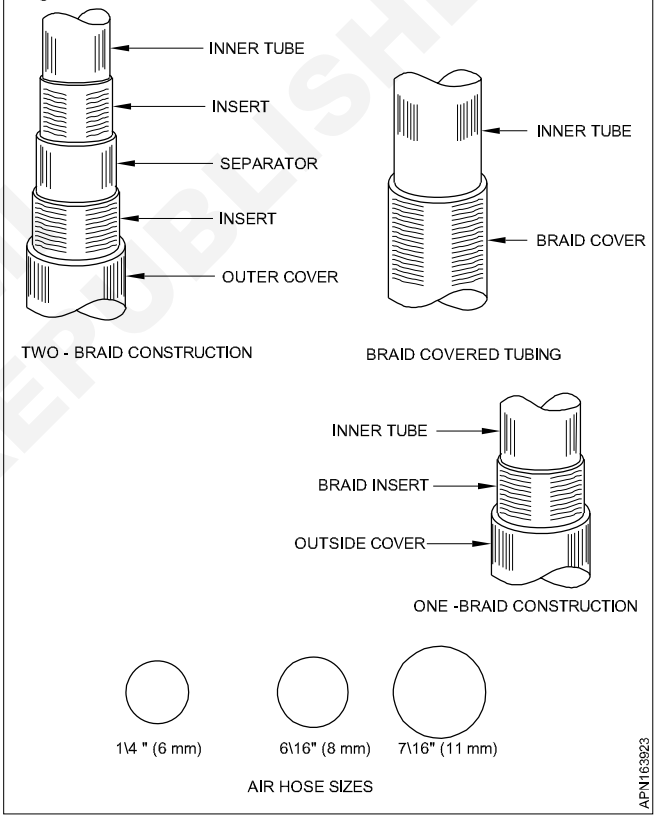
Fresh water line colour code is green and white

Fuel line colour code

Fuel gas line colour code is yellow/block and brown/white and fuel oil line colour code is also same as above mentioned colour.

Pipes are used in facilities to transport liquids and gasses from one place to another, both short and long distances. The pipe colour coding is very essential to track the correct pipe line during pipe line maintenance or repair.

Fig 3



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Auto body welding

Objectives: At the end of this lesson you shall be able to
- **state the joining metals**
- **state the welding characteristics and welding techniques**
- **state the gas cutting torch flame adjustment**
- **state the advantage and disadvantage over different type of welding methods.**

Joining of metals: Auto body panels must be replaced and welded into place of damaged and installed repair panels. There are three basic method of joining metal together in the automobile assembly.

1 Metal fastener methods (Mechanical)

2 Adhesive fastening methods (Chemical)

3 Molten metal fusion methods (Welding)

Welding uses extreme heat to joining or fusion the metal pieces together. Welding can be divided into three main categories.

- Pressure welding
- Fusion welding
- Braze welding

Weld terminology: Weld root is the part of the joint, where the electrode is directed. The weld face is the exposed surface of the weld on the side that has been welded.

Weld penetration is indicated by the height of the exposed surface of the weld on the back side and full weld penetration is needed to assure maximum weld strength.

A burn mark on the back of a welded is an indication of good weld penetration. Burn through results is a hale through the back side of the metal.

Fillet weld parts included the weld legs are the width and height of the weld head. The weld throat refers to the depth of the Triangular section of welding space.

Joint fit up is holding the work pieces tightly together. Alignment to prepare for welding.

Welding characteristics: The characteristics of welding is as follows.

- The shape of welding joints is limitless, it is the perfect method for joining a damaged parts of vehicle panels for maintaining auto body integrity.
- Weight can be reduced
- Air and water resistant are excellent
- Production efficiency is very high
- The strength of welded joint is greatly influenced
- Surrounding panels will warp if too much heat is used

Weld symbols: Weld symbols are used to indicate the welding processes used in metal joining operations, whether the weld is localized or all around whether it is a shop or field weld and the contour of welds.

Arc of gas supplementary symbols.

The assemble "welding symbol" consists of the following eight elements or any of these elements as necessary.

- Reference line
- Arrow
- Basic weld symbols (Table 1)
- Dimensions and other date
- Supplementary symbols (Table 2,3)
- Finish symbols
- Tail line symbols
- Specifications

Welding symbols provide complete welding information on drawings. The joint is the basic of reference for welding symbols. The reference line of welding symbol is used to designate the type of weld to be made, its location, dimensions extent, contour and other supplementary information.

- The weld symbol indicates the desired type of weld
- The welding symbol is method of representing the weld symbol of drawing

Table 1

Elementary symbols

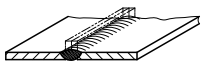
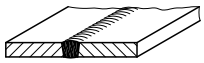
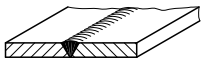
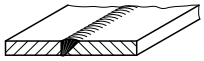
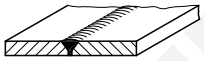
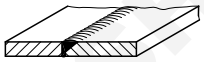
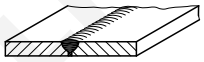
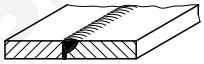
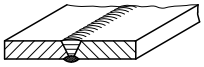
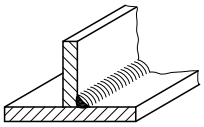
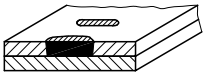
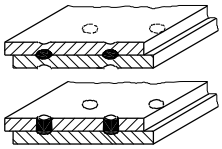
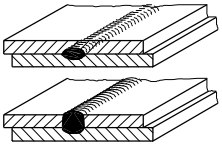
Sl. No.	Designation	Illustration	Symbol
1	Butt weld between plates with raised edges (the raised edges being melted down completely)		
2	Square butt weld		
3	Single V butt weld		
4	Single bevel butt weld		
5	Single V butt weld with broad root face		
6	Single bevel butt weld with broad root face		
7	Single U butt weld (parallel or sloping sides)		
8	Single J butt weld		
9	Backing run; back or backing weld		
10	Fillet weld		
11	Plug weld; plug or slot weld/USA		
12	Spot weld		
13	Seam weld		

Table 2
Supplementary symbols

Shape of weld surface	Symbol
a) Flat (usually finished flush)	
b) Convex	
c) Concave	

Weld symbol: It represents the type of weld made on a weld joint. It is also a miniature drawing of any metal edge preparation required prior to welding.

Welding symbol: The complete welding symbol will indicate to the welder how to prepare the base metal, the welding process to use, the method of finish and the required dimensions and other details with the basic weld symbol. They consist of 7 elements as mentioned below. (Fig 1)

1 Reference line

2 Arrow

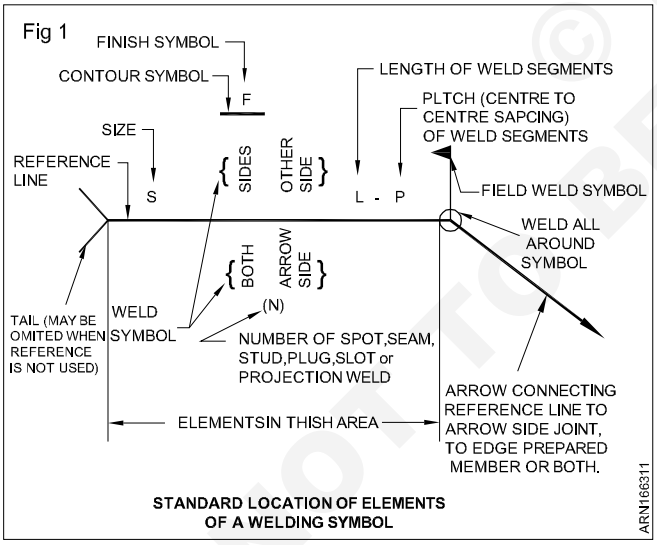
3 Welding elementary symbols

4 Dimensions and other details

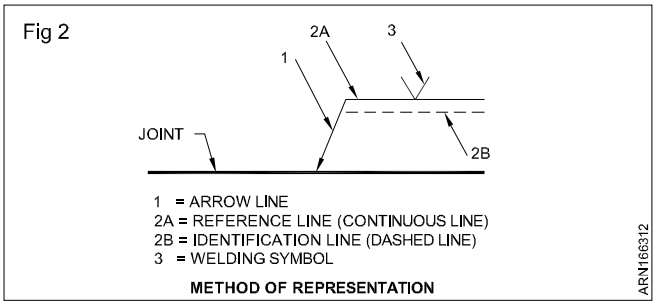
5 Supplementary symbols

6 Finish symbols

7 Tail (specification, process)



Methods of representation (Figs 2 and 3)



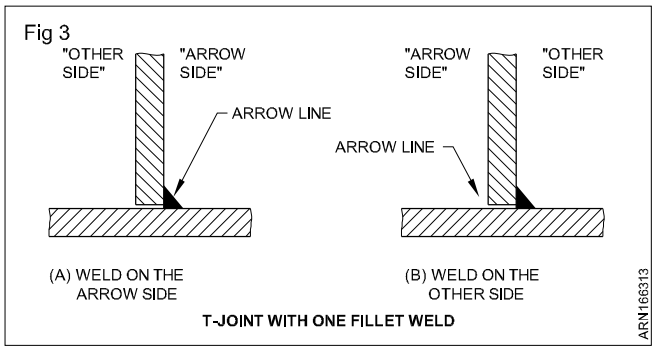


Table 3
Examples of application of supplementary symbols

Designation	Illustration	Symbol
Flat(flush)single V butt weld		
Convex double V butt weld		
Concave fillet weld		
Flat (flush) single V butt weld with flat (flush) backing run		

The reference line, arrow-head and tail

The reference line shown in Figs 1 and 5 is always drawn as a horizontal line. It is placed on the drawing near the joint to be welded. All other information to be given on the welding symbol is shown above or below the reference line.

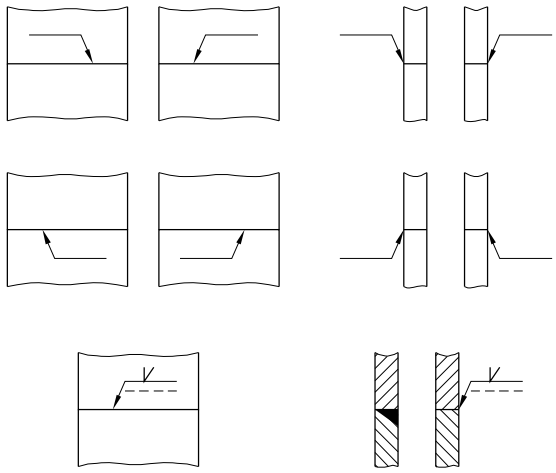
Arrow: The arrow may be drawn from either end of the reference line. The arrow always touches the line which represents the welded joint.

On the welding symbol the arrow side weld information is always shown below the reference line. The other side weld information is always shown on the dash–line side. (Figs 2 and 4)

Tail: The tail is used only when necessary. If used it may give information on specification, the welding process used, or other details required which are not shown in the welding symbol.

Welding/elementary symbol: Figs 6 and 7 illustrate how some of the various types of weld symbols are used in welding symbols.

Fig 4



POSITION OF THE ARROW LINE

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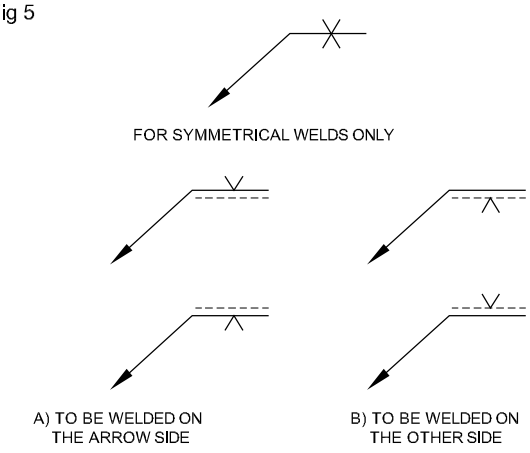
Fig 5



POSITION OF SYMBOLS ACCORDING TO THE REFERENCE LINE

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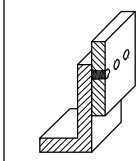
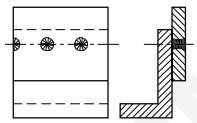
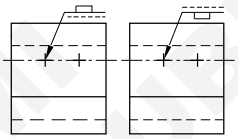
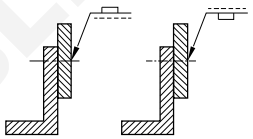
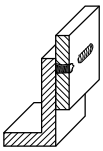
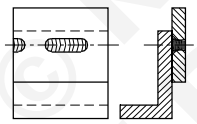
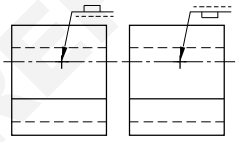
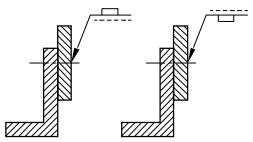
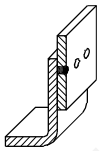
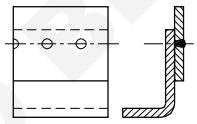
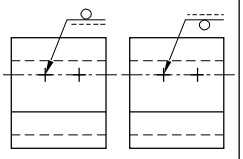
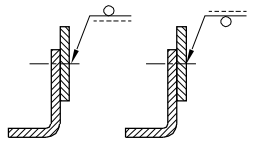
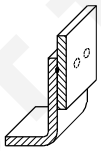
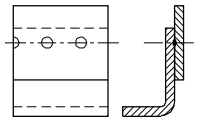
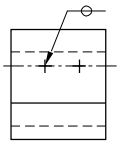
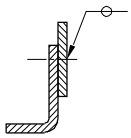
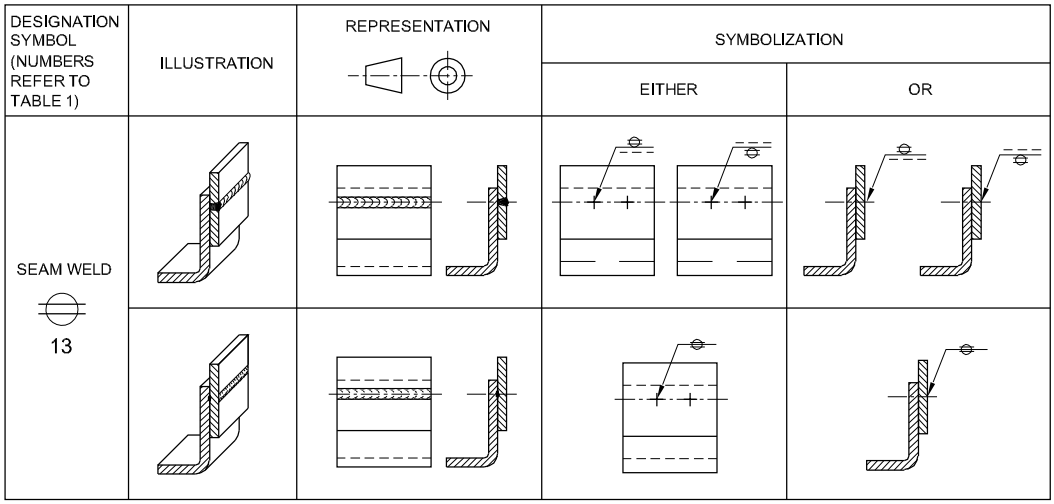
Fig 6

DESIGNATION SYMBOL (NUMBERS REFER TO TABLE 1)	ILLUSTRATION	REPRESENTATION	SYMBOLIZATION	
			EITHER	OR
PLUG WELD 11				
				
SPOT WELD 12				
				

EXAMPLES OF USE OF ELEMENTRY SYMBOLS

ARN166316

Fig 7



EXAMPLES OF USE OF ELEMENTRY SYMBILS

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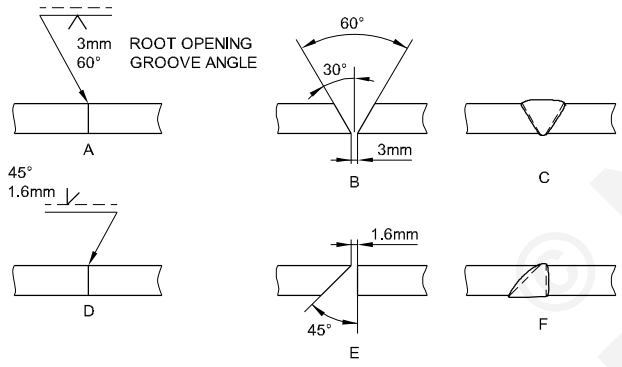
Root opening and groove angle: The root opening size appears inside the basic weld symbol on the complete welding symbol. The included angle or total angle of a groove weld is shown above the basic weld symbol. (Fig 8)

Fig 8



A AND D SHOW THE WELD SYMBOL FOR A GROOVE WELD
B AND E SHOW THE PIECES CUT AND SET UP FOR WELDING
C AND F SHOW THE COMPLEETED WELD

ROOT OPENING AND GROOVE ANGLE

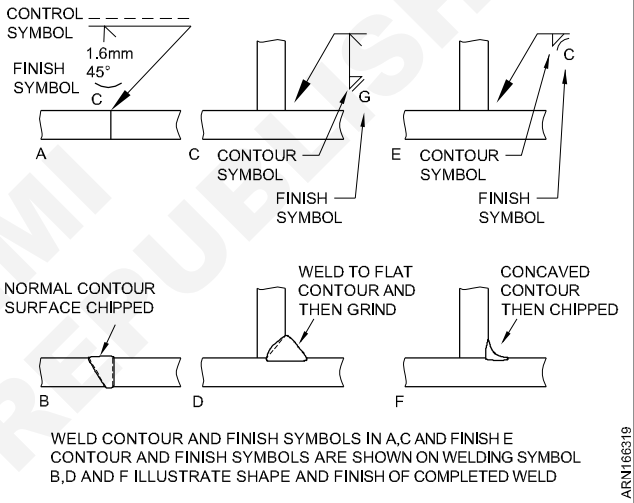
ARN166318

Contour and finish symbols: The shape or contour of the completed weld bead is shown on the welding symbol as a straight or curved line between the basic weld symbol and the finish symbol. The curved contour line indicates a normal convex or concave weld bead. (Fig 9)

Dimensions and other details: The size of a weld is important. The term 'size of weld' means different things for the fillet weld and butt weld. The dimensions of a fillet weld are shown to the left of the basic weld symbol. (Fig 10) The number 300 indicates the length of the weld is 300mm; a5 indicates that the throat thickness is 5mm; z7 indicates the leg length is 7mm.

As per AWS (American welding society), basic weld symbols and their location on welding symbols is given as per following charter.

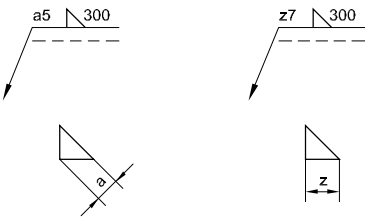
Fig 9



WELD CONTOUR AND FINISH SYMBOLS IN A,C AND FINISH E
CONTOUR AND FINISH SYMBOLS ARE SHOWN ON WELDING SYMBOL
B,D AND F ILLUSTRATE SHAPE AND FINISH OF COMPLETED WELD

ARN166319

Fig 10



METHOD OF INDICATING DIMENSIONS FOR FILLET WELDS

ARN16631A

Common auto body welding techniques: Several types of welding from all positions are recommended during collision repair of high tech vehicles auto body welders after have to do the following welding operations

- MIG or wire feed arc welding
- TIG (Tungsten inert gas) welding
- Soft brazing or soldering

MIG welding: it is the common type of welding for steel unibody panels, medium thickness hydro formed frames and heavy gauge full forms.

TIG welding: it is uses a handheld rod and gas - shielded arc is often recommended for aluminum alloy body panels. This type of welding used for light weight corrosion - resistant aluminum allow panels and even whole unibody structures can be welded aluminum.

Soft brazing weld: Brazing is recommended to join and seal the corners of roof panels and other large surface are panels. A soft, low temperature rod is used to braze critical locations on large panels to form a softer, more flexible bead to prevent metal cracks and water leakage.

Factory weld specifications: The vehicle manufacturers established their vehicle repair informations by considering the crack metal gauge, metal type, (HSS, aluminum, cold rolled steel) as well as the original weld specs that were used during vehicle manufacturing. The following welding information should know before starting to welding work.

- Type and thickness of unibody metal
- Location of factory welds for proper panel removal
- How to prepare a new panel for installation
- Number and location of clamps needed to secure panel before welding
- Measurement points and factory values for accurately positioning a new panel.
- Number and locations of weld required to secure a panel.
- Sizes of holes that must be punched in a new panel flange when using plug welds to replace factory spot welds.
- Type of required welds for each weld locations
- How to cut and fit a backer panel required behind most but weld joints

Note: Always refer to factory values and methods for repairing a specific vehicle make and model.

Auto body MIG wire sizes: The steel unibody panels are commonly welded using 0.58 mm MIG wire and 0.76 mm MIG wire is used for medium thickness hydro formed frames. Very thick body over frame steel members may require 0.89 mm MIG welding wire. The aluminum alloy body welding may require 0.76 to 0.89 mm MIG welding wire sizes. The actual thickness of an aluminum panel will determine which wire size would result in the best weld so check factory specifications for correct MIG wire sizes for the specific vehicle panel welding.

Auto body shielding gasses: The auto body manufacturers are recommend for using C-25 insert shielding gas for MIG welding steel. C-25 gas is 25 percent carbondioxide and 75 percent argon. When welding aluminum alloy, the most common MIG and TIG shielding gas is 100 percent argon.

Before start the panel repair refer the auto manufacturers specifications for wire size and type, shielding gas, number and size of weld for ultra light weight metal of a specific vehicle.

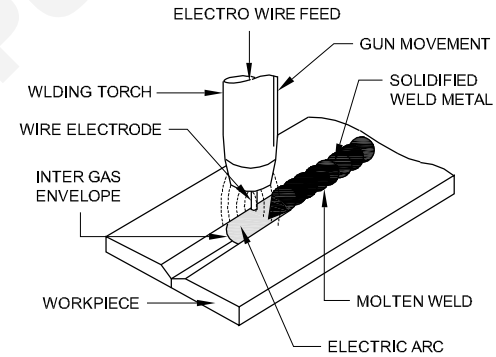
Heat affect zone: The heat effect zone is the area around the welded that area becomes adversely hot. The heat effect zone should always be kept to a minimum to prevent panel warpage and part damage. Heat sink compound can be placed on the body panel around the weld area to reduce the heat effect zone.

Auto body MIG welding - principle and characteristics

MIG welding is not limited to body repair alone it is also ideal for repairing mechanical parts. MIG welding uses a welding wire that is feed automatically at a constant speed as on electrode. A short arc is generated between the base metal and the wire. The resulting heat from the arc melts the welding wire and joins the base metals together. Because the wire is feed automatically at constant rate.

MIG flux core wire has its own flux contained in a tubular electrode and does not require a shielding gas. MIG welding uses the short circuit arc method - a unique method of depositing molten drops of metal onto the base metal. MIG welding is called carbon dioxide arc welding. MIG welding uses a fully inert gas, such as argon, helium as a shield gas. (Fig 11)

Fig 11



In MIG weld the current is flowing through an arc, the current is pulled toward the weld. This works as a constricting force in the direction of the center of the cylinder. This action is known as the pinch effect and the size of force is called the pinch force.

MIG welding process works as follows

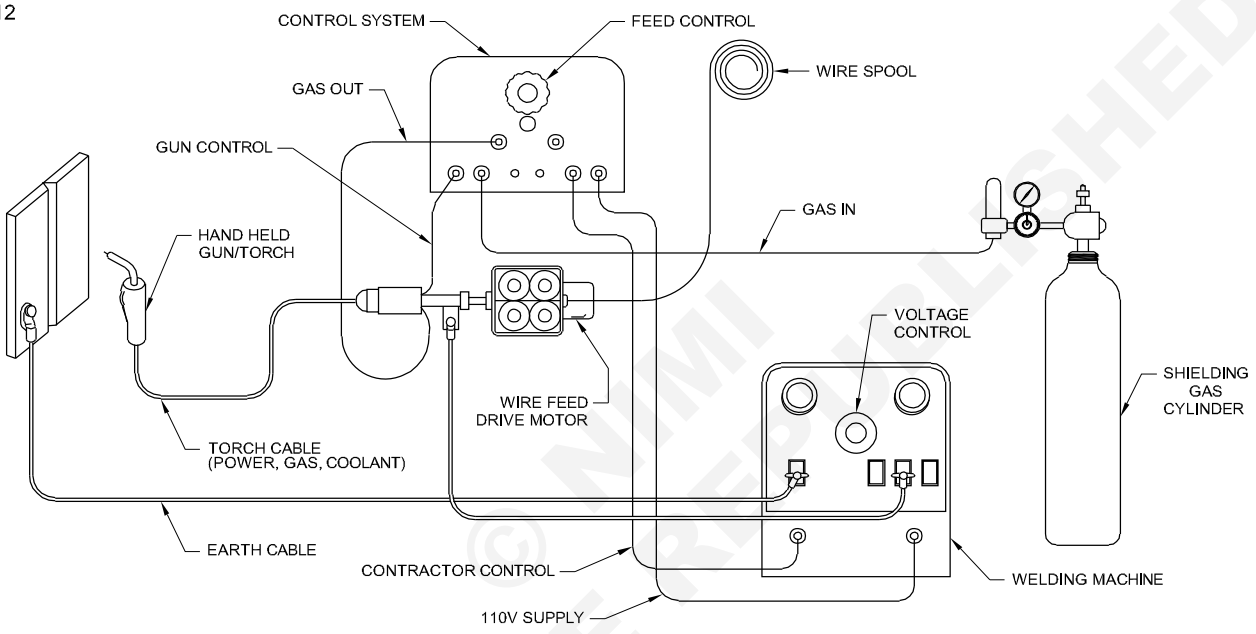
- At the weld point, the wire under goes a split second sequence of short circuiting, burn back and arcing.
- Each sequence produces a short arc transfer of a minute drop of electrode metal from the tip of the wire to the weld puddle.
- A gas curtain or shield surrounds the wire electrode. This gas shield prevents contamination from the atmosphere and helps the arc.

- The continuously feed electrode wire contacts the work and sets up a short circuit and resistance heats the wire and the weld site.
- As the heating continues, the wire begins to melt and thin out or neck down.
- Increasing resistance in the neck accelerates the heating in this area.
- The molten neck burns through depositing a puddle on the work piece and starting the arc.
- The arc tends to flatten the puddle and burn back the electrode.
- With the arc gap at its widest, it cools allowing the wire feed to move the electrode closer to the work.
- The short and starts to heat up again, enough to further flatten the puddle, but not enough to keep the electrode from recontacting the work piece. This extinguishes the arc, reestablished the short circuit and restarts the process.
- This complete cycle occurs automatically at a frequency ranging from 50 to 200 cycles a second.

MIG welding equipment

Most MIG welding equipment for collision repair work is considered semiautomatic, in this system the machine operation is automatic but the gun is hand controlled. Before starting to weld the operator sets the voltage for the arc, wire speed, shielding gas flow rate. (Fig 12)

Fig 12



BLOCK DIAGRAM (GMAW/MIG)

The MIG welding equipment will comprise the following basic components.

- Supply of shielding gas with a flow regulator to protect the molten weld pool from contamination.
- Wire/ feed control to feed the wire at the required speed.
- Spool of electrode wire of a specified type and diameter.
- Power supply to control welding current
- Work cable and clamp assembly
- Welding gun and cable assembly that the welder holds to direct the wire to the weld area.

Welding wire diameter range from 0.584 mm to 0.792 mm. The small diameter wires can be used at low current (10 to 20 amps and voltages (120 volts)) thus greatly reducing heat input to the base material. The welding wire must carry a minimum specification of AWS- ER 70- 6.

When you are spot welding different thickness of materials, the lighter gauge material should always be spotted to the heavy material. Spot welding requires greater heat to the weld than continuous or pulse welding.

Voltage adjustment and wire feed speed must be set according to the diameter of the wire being used and metal thickness. It should be that when setting these parameters, the manufacturers recommendations should be followed to reach approximate settings. MIG welders can be turned in using both visual and audio signals.

Welding lens: A welding filter lens is a shaded glass welding helmet insert for protecting your eyes from ultra violet burns. The lenses are graded with numbers from 4 to 12, the higher number the darker the filter. The American welding society (AWS) recommends lens grade 9 or 10 for MIG welding steel. The self darkening filter lenses available that instantly turn dark when arc is struck. There is no need to move the face shield up and down.

MIG welding operation method

- Connect the input voltage to the MIG welding machine
- Follow the operating procedure in manufacturers manual for the specific procedure to assemble, install, and adjust the wire feeder components.

- Handle the shielding gas cylinder with care, it might be pressurized to more than 2000 PSI. Chain or strap the cylinder to support and hold it.
- Install the regulator on the cylinder
- Observe the safety precautions
- Attach the clamp to clean metal on the vehicle near the weld side
- Check the welding circuit and ground connection
- Place the MIG welding machine as close to the weld area as possible. Keep away the welding machine as far as away from the vehicle and computers to avoid electronic circuit damage
- Disconnect the vehicles battery cables (both + & -)
- The proper handling of any welding equipment is and essential ingredient in successful welding.
- Ensure the number of parameters, machine input voltage, welding current arc voltage, top -to -base metal distance, torch angle, welding, direction, shield gas flow volume, welding speed and wire speed.

MIG welding current: Welding current affects the base metal penetration depth, the speed at which the wire is melted, arc stability and amount of weld spatter. As the electrical current is increased, the penetration depth excess metal height and lead width also increase.

MIG Arc voltage: The length of the arc is determined by the arc voltage. When the arc voltage is set properly, a continuous light hissing or cracking sound is emitted from the welding area. When the arc voltages high, the arc length increases the penetration is shallow and the bead is wide and flat. When the arc voltage is low the arc length decreases penetration is deep and the bead is narrow and done shaped. A sputtering sound and no arc means that the voltage is low.

MIG tip to base metal distance: The top to base distance is an important factor in obtaining good welding results. The standard MIG welding top to base distance is approximately ¼ to 5/8 inches (6.3 to 40 mm). If the top to base metal distance is too long, the length of wire protruding from the end of the gun increases and becomes preheated, which increases the melting speed of the wire. If the top- to - base metal distance is too short, it becomes difficult to see the progress of the weld because it will be hidden behind the tip of the gun.

MIG gun angle and welding direction: There are two types of welding methods are the forward and reverse method with the forward method, the penetration depth is shallow and the bead is flat. With the reverse method, the penetration is deep and a large amount of metal is deposited. The gun angle for both methods should be 10 and 30 degrees.

MIG shield gas flow volume: The standard shield gas flow volume is approximately 1 3/8 to 1 1/2 cubic inches per minute or 15 to 25 cubic feet per hour.

MIG welding speed: Welding speed is increase even faster, under cutting - producing a weld surface level lower than the base metal can occur. Welding at too low speed can cause burn - through holes. Ordinary welding speed is determined by base metal panel thickness and voltage of the welding machine.

MIG wire speed: High pitched buzzing sound indicates the correct wire to heat rate, producing a temperature in the 9000oF (4986oC) range. If the correct setting occur when a steady reflected light starts to fade in intensity as the arc is shortened and wire speed is increased.

The wire speed is too slow, a hiss and a pop sound will be heard as the wire melts away from the puddle. Too much wire speed will check the arc. More wire is being deposited than the heat and puddle can absorb. The result is spitting and sputtering as the wire melts into tiny balls of molten metal that fly away from the weld.

In slow motion, after the arc transfers has been started an on- off action occurs. Every time the metal is deposited a plop is heard. When it pulls away, a hiss is heard, speeded up to 200 plops and hisses per second. The overhead welding should be done by using a higher wire speed with the arc and ball kept tiny and close together. Balls caused by too slow a wire speed must be removed before a short is formed.

MIG gun nozzle adjustment: The gun is used on automotive MIG welder serve two main function.

- To provide proper gas protection
- To feed the wire into the arc at the right speed

The basic adjustment procedure of gas nozzle, as follows.

- Arc generation: if the distance between the tip of the base metal is shortened a little, it will be easy to generate on arc. If the end of the wire forms a large ball, it will be difficult to generate an arc, so quickly cut off the end of the wire with a pair of wire cutters.
- Spatter treatment: remove the weld spatter promptly. Antipater compounds are available that reduce the amount of spatter that adheres to the nozzle. Weld spatter on the tip will prevent the wire from moving freely. If the wire feed switch is turned on and the wire is not able to move freely through the tip, the wire will become twisted inside welder use a suitable tool such as a file, to remove spatter from the tip and then check to see that the wire comes out smoothly.
- Contact tip condition: To ensure a stable arc, the tip should be replaced, if it become worn. For a good current flow and stable arc, keep the tip properly tightened.

Heat buildup prevention: Heat sink compound is a paste that can be applied and reused. Heat sink compound is sticky and can be placed on the panel next to the weld. Heat will flow into the compound and out of the metal to prevent heat damage. Heat crayons or thermal paint also be used. When a panel is becoming too hot. They are used on aluminum, which does not change colour with heat.

Clamping tool for welding: The following tools are used for clamping the welding jobs.

- Locking jaw or vice pliers, C-clamps, sheet metal screws, tack welds, special clamps fixtures are necessary for good welding practice.

Welding positions: In auto body repair the welding position is important by the location of the weld in the structure of the vehicle. Both the heat and wire speed parameters can be affected by the welding position. The following welding positions are used in auto body repair work.

- Flat welding
- Horizontal welding
- Vertical welding
- Overhead welding

Welding techniques: There are six basic welding techniques used with MIG welding equipment.

1 **Tack welding:** The tack weld is exactly tack a relatively small, temporary MIG spot weld is used. Instead of a clamp or sheet metal screw to tack and hold the fit in place while proceeding to make a permanent weld. Temporary welds are very important in maintaining proper panel alignment and must be done accurately.

2 **Continuous weld:** the forward method moving the torch continuously at a constant speed, looking frequently at the welding bead. The gun should be in inclined between 10 and 15 degrees to obtain the best bead shape, welding line and shield effect. Maintain proper tip to base metal distance and correct gun angle. For proper penetration and a better weld, bring the gun closer to the base metal. If the gun handling is smooth and even, the bead will be consistent height and width a uniform closely spaced ripple.

3 **Plug weld:** A plug weld is used for drilled or punched hole through the outside piece. The arc is directed through the outside piece. The arc is directed through the hole to penetrate the inside piece. The hole is then filled with molten metal.

4 **Spot weld:** MIG spot weld, the arc is directed to penetrate both pieces of metal, while triggering a timed impulse of wire feed.

5 **Lap weld:** MIG lap spot technique, the arc is directed to penetrate the bottom piece and the puddle is allowed to flow into the edge of the top piece.

6 **Stitch weld:** A stitch weld is a series of connecting or overlapping MIG spot welds, creating a continuous seam.

Intermittent weld: This is the process which is the metal filling between two panels joint by MIG welding is known as intermittent weld.

Basic welding method: Basic welding technique used depends mainly on the given welding situation.

- Thickness or thinness of metal
- Condition of the metal
- Amount of gap, if any, between the pieces to be welded
- Welding position

Butt welds: Butt welds are formed by fitting two edges of adjacent panels together and welding along the mating or butting edges of the panels. I butt welding do not weld more than 19 mm at one time. MIG butt welds are used to make two joints when sectioning frame rails, rocker panels, and door pillers. For butt welds keep a gap between the two pieces thickness of piece. This helps weld penetration and prevents expansion and contraction problems. Hold the gun at 90° to the joint. Try holding the tip of the gun at several distance away from the base metal until the proper distance gives the desired result.

- Moving the gun too fast or too slow will produce poor welding.

Lap and Flange welding: Lap and flange welds are made with identical techniques. They are formed by welding or fusing the two surfaces to be joined at the top edge of two overlapping surfaces. Lap and flange welds should be made only in auto body repair works. Lap and flange welding not to be used to join more than two thicknesses of material together. Welds should never be made continuously but should be sequenced to allow for natural cooling and to prevent temperature buldup in the welding area.

Plug welding method: Plug welding has ample strength for welding load bearing structural members. It can also be used on cosmetic body skins and other thin- gauge sheet metal. A plug weld is used to replace a factory spot weld. A plug weld is formed by drilling or punching a hole in the outer panel being joined. The materials should be tightly clamped together. Holding the torch at right angles to the surface, aim the electrode wire in the hole and trigger the arc, while moving the gun in a circular motion around the hole. The puddle fills the hole and solidifies.

Remember the following two point while replace the spot welds by MIG plug welding.

- Follow the manufacturer's recommendations for number, size and location of plug welds
- If this information is not available, duplicate the number, size and location of the original factory welds.

The area welded should be allowed to cool naturally before any adjacent welds are made. Area around the weld should be force cooled using water or air. It is important they be allowed to cool naturally. Plug welds can also be used to join more than two panels together.

Stitch welding method: MIG stitch welding is used the standard nozzle, note the spot weld nozzle to make a stitch weld, combine spot welding with the continuous welding technique. To do the stitch welding, set the automatic timer. On the MIG machine the spot weld pulses and shut offs occur with automatic regularity, if the MIG machine does not have automatic stitch modes, the spot and stitch welds can be made manually. The operator has to be capable of triggering the gun in the same way the automatic MIG machine system does.

MIG welding galvanized metals and aluminum: When MIG welding galvanized or zinc- metalized steels do not remove the zinc if the zinc is ground away, the thickness of the metal is reduced and it is and inviting target for corrosion. With galvanized or zinc coated steels, use a slower gun travel speed than under coated steel welding. A slower travel speed allows the zinc to burn off at the front of the weld. How much to reduce the gun travel speed will depend on the thickness of the zinc coating the joint type and the welding position. The welding gun should be handled with a side to side weaving motion to prevent burn through or excessive penetration of the wider gap.

Apply antispatter compound inside the gun nozzle and clean the nozzle frequently to avoid more spatters deposited when welding galvanized or zinc - coated steels than uncoated steels.

Aluminum welding: Modern vehicles have a auto body, frame and chasses parts made of aluminum. As a result, the need for aluminum welding during auto body repair. When welding aluminum be sure to protect wire harness and electronics parts from potential damage caused by spreading heat. Use the following guide lines to weld aluminum MIG welding.

- Match the wire to the aluminum alloy
- Set wire speed faster than with steel
- Hold the gun closer to vertical and tilt it only about 5 to 10 degree from the vertical in the direction of weld.
- Use only the forward welding method
- Set the tension of the wire drive roller lower to prevent twisting
- Use an antispatter compound to control buildup at the end of the nozzle and clean off any excess to keep it out of the weld puddle.
- Do not have enough amperage for aluminum and do not use resistance spot welders
- Use skip and stitch welding techniques to prevent heat warping. Set wire speed slightly faster. Hold the gun closer to vertical than steel welding.
- Use about 50 percent more shielding gas
- Use 100 percent argon for the shield gas
- Clean the weld area completely
- Sand a strip about 19 mm with a stainless steel wire brush
- Load 0.030 aluminum wire into the welder and trigger it to extend about 25 mm beyond the nozzle.
- Set the voltage and wire speed according to the instructions supplied with the welding machine.
- Position two pieces together and lay a lead along the entire joint the distance between the contact tip and the weld should be 8 to 14 mm.
- If the arc is too large, turn down the voltage and increase the wire speed. The bead should be uniform on top, with even penetration of the back side.

Testing the MIG welding: Testing the MIG welding can be done simply with test panels. Before welding on a vehicle make some welds on pieces of scrap sheet metal like the panel that are going to be installed on the vehicle. The proper settings on the MIG welding machine obtained on the test pieces, the quality of the weld on the vehicle can ensured.

MIG welding defects: Proper welding techniques ensure good welding result. If welding defects occur change your procedures to correct the defects. A welding problem causes a weak joint that reduces quality. Common weld problems as follows.

- Weld prosity
- Weld cracks
- Weld distortion
- Weld spatter
- Weld overlap
- Weld under cut
- Too little penetration
- Too much penetration

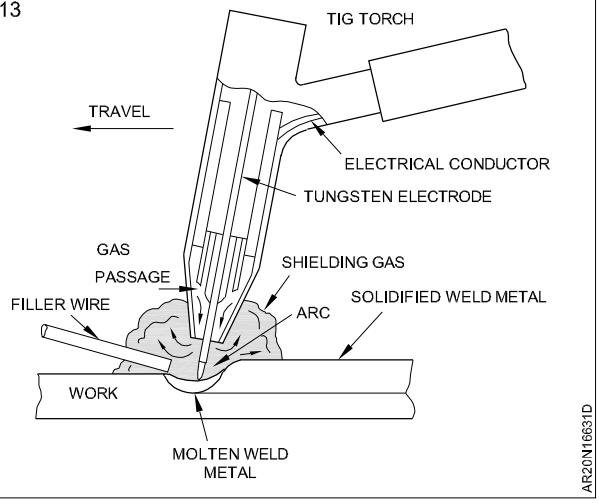
Flux - cored arc welding: Flux- cored arc welding is an electric arc welding process that uses a tubular wire with flux inside with the development of 0.030 self- shielded, flux - cored wire the flux - cored welding process has proven to be valuable for work on high strength steel. FC AW process uses the power source as MIG. It also uses the electrode feed system, contact tube, electrode conduct welding gun and many other pieces of equipment that are used in MIG.

There is no external shield gas in FCAW. As the flux within the wire melts in the heat of the arc, the created gases shield the weld puddle, stabilize the arc, help control penetration and reduce probity. The melted flux also mixes with the impurities on the metal surface and brings them to the top of the weld as slag. The slag can be chipped or brushed away. There are two important advantages of the FCAW process over MIG are its ability to tolerate surface impurities and stabilize the arc. Only ferrows metals can be welded. FCAW machine uses with 0.76 or 0.89 mm wire uses straight polarity uses;

TIG welding: (Fig 13) Tungsten inert gas (TIG) welding another form of GMAW uses a nozzle feed shielding gas and a hand - held filler rod it is limited use in auto body shop. TIG welding weld speed is 127 to 254 mm per minute. A TIG welding can be used to repair cracks in aluminum cylinder heads and reconstruct combustion chambers and other automotive components.

TIG welding machine uses inert gas and tungsten electrode with a very high melting point to strike and arc between the welding gun and the work. The tungsten electrode has such a high melting point. It is not consumed during the welding process. A filler rod must be used for welding thicker materials.

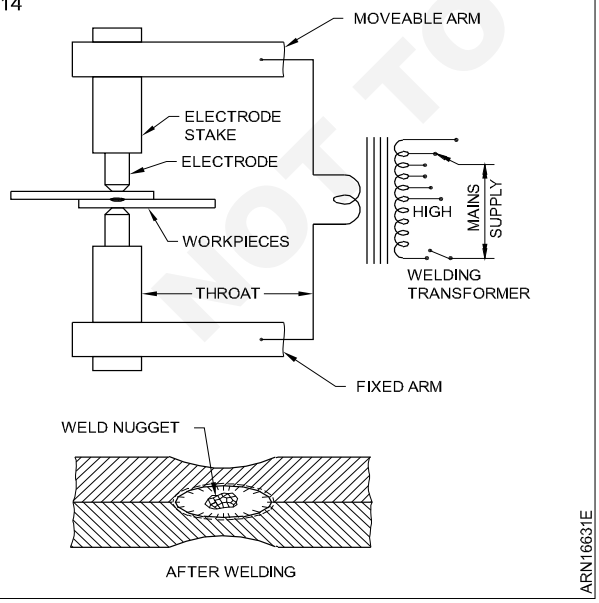
Fig 13



Resistance spot welding: It is used on auto body assembly lines to make many of OEM welds on unibody cars and it also used for sun roof installations and vehicle conversions including recreational vehicle. The resistance spot welding uses for repair the uni body's thin gauge sections that require good weld strength and no distortion, its application, vehicle roofs, window & door openings, rocker panels and many exterior panels. Due to the strength requirements of vehicle's uni body repairs. Resistance spot welding has several advantages.

Resistance spot welding components: (Fig 14) The components of a resistance spot welding are the welding transformer, welder control and welding gun with interchangeable arm sets. The transformer converts low amperage, 240-volt shop line current to high secondary amperage, low voltage welding current and safe from electrical shock. The transformer long cables are connected to the gun. A high weld current output can be adjusted to a lower intensity by use of the welder control. The welder control adjusts the transformer weld current output and permits precise adjustment of the weld time.

Fig 14



The welding gun applies the squeeze force and delivers the welding current through the welder arms to the metal being welded. Resistance spot welders used for unibody repair welding with a full range of inter changeable arm sets. Standard arm sets are designed to reach difficult areas on most of the vehicles.

Spot welder adjustments: To obtain sufficient strength of spot welded portions, perform the following checks and adjustments on the resistance spot welding gun before starting.

- Select the arm according to the area to be welded
- Keep the gun arm as short as possible to obtain the maximum pressure for welding. Securely tighten the gun arm and tip so that they will not become loose during the operation.
- Align the upper and lower electrode tips on the same axis. Poor alignment of the tops causes insufficient pressurizing and this results insufficient current density and insufficient strength at the welded portions.
- The diameter of the spot weld decreases as the diameter of the electrode tip increases. If the electrode tip is too small, the spot weld will not increase in size. The tip diameter must be properly controlled to obtain the desired welding strength. Premature tip wear increases resistance and causes the welding current to drop drastically of the tips are worn use a tip dressing tool to reshape the tips.
- Current flow time also has a relationship to the formation of a spot weld. When the electrical current flow increases, the heat is generated increases the spot weld diameter and penetration. The amount of heat is dissipated at the weld increases as the current flow time increases. However welding strength can be ensured by lengthening the current flow time.

Operating a squeeze - type resistance spot welding: Hold the welding gun and position it welder arm electrode contact the body parts to be welded. Then use the squeeze mechanism to apply weld force to both sides of the metal being welded. The force mechanism initiates and electrical signal to the welder control that switches on the flow of weld current for a preset time and then switches it off. The entire welding process is very fast.

The other important operational conditions of squeeze type resistance spot welding.

- Clearance between surfaces
- Metal surface to be welded (remove the paint film, rust, dust on metal surface)
- Corrosion - coat the anti - corrosion agent on the surfaces to be welded.
- Performance of spot welding operations - use the direct welding method
- Number of points of spot welding
- Minimum welding pitch
- Position of welding spot from edge and end of panel

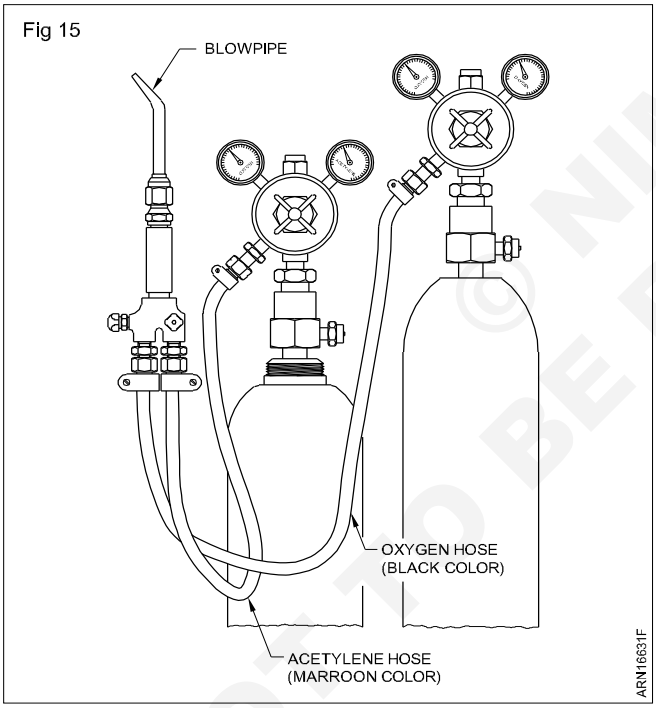
- Spotting sequence - do not spot continuously in one direction
- Welding corners - do not weld the corner radius portion

Other spot welding functions: The squeeze type welding gun is used with spot welding equipment with the proper gun attachment, a spot welder can be used as a panel spotter, stud welder, spot shriner and mold rival welded.

Stud spot welding for dent removals: studs used indent removal can be resistance welded with a special stud welder or a panel spotter equipped with stud welding attachments. To remove a dent properly with stud or stud spot welder, a good quality stud is necessary. The stud combination of pull strength remaining extremely flexible. The flexibility allows the stud to be bent out of the way when working on adjacent studs, then bent back when required. Maintain the flexibility of the steel being applied and removed.

Oxyacetylene welding: It is a type if fusion welding, Acetylene and oxygen are mixed in a chamber, ignited at the tip and used as a high- temperature heat source (approximately 2,984°C) to melt and join the welding rod and base metal together. (Fig 15)

Fig 15



Welding and cutting equipment: an oxyacetylene welding and cutting outfit consists of the following.

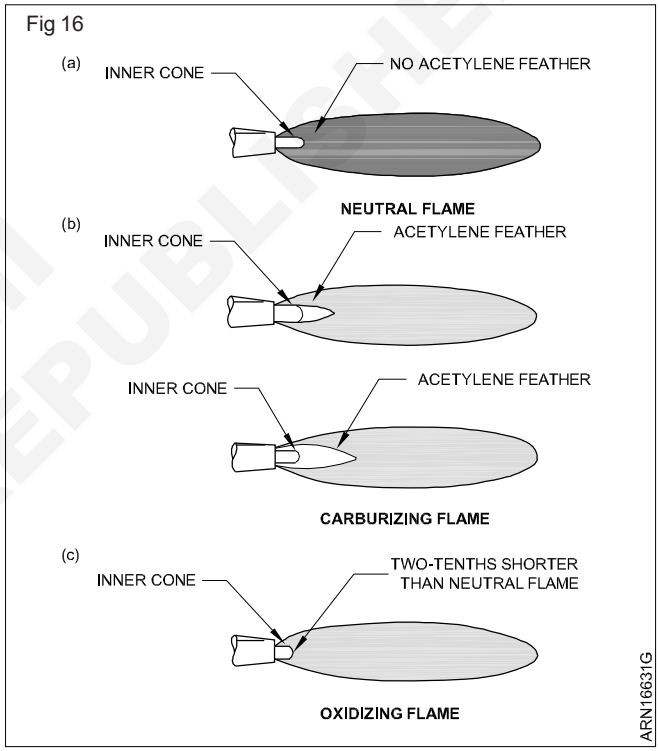
- Steel cylinder filled with oxygen and acetylene gas
- Regulators used for reduce pressure coming from the tanks to the desired level and maintain a constant flow rate of oxygen pressure 15 to 100 PSI and acetylene pressure 3 to 12 PSI
- Hoses from the regulators and cylinders connect the oxygen and acetylene to the torch
- Torch body mixes the oxygen and acetylene from the tanks in the proper proportions and produces a heating flame capable of melting steel. There are two main types of torches
- Welding torch
- Cutting torch

The low pressure torch is used for acetylene welding. This torch can be used at an extremely low acetylene pressure and has an injector nozzle. The gases are mixed by discharge of oxygen from the center nozzle.

The cutting torch has an oxygen tube and valve for conducting high pressure oxygen attached to a welding torch. The flame outlet has a small oxygen hole located in the center of the tip that is surrounded by holes arranged in a spherical pattern. The outer holes are used for preheating. Spark lighter is used for light on the gas flame.

Types of flame and adjustment: (Fig 16) When acetylene and oxygen are mixed and burned in the air, the condition of the flame varies depending on the volume of oxygen and acetylene. There are three forms of flame as follows.

Fig 16



- Neutral flame - The acetylene and oxygen standard flame is said as neutral flame
- Carburizing flame - Acetylene gas mixing slightly more than oxygen gas
- Oxidizing flame - The oxidizing flame is obtained by mixing slightly more oxygen than acetylene gas

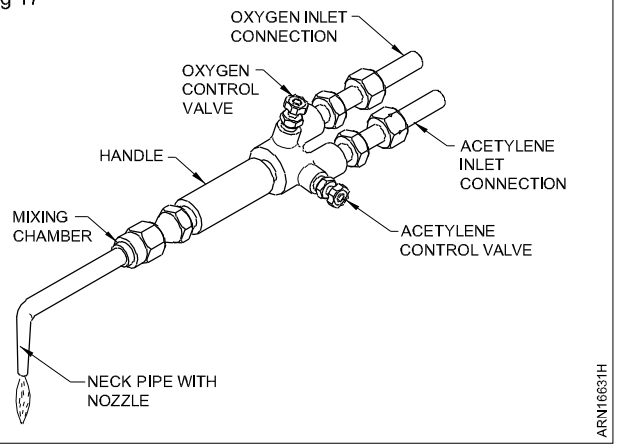
Welding torch flame adjustments: (Fig 17) Welding torch flame is used for brazing certain nonstructural panels at factory brazed seams. The following procedures using a welding torch.

- Attach the suitable tip to end of the torch use the standard tip for sheet metal.
- Set the oxygen and acetylene regulator at proper pressure as,

  Oxygen = 8 to 25 PSI

  Acetylene = 3 to 8 PSI

Fig 17



- Open the acetylene valve about half a turn and ignite the gas. Continue to open the valve until the black smoke disappears and a reddish yellow flame appears. Slowly open the oxygen valve until a blue flame with a yellowish white core appears. Further open the oxygen valve until the center core becomes sharp and well defined. This type of is called neutral flame and is used for welding mild steel.
- If acetylene is added to the flame or oxygen is removed from the flame resulting a carburizing flame. If the oxygen is added to flame or acetylene is removed from the flame resulting an oxidizing flame.

Gas cutting torch flame adjustment: Gas cutting torch is used in collision repair shops to rough cut the damaged panels. Gas cutting torch flame adjustment as follows.

- Adjust the oxygen and acetylene valves for preheating neutral flame
- Open the preheating oxygen valve slowly until and oxidizing flame appears
- Heat a portion of the base metal until it is red hot, just before it melts, open the high pressure oxygen valve and cut the panel. Advance the torch forward while making the panel is melting and being cut apart. This method is used for thick panel cutting of auto body.
- Heat the small spot on the base metal until it is red hot. Just before melts, open the high - pressure oxygen valve and incline the torch to cut the panel. When cutting this material, incline the tip of the torch so that the cut will be clean and fast.

Note: As soon as the cutting operation completed, quickly turn off the high pressure oxygen flow used for cutting and pull the torch away from the base metal.

Cutting HSS for salvage purpose: General purpose salvage - cutting components must be cut with a grinding wheel disc, air chisel metal cutting saw and plasma cutter. Gas cutting torch is necessary to cut the HSS metal components for salvage purposes or cutting a damaged body structure.

- Cut the metal structure at least 51 mm away from the desired cut line.
- After the torch cutting, the sheet metal use a grinding wheel disc and air chisel or a metal saw to make the final cut at the originally intended dimension line. HSS damage will then cut out of the salvaged part.

Oxyacetylene gas should not be used on HSS components for welding or cutting. HSS sheet metal should be exposed to high temperatures from an Oxyacetylene torch for only a very short period of time. Two minutes is recommend maximum time span for exposing HSS to 538°C temperature to reduce the amount of scaling that normally takes place on the metal surface. High - temperature exposure causes discoloration. To determine and control temperatures of HSS parts is necessary to use a temperature indicating crayon.

Heat crayons: Heat crayons can be used to determine the temperature of the aluminum or any other metal being heated. They will melt at a specific temperature and warn you to prevent overheating. The crayon or paint is applied next to the aluminum area to be heated. The mark will begin to melt when the crayon's or paints melting point reached. The melting will let you know that you are about to reach the melting point of the aluminum. Using such a crayon will indicate to the welder whether an excessive amount of heat is being applied. Thus metal temperatures can be controlled within safe levels and HSS damage easily prevented.

Clean with a torch: Before start the welding, the surfaces to be joined must be thoroughly clean. Otherwise the finished weld is quite likely to be brittle, porous and poor integrity. To remove heavy under coating, rust proofing, tars, caulking, sealants, road dirt and primers. First use a scraper to remove the loose material and then use an oxyacetylene torch. If needed use the wire brush and the torch, using a carburizing flame. Keep the torch at a very low, controlled heat to prevent part damage.

Probable causes and remedies for flame abnormalities:

When changes occur during the welding operation i.e. overheating of the flame outlet, adhesion of spatter or fluctuations in the gas adjustment pressure, the result will be variations in the flame. Therefore, the operator must always be aware of the condition of the flame. Flame abnormalities and their causes and remedies are shown in the table below.

Flame abnormalities and remedies

Symptom	Cause	Remedy
Flame fluctuations	• Moisture in the gas, condensation in the hose. • Insufficient acetylene supply.	• Remove the moisture from the hose. • Adjust the acetylene pressure. • Have the tank refilled

Explosive sound while lighting the torch	• Oxygen or acetylene pressure is incorrect • Removal of mixed - in gases are incomplete • The tip orifice is too enlarge • The tip orifice is dirty	• Adjust the pressure • Remove the air from inside the torch • Replace the tip • Clean the orifices in the tip
Flame cut off	• Oxygen pressure is too high. • The flame outlet is clogged	• Adjust the oxygen pressure • Clean the tip
Popping noises during operation	• The tip is overheated • The tip is clogged • The gas pressure adjustment is incorrect • Metal deposited on the tip	• Cool the flame outlet. (while letting a little oxygen flow). • Clean the tip • Adjust the gas pressure • Clean the tip
Oxygen flow is reversed (Oxygen is flowing into the path of the acetylene)	• The tip is clogged • Oxygen pressure is too high • Torch is defective. (The tip or valve is loose) • There is contact with the tip and the deposit metal	• Clean the tip • Adjust the oxygen pressure • Repair or replace the torch • Clean the orifice
Back- fire (There is a whistling noise and the torch handle grip gets hot. Flame is sucked into the torch)	• The tip is clogged or dirty • Oxygen pressure is too low • The tip is overheated • The tip orifice is enlarged or deformed • A spark form the base metal enters the torch causing an ignition of gas inside the torch. • Amount of acetylene flowing through the torch is too low.	• Clean the tip • Adjust the oxygen pressure • Cool the tip with water (Letting a little oxygen flow) • Replace the tip • Immediately shut - off both torch valves • Let torch cool down. Then relight the torch • Readjust the flow rate

Brazing: The term of brazing refers to the use of a filler material with a lower melting point than the base metal, that is melted and flows into the narrow spaces between the pieces of base metal by capillary attraction. There are two types of brazing - soft brazing (soldering) and hard brazing, normally the term brazing refers to hard brazing.

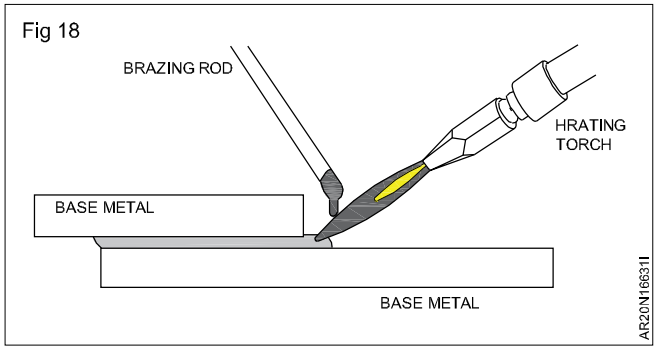
Allow - based brazing materials

Types of brazing materials	Main ingredients
Brass brazing metal	Copper, Zinc
Silver brazing metal	Silver, Copper
Phosphor copper brazing metal	Copper, Phosphorus
Aluminum brazing metal	Aluminum, Silicon
Nickel brazing metal	Nickel, Chrome

Interaction of flux and brazing rods: Normally the surfaces of metals exposed to the atmosphere are covered with and oxidized film, if heat is applied, thickens of flux removes this oxidized film and prevents the metal surface from deoxidizing. It also increases the bond between the base metal and the brazing material.

The oxidizing film can be removed by applying flux to the surface of the base metal and then heating it until it becomes liquid. After the oxidation has been removed, the brazing material will adhere to the base metal and the flux will prevent further oxidation. (Fig 18)

Fig 18



Brazing joint strength: The strength brazing material is lower than that of the base metal, the shape of the joint and the clearance of the joint are extremely important. Joint strength is dependent of the surface area of the pieces to be joined therefore, makes the joint overlap as wide as possible.

If the items being joined are of the same material, the brazed surface area must be larger than that of welded joint. As per general rule, the overlapping portion must be three or more times wider than the panel thickness.

Brazing operations: The brazing procedure is as follows

Cleaning the base metal: Clean the metal surface before brazing. If the contaminants, like oxidation, oil, paint of dirt on the surface is allowed to remain on the surface, can cause eventual joint failures. Even though flux is acts to remove oxidized film and most contaminants, it is not enough to completely remove everything. There fore before brazing clean the surface with wire brush.

Flux application: After the base metal cleaning, apply flux uniformly to the brazing surface. If the brazing rod with flux in it is used this operation is not necessary.

Base metal heating: Heat the joining area of the base metal to a uniform temperature capable of accepting the brazing material. Adjust the torch flame, so that it is a slight carburizing flame. By watching the melting flux, you can estimate the proper temperature for the brazing material.

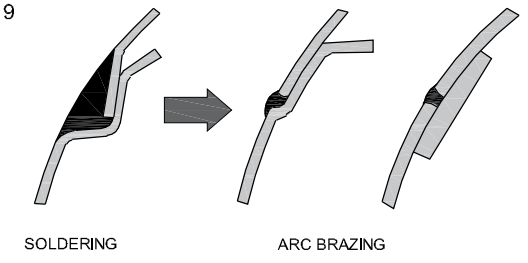
Base metal brazing operation: When the base metal has reached the proper temperature melt the brazing material on the base metal letting it flow naturally. Stop heating the area when the brazing material has flowed into the gaps of the base metal. Important points of brazing operations as follows.

- Because brazing flows easily over a heated surface, it is important to remember to heat the entire joining area to a uniform temperature.
- Do not melt the brazing material prior to heating the base metal because the brazing material prior to heating the base metal because the brazing material will not adhere to the base metal.
- If the surface temperature of the base metal becomes too high, the flux will not clean the base metal, resulting in a poor brazing bond and interior joint strength.
- Brazing temperature must be higher than the melting point of brass by 10° to 89°C.
- Preheat the panel to deposit brazing filler metal more efficiently.
- Evenly heat the portion to be welded without melting the base metal
- Control the heat by cutting the torch more horizontally.
- The brazing time must be as short as possible to prevent lowering weld strength and avoid brazing the same place again.

Treatment after brazing: The brazed portion has cooled down sufficiently rinse off the remaining flux sediment with water. Scrub the surface with a stiff wire brush. Based and blackened flux can be removed with a sander. If flux sediment is not adequately removed, corrosion and cracks might form in the joint. (Fig 19)

Soldering: It is used for leveling the panel surface and correcting the surface of the welded joints. Before attempting to solder a joint, remove paint rust, oil and other foreign substance. (Fig 19)

Fig 19

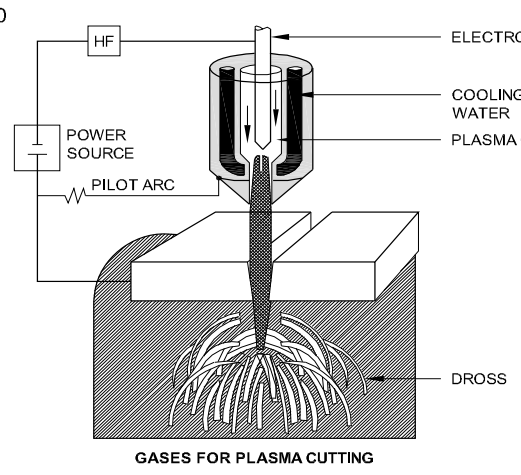


Soldering procedures: the soldering procedures as follows:

- Heat the portion to be soldered. Wipe it with a cloth after heating
- Stir solder paste well. Apply it with a brush to an area 1 to 1 ½ inches (25.4 to 38 mm) larger than the built up area. Heat it from a distance.
- Wipe the solder paste from the center to the outside. Makes sure the solder portion is silver gray, if it is bluish, it is due to overheating. If any spot is not soldered, reapply the paste for soldering.
- If the gas welding torch is used, the oxygen and acetylene gas pressures must be 4.3 to 5 PSI.
- The solder must be contain atleast 13 percent Zinc and maintain the appropriate temperature. Move the torch so that the flame evenly heats the entire portion to be soldered. When solder begins to melt, remove the flame and start finishing with spatula.
- When additional solder is required, the previously buildup solder must be reheated.

Plasma arc cutting: (Fig 20) Plasma arc cutting creates an intensely air system, which melts and removes metal over a very small area. Extremely clean cuts are possible with Plasma arc cutting. Because of the tight focus of the heat, there is no warpage, even when cutting thin sheet metal.

Fig 20



Plasma arc cutting is replacing oxyacetylene as the best way to cut metals. If cuts damaged metal effectively and quickly but does not destroy the properties of the base metal.

In plasma arc cutting, compressed air is often used for both shielding and cutting. As a shielding gas air covers the outside area of the torch nozzle. Cooling the area so the torch does not overheat. The extreme heat and force of the

cutting arc melt a narrow path through the metal. This serves to dissipate the metal into gas and tiny particles. The force of the plasma literally blows away the metal particles, leaving a clean cut.

10 to 15-amp plasma arc cutter is generally adequate for mild steel up to 3/16 inch (5 mm) thick, a 30 amp unit can cut metal upto 6 mm thick and 60 MP unit will slice through metal up to 13 mm thick. Plasma arc cutters made specifically for thinner metals might only have an ON- OFF switch and a ready light. More elaborate equipment can include a built in air compressor, variable output control, on board coolant and other features.

Check the air pressure regularly, using the wrong pressure can reduce the quality of the cuts, damage parts and decrease the cutting capacity of the machine.

Operating a plasma arc cutter: Operating procedure of plasma arc cutter as follows.

- Connect the plasma arc cutter to a clean, dry source of compressed air with a minimum line air pressure of 60 PSI.
- Connect the torch and ground clamp to the unit and connect the ground clamp to a clean metal surface on the vehicle.
- Move the cutting nozzle into contact with an electrically conductive part of the work.
- Hold the plasma torch so that the cutting nozzle is perpendicular to the work surface. While keeping the cutting nozzle in light contact with the work, drag the gun lightly across the work surface.
- Move the plasma torch in the direction the metal is to be cut. The speed of the cut will depend on the thickness of the metal. If the torch is moved too fast, it will not cut all the way through if moved slowly, it will put too much heat into the workplace and might also extinguish the plasma arc.
- When piercing materials 3 mm thick or more angle the torch at 45 degrees until the plasma arc pierces the material.
- Allowing the plasma arc cutting unit for a couple of minutes after the cut is made to extend the life of electrode and nozzle.
- Be aware of the fact that the sparks from the arc can damage painted area and also pit glass. Use a welding blanket to protect these surface.
- Make sure there is nothing behind the panel that can be damaged. Check for wiring, fuel lines, sound-deadening materials, and other objects that could cause a fire.
- Ensure the plasma torch travel speed, parts wear and supply air quality to bearing a good quality metal cut by plasma arc cutter.

When angling the torch, be aware that the sparks can shoot as far as 20 feet away. Be sure that these are no combustibles or other workers in the area.

Advantage and disadvantage of different types of welding

There are many types of welding methods used in auto body repair works. Each welding method have some advantages and disadvantages as follows.

Welding method	Advantages	Disadvantages
Pressure welding	- Reduce welding costs - No consumable filler wire rod organs is required - Clean with no smoke - Restore corrosion protection to repair joints - Factory weld appearance - Fast weld times of a second - Elementary distortion of metal	- Electrode costly - Welding machine costly - Argon or helium gas need to operate the unit - Cannot be used without power source - Electrode melting point is very high
Fusion welding	- Mechanical arc welding used to join the metals - Oxyacetylene gas used for fusion the metal - Oxyacetylene gas welding used for very thin metal and brazing the metal	- Electric power is need to operate the arc welding machine - Oxyacetylene gas welding cannot be used for thick metal - Arc welding machine cannot be used for brazing welding
Braze welding	- Soldering and brazing rod used for braze weld - Less operating cost - Can be shift the machine any where as you desire - Soldering rod melt at low melting temperature - Brazing weld helps fine finishing on metal joints	- Cannot joint the thick metal sheet - Braze weld cannot be used for cut the metal sheet

Sheet metal repair

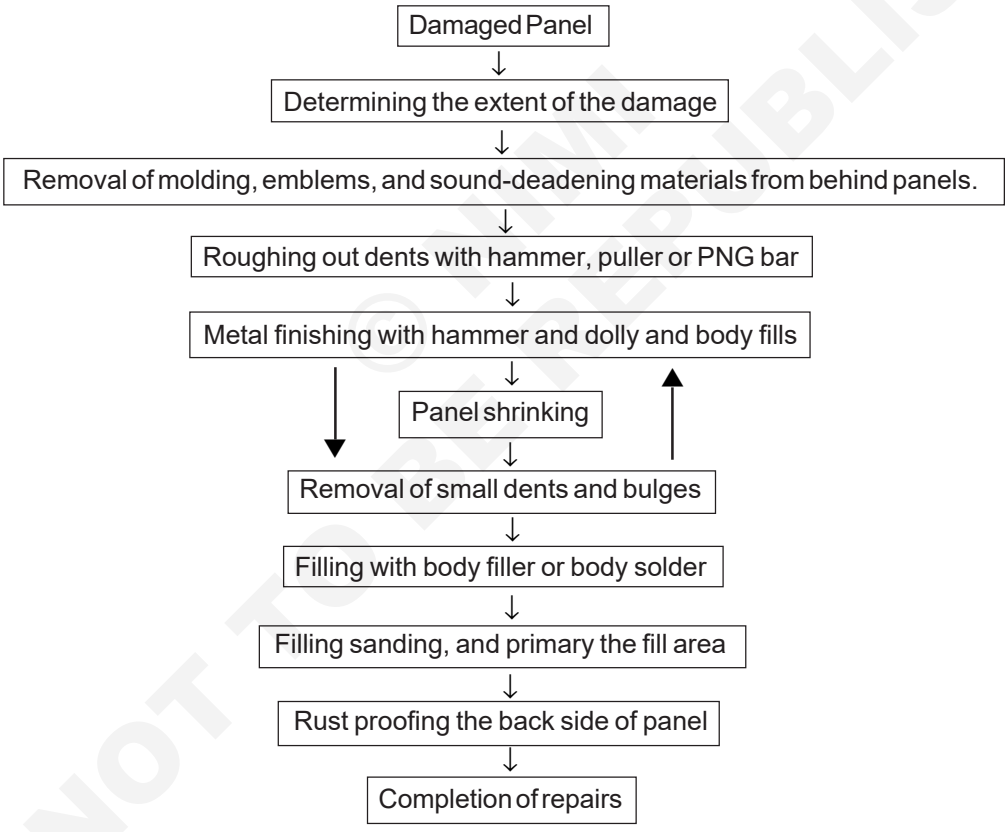
Objectives: At the end of this lesson you shall be able to
- **state the automotive sheet metal**
- **correct minor sheet metal damage**
- **state the types of loading**
- **state the properties of sheet metal**
- **state the classifying body damage.**

Automotive sheet metal

Sheet metal is metal formed by an industrial process into thin and flat pieces. It can be cut and bent into a variety of shape. The most common sheet metal used in automotive to make shape to make body parts. The next best metal is aluminium, it is lighter but harder to bend into tight shapes without cracking it also harder to weld in mass production. There are three type of sheet metal sheet and aluminium sheet is used in automobile construction work.

- Boron sheet
- Mild and low carbon steel
- Higher carbon steel
- Aluminium sheet

Basic steps for repair the minor sheet metal damage



Low carbon steel: Low carbon steel or mild carbon steel has a low level of carbon and is relatively soft and easy to work. Low carbon or MS is easily deformed and relatively heavy vehicle manufactures have begun using high strength steels in load carrying parts of the vehicle.

High strength steels: HSS is stronger than low carbon steel because of heat treatment. Most new vehicles contain HSS in their structural components,

Types of High-Strength steel: Many types of steels are generally classified as high strength steel. There are two types of strength. They both relate to the ability of the metal to resist permanent deformation.

1 **Yield strength:** Yield stress is measured as the minimum force per unit of area that cause the material to begin to permanently change its shape

2 **Tensile strength:** Tensile stress is measured as the maximum force per unit of area that causes a complete feature or break the material.

High tensile strength steel (HTSS): HTSS steel is stronger than low carbon or mild steel because of heat treatment. The modern vehicles are used the HTSS sheets in auto body structural construction. When heat is applied to HTSS component to assist in straightening the stresses resulting from collusion are decreased, there by restoring the strength to a lower level. If the collision exceed the tensile strength the material will tear or fracture. Thermal crayons or paint should be applied around the area to be heated with an oxyacetylene torch to restrict temperature 649°C.

Type of loading: Loading refers to the types of force applied to a part to damage it. There five basic types of loading are as followed.

1 **Tensile load:** A load that tries to pull parts straight apart

2 **Compression load:** A load that force the parts straight into each other

3 **Shear load:** A load that pulls parts sideways

4 **Cleavage load:** A load that tries to force parts apart from an angle

5 **Peel load:** A load that pulls parts straight away from each other.

Properties of steel sheet metal: There are four ways to measure the strength of metal. All related to the metal is ability to resist deformation

Yield stress: It is the amount of strain needed to permanently deform a test specimen. Ultimate strength is a measure of the load that breeks a specimen. The tensile of a metal can be determined by a tensile strength of a metal can be determined by a tensile testing machine.

- **Compression strength :** It is the properties of a material to resist being crushed.
- **Shear strength:** It is a measure of how well a material can with stand forces acting to cut or slice it apart.
- **Torsional strength:** It is the properties of a material that with stand a twisting force.

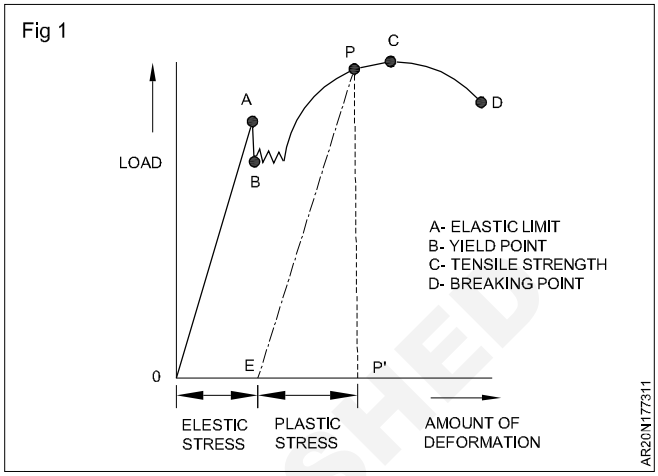
The strength of sheet metal is expressed in PSI or Kpa (Kilograms per square multimeter. When flat steel sheet is formed into a shape for a part, it takes on certain properties. The structure of the metal in the affected areas has change, causing the metal to become harder and more resistant to corrective force.

Effect of impact force: Sheet metal resistance to change has the properties elastic deformation, plastic deformation and work Harding. Yield point is the amount of force that a piece of metal can resist without tearing or breakings. Spring back is the tendency for metal to return to its original shape after deformation.

Elastic deformation: It is the ability of metal to stretch and return to its original shape. For example, take a piece of sheet metal and gently bend it to form a slight are when released it will spring back to its original shape.

Plastic deformation: Plasticity is the ability of metal to be bend or formed into different shapes. Plasticity is important to the collision repair. Plastic deformation is, when the metal has permanently changed shape. The graph shows the relationship between the size of the load and the elongation of sheet metal, when a tensile load is applied (Fig 1).

Fig 1



Work hardening: Work hardening occurs when plastic deformation has caused the metal to become very hard in the bent area the plastic deformation has been the metal became hard and brittle where bent. This increased hardness is called work hardening.

Classifying body damage: The first step in auto body repair is analysing the damaged area. The three items are listed below is a condition that occurs. When metal is damaged by inspect

- Direct damage - a tear, scratches
- Indirect damage - buckle or pressure
- Work Hardening - normal and impact created

Direct damage: Direct damage is a single, visible damage that is easy to identify such as gauge, a tear or a scratch it is the damaged portion of the panel that came indirect contact with the object that caused the impact direct damage is usually about 20 present of the total damage. Direct damage repair at the point of impact is limited. Direct damage varies from job to job (Fig 2).

Indirect damage: Indirect damage is caused to the shock of collision forces travelling through the body and internal forces acting on the rest of the unibody. Indirect damage can be more difficult to completely identify and analyse. Indirect damage represents on average 10 to 20 persent of the overall damage (Fig 2).

Analysing sheet metal damage: Work hardening is in all sheet metal panels of a vehicle to varying degrees. It is important to know where the metal was hardest and softest before it was damaged. The Fig 3 fender shows soft areas, (unshaded) and hard areas (shaded). The shaded areas are harder to damage however, when damaged they are more difficult to straighten.

Fig 2

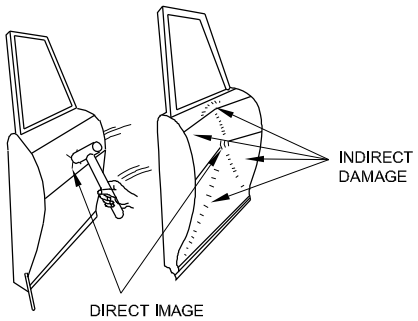
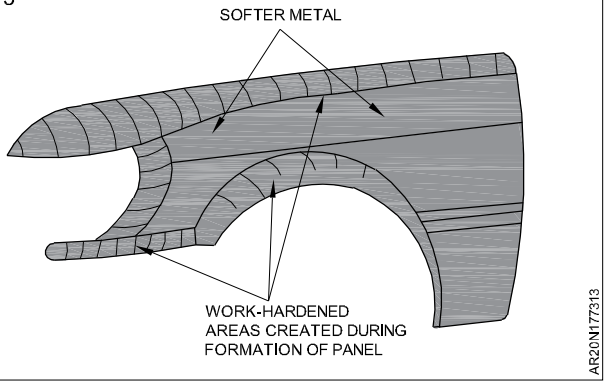


Fig 3



Buckles: If the panel bent part a certain elastic limit, the metal takes a set is called a buckles. The buckles are a result of bending metal part its elastic limit bent beyond this limit, metal will not return to its original shape.

Simple hinge buckles: The simple hinge buckle bends like a hinge equally along its entire length. The buckle usually causes little stretching, if straightening incorrectly, it will cause considerable trouble. Any metal that is bent to form an angle is considered a box section, Boxed structure rails, rocker panels, wind shield pillars, center pillars, and roof rails are just a few, some boxed sections such as the assembly.

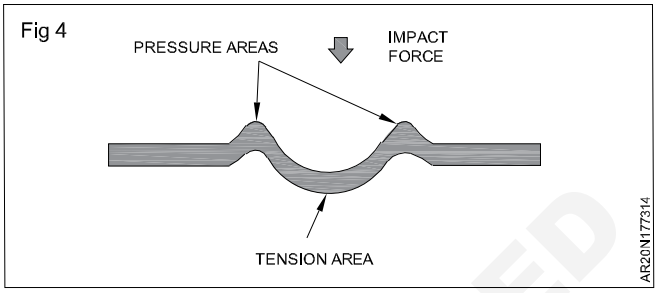
Pressure force: The term pressure commonly used to describe the conditions in metal after damage. These conditions are also referred to as high spots and low sports. A high spot is an area that sticks up higher than the surrounding surface. A low spot is just the opposite. Mirror low and high spots in sheet metal can offer be fixed with metal working tools.

Sheet metal raising means to work a dent outward from the body. The term sheet metal lowering means to work a high spot or bump down into the body. The metal that is pushed up is called a pressure area. Areas that are pushed down are called tension should never strike the underside of a pressure area. Power hook ups are determined by the direction of pressure forces. No body filling can be done, when there are pressure areas present.

Single crown panels: A single crown panel is flat in one direction and crowned in another. The damage has tension is one direction and pressure in another.

Door dings: The figure shows exaggerated drawing of a simple door, dings, pressure and tension areas in the damage. The impact creates a shallow tension area surrounded by a ridge or pressure area. Correct the small dings by using a pick from inside the door. Carefully position the pick and push for deeper dings with more serious tension areas use a hammer and dolly to work the ding. The ridge around the dings must be tapped down level with the panel and the low area must be pushed out with a dolly that has the correct contour. Then the area might need to levelled with body filler and refinished (Fig 4).

Fig 4



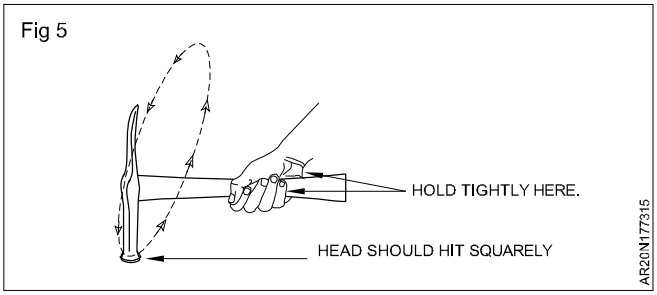
Determining the direction of damage: All the damage information are help to determines the direction of damage. To fix collusion damage, must apply force in the reverse of how the damage occurred sometimes visual inspection making a determination becomes completed when there are overlapping conditions. By imaging the accident in reverse, studying each buckle, and unfolding each work hardened section of metal, you can visualize how the repair operations should be formed.

Metal straightening techniques by using body hammer: The metal straightening procedure being with a diagnosis of the damage. The actual work on the metal begins with the rough out stage. Rough out means to remove the most obvious damage to get back the original part shape. It must be done properly.

Roughing out the damage can be as simple as using a rubber or plastic hammer on the edge of a door carefully placed hammer blows on the back of the panel may be all that is needed to straight mirror damage. When using hammer blows, always grasp the end of the handle and make sure the hammer heed strikes the metal squad.

Hold the hammer with your third and fourth fingers and swing it with a circular motion to hit the damaged area. (Fig 5)

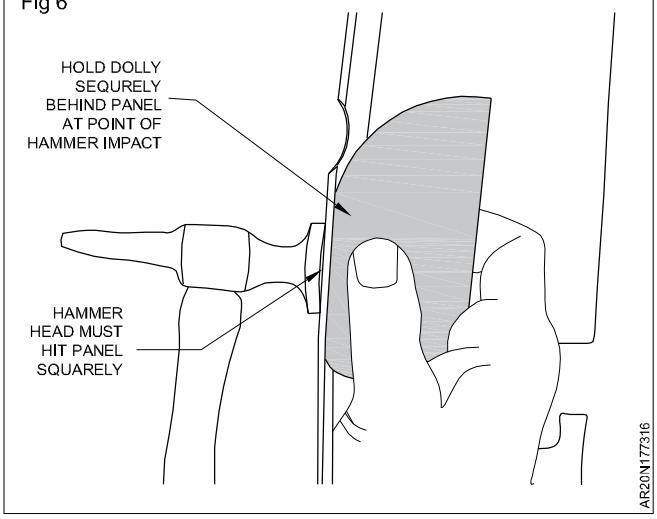
Fig 5



Bumping dents with dollies (Fig 6): A dolly is a hear by sized block with various shapes on each side for straightening sheet metal. A heavy steel dolly block is used as an impact tool. A dolly is often used as a striking tool on the back of panels, use the accurate hammer blows. Start out with light blow from the dolly. Make sure

you are hitting exactly where needed. Gradually increase the force of your blows to raise the damage. Increase the rebound blows by releasing pressure as soon as the dolly hits the panel using large dolly will also increase impact and rebound on the panel. (Fig 6)

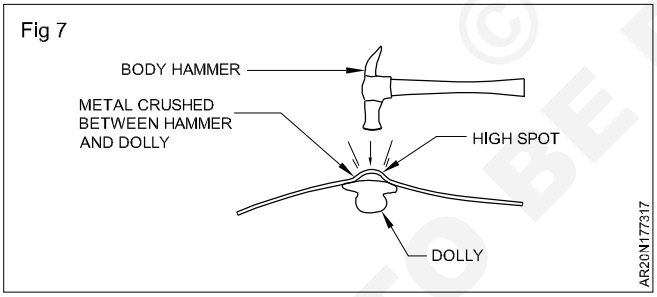
Fig 6



Hammer-on-dolly method (Fig 7)

Hammer -on-dolly repairing is done by hitting the panel right over the dolly. Hammer-on-dolly is a method used to exach a smoothing force to a small area on a damaged panel. The dolly is held against the back of the damage and the hammer hits the metal right over the top of the dolly. The exach a pinching force on the metal between the dolly and hammer head, gradually work toward the centre of the dent damage.

Fig 7

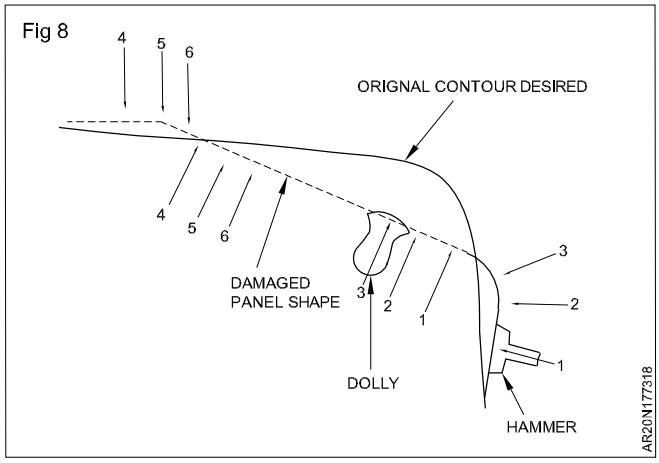


The hammer-on-dolly method, the shapes of the dolly and hammer head must match the desired shape of the panel if the area to be straightened is flat, the dolly surface and hammer head must also be curved to matched the panel shape. Always start out with light hammer blows, excessively hard or poorly aimed hammer blows that dent, stretch, and damage the panel, control dents (Fig 8).

You can control the effects of hammer on dolly straightening by:

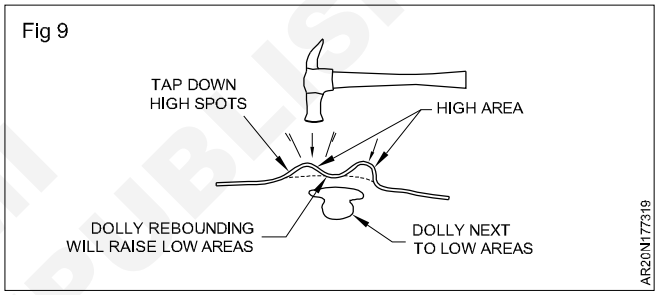
- changing the shape of the hammer face
- using a different shaped dolly face
- altering how hard you hit the metal
- increasing the force of the dolly against the back of the panel.

Fig 8



Hammer-off-dolly method: The hammer-off-dolly method is used to raise low spots and lower high spots simultaneously. The hammer hits the panel slightly to one side of where the dolly is being held, It is often used to rough out large areas of damages during initial straightening. (Fig 9)

Fig 9



If the panel has a raised ridge of damage, you can also use the dolly-off method once the area has been brought back to its basic shape, use the hammer-on-dolly method to smooth and level smaller damaged areas. You can control hammer-off-dolly straightening by:

- Altering how hard you hit the panel, start out with light blows and than increase their force as needed to lower high spots in the panel.
- Changing how hard to push the dolly against the back of the panel. Pushing harder tends to increase lifting action to raise low spots.
- Adjusting how for away the dolly is from the hammer blows. Moving the dolly further away tends to spread out the lowering force to a larger area on the panel. Moving the dolly next to the hammer blow tends to concentrate the effect of the lowering/raising force.

Picking dents: Picking dents often involves final straighten of very small areas of damage with the pointed end of a body hammer or with a long rod that has a curved, pointed tip on body hammer is often used to lower any small, high spots in the repair areas. Long picking tools can also be used to pry up metal in areas that cannot be reached with a dolly or spoon. A car door is a good example, Picks are used during pointless dent removal. When prying with a pick, be careful not to stretch the metal by exerting to much pressure, slowly pry the crease up on larger dents use a flat blade pick rather than a pointed one tap down pressure areas while prying low tension areas.

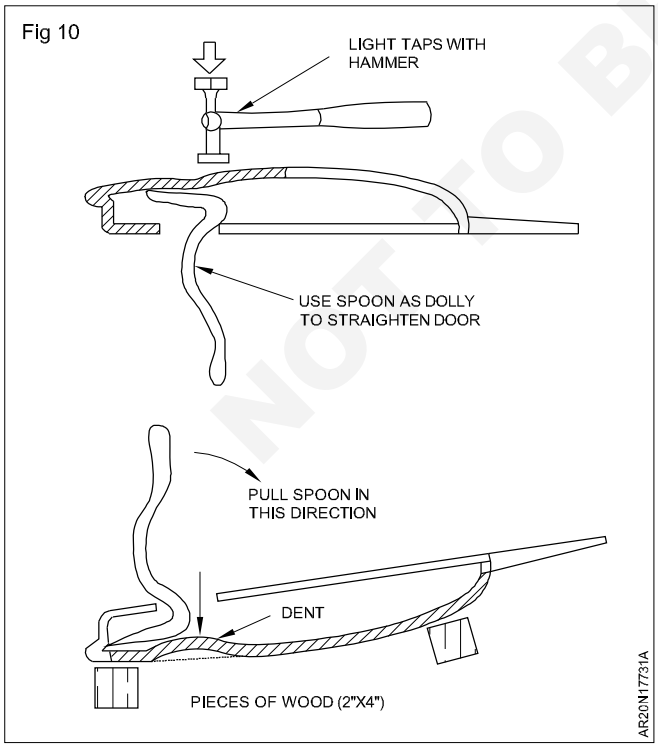
Unlocking on a hammer & dolly: A minor dent is often straightened by using hammer and dolly to roll out the metal in reverse of the order the damage happened. To remove the dent, roll set the damage from the out side, working toward the centre in reverse order of damages. Hold the dolly tightly under the channel at the outer end where there is the last amount of damage. A flat faced dinging hammer might be used to direct light to medium blows at the outer ends of the ridge closest to the dolly. The blows from the hammer will gradually forces down the ends of the ridges.

The off-dolly method is gradually worked toward the centre or where the greatest degree of bend exists in the ridges and channels. Once the area has been brought back to its basic shape, use the light on-dolly method to smooth and level the area. It is ready for either metal finishing or filling procedure.

Straightening dents with spoons: Spoons can be used in a number of ways to straighten sheet metal. They can be used to pry out dents and certain kinds can be struck with a human to drive out dents. In hard to reach areas, a spoon can be used as a dolly. Spoons are designed to be used in place of a hammer. The dinging spoon is light and has low crown. Always keep firm pressure on the spoon when spring hammering it must never be allowed to bounce, work begin at the ends of a ridge and work toward the high point on the ridge alternating from side to side.

Spoons can be used to back up the hammer or is combination with a slapping spoon. With long body spoon reach into places inaccessible to a hammer or dolly. Pressure can be applied to tension area with the spoon. While high areas are bumped down. Spoons can also be used to pry metal up in the rough out stage or to drive out deep dents out (Fig 10).

Fig 10



Other metal straightening methods: When a hammer and dolly will not fit behind the damaged body panel, long steel picks can often be used to reach and push out dents. As bladders can be used to pushout large dents from the back of some panels. The air bledders can be installed inside doors, quarter, panels and other unibody areas to push out large dents.

Paint removal: Depending on the type damage, have to sand or grand off the paint, when straightening sheet metal damage. Paint removal is done with a disc grinder, when their metal used in damaged area can be used a 36 grit disc or hard synthetic scuff pad. There are two types of metal, such as weld beads. A soften backup pad should be used to removing paint on polishing metal. The softer pad allows the disc to roll with the metal.

The grinder used in two ways

1 Buffing to remove paint and smooth body filler with little overlap of grinding marks.

2 Grinding marks overlap (Cross cutting) is used to removed metal. When using a grinder only the top 1.5 to 2 inches (38 to 51mm) should contacts the surface. Dont use excessive pressure. The weight of the grinder should be just about enough on vertical surfaces, the grinder should be held so the back of disc is raised 10 to 20 degrees off the metal.

Pulling dents: Dents can be pulled out with a number of tools, suction cups, dent pullers, and spot weld dent pullers. The purpose of dent puller is to lift out simple dents that cannot be reached easily or lifted out by other tools. The dent puller is probably used frequently used tools by auto body repair mechanic.

A suction cup can be used to pull out large, shallow dents. Wet the area and install the cup. If hand held pull straight out on the cups handle. If mounted on a slide hammers, use a quick blow to pop to pop out the dent.

To use the dent puller, thread the appropriate tip on the end of the puller. Hold the handle of the dent puller is one hand and slide the weight straight back against the handle. This will exert a powerful pulling force on the damaged panel.

A vacuum suction cup uses a remote power source to produce negative pressure (a vacuum) in the cup. This increases the pulling power, because the cup is forced tightly against the panel larger, deeper, dents can be pulled with a vacuum suction cup. Avoid drilling or punching holes in panels that are going to be reused. Only make holes when the panel is replaced or under unusual circumstance.

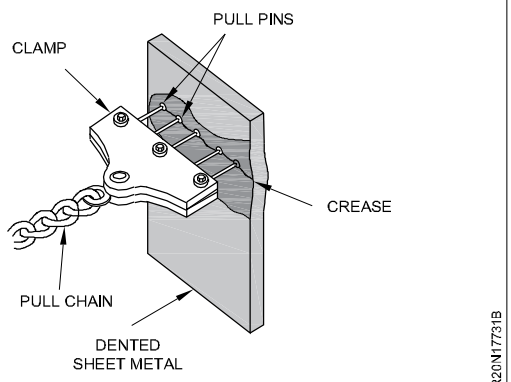
Spot weld dent pullers: A spot weld dent pullers can be used to remove dents in steel panels from the front without drilling holes. The heat from the resistance spot welder fuses a metal pull tip or pin to the steel body. This allows the damage to be pulled out from the front without accessing the back of the panel.

Resistance spot weld dent pullers are a for superior method of straightening damaged sheet metal (Steel but no aluminium panels). There are two basic types of spot weld dent pullers. Reusable tip and disposable tip types.

For deeper dents a slide hammer can be attached to a pulling pin. Slide hammer blows will easily pull the sheet metal back out and level with surrounding surface several pins can be welded to each low spot or a larger dent in the body panel for added pulling power. After the dent has been pulled out straight cut of the pull pins and grind the area flish. Finish straightening the panel with a body hammer and dolly.

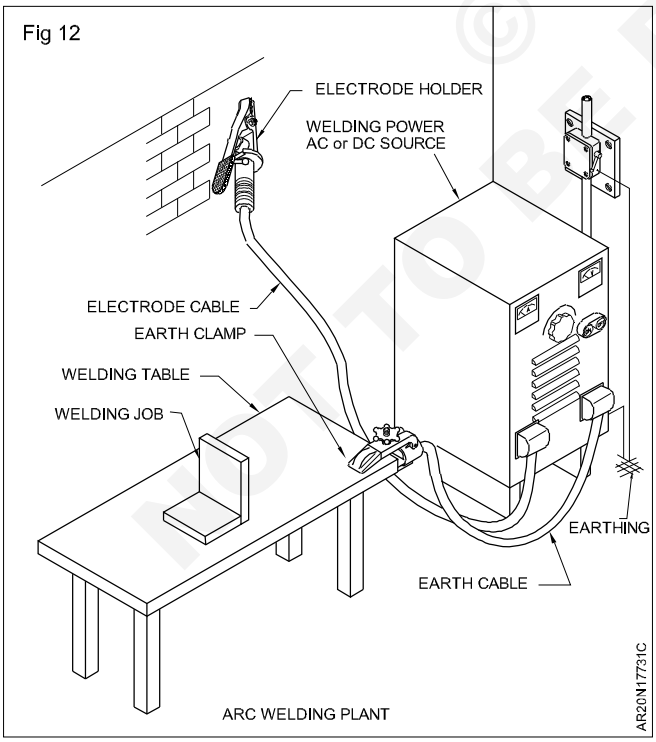
The figure shows large dents or creases pulling chain and large clamp to several pulling pins. By engaging the pulling tower chain on the frame rock, a large crease can be pulled out quickly and easily (Fig 11).

Fig 11



A modern spot weld dent puller is the quickest way to removing small dents from sheet metal body panels. This machine has a magnetic ground clamp and a replaceable welding tip with a slide hammer built onto the welding machine (Fig 12).

Fig 12



Metal shrinking: Shrinking metal is needed to remove strain or tension on a damaged, stretched sheet metal area during impact the metal can be stretched. When pulled or hammered straight, the area can still hole tension or strain on it.

Stress reliving: If a strained area is filled with body filler, road vibrations can cause the panel to make a popping or flapping noise. After prolonged movement of the strained area, the filler can crack or fall off due to stress relieving.

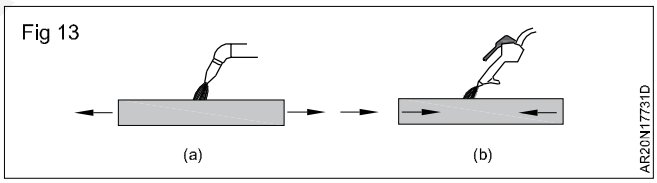
Stretched metal: Stretched metal has been forced thinner in thickness and larger in surface area by impact. When metal is several damaged is a collisson. It is often stretched in badly buckled areas. Most of the stretched metal will be found along rides, channels, and buckles in the direct damage area. When there are stretched areas of metal it is impossible to correctly straighten the area back to its original contour. The stretched areas can be compare to a bulge on a tire.

Principles of shrinking: This principle of shrinking steel also applies to the shrinking of a warped area in a piece of sheet metal. A small spot in the center of the warped area of steel is heated to a dull red. When the temperature rises, the heated area of the steel panel swells and attempts to expand outward toward the edges of the heated circle (circumference). Because the surrounding area is cool and hard, the panel cannot expand, so a strong compression load is generated.

If heating continues, the expansion of the metal is centered in the soft, red hot portion, pressing it out. This causes it is to thicken, thus relieving the compression load. If the red hot area is suddenly cooled while in this state, the steel will contract and the surface area will shrink to less than its area before heating.

The Fig 13 shows that a steel bar with both ends free to expand when heated metal will expand and contact to its original length when it is cooled.

Fig 13



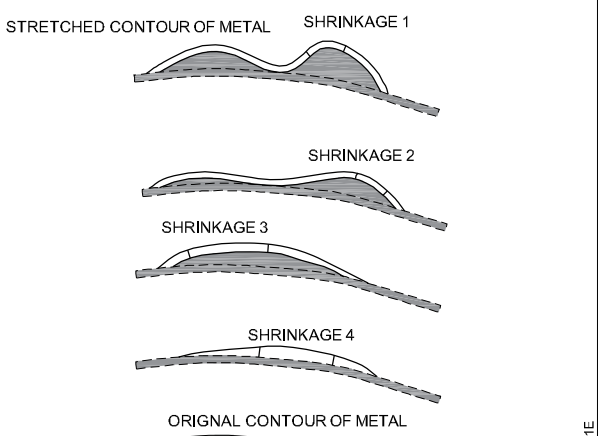
Shrinking steel panels with heat: To shrink a damaged area with heat from an electric welder or gas torch, a small spot in the middle of the stretched area of sheet is heated to a “cherry-red colour”. The shrink is placed in the highest spot of the stretched area, then in the next highest spot, and so on. This is repeated until the area has been shrunk back to its proper position. (Fig 14)

The size of the shrink or hot spot is determined by the amount of excess metal in the area to the shrunk. The shrinks can be anywhere in size from a silver dollar down to the head of a thumbtack. The larger the hot spot, the harder the heat is to control. An average-sized shrink is usually about the size of a dime. Small shrinks should always be used on flat panels, because panels tend to warp easily.

Shrinking stretched metal usually requires heating more than one spot. Always heat the highest or lowest spot. A natural flame and number 1 or 2 tip are often used to heat the hot spots. The point cone is brought straight down to within 1/8 inch 302mm of the metal and held steady until

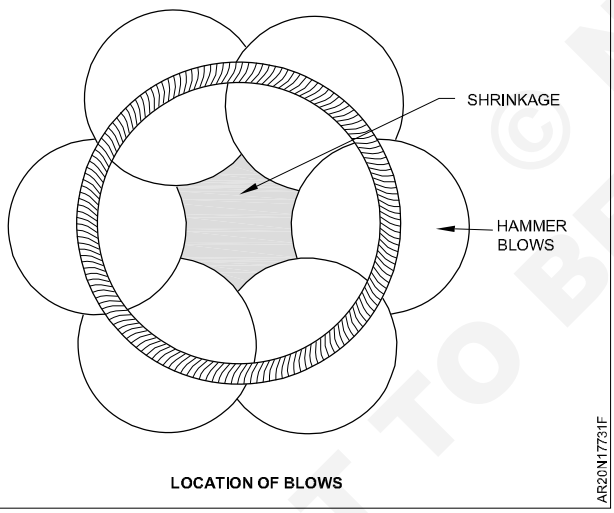
the metal starts to turn red. The torch is then slowly moved outward in a circular motion. Until the complete hot spot is cherry-red.

Fig 14



After the deformed area on the body panel has been carefully heated, use controlled hammer/dolly blows on the hot area first because the metal is more pliable, when heated hitting this area will force the molecules in the stretched metal back together to lower the hump high spot on the panel. (Fig 15)

Fig 15



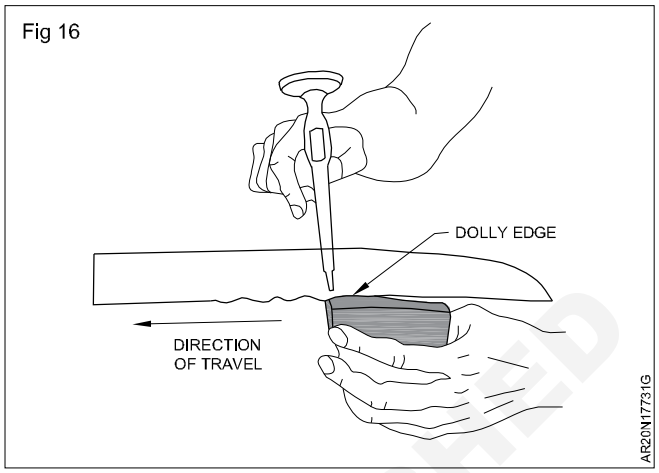
Over shrinking is corrected by using head hammer-on-dolly blows to stretch the last shrink. The last shrunken area is usually the direct cause of over shrinking.

Kinking: Kinking involved using a hammer and dolly to create least, or kinks, in the stretched area to shrink its surface area. Instead of using heat to shrink the metal. Kinking is another way to deal with stretched metal. (Fig 16)

Kinking the metal will lower the area slightly below the rest of the panel. The low spot should be filled with body filler, then field and sanded level with the panel.

Shrinking a gouge: A gouge is caused by a focused impact that forces a sharp dent or crease into a panel. A gouge causes the metal to be stretched. Gouges must be shrunk to their original size to properly repair the damage. Simply picking up the low area only distorts the panel. Filling the gouge with filler without restoring the panels original control leaves tension in the panel that can cause the filler to crack or pop off.

Fig 16



Follow this procedure for shrinking gouges

1 Heat the lowest point of the gouge with a gas torch until the metal is a dull red.

2 Use a dolly to hammer up the hot spot. This will increase the tension on the soft spot, forcing it to swell and return to its original position.

3 While the metal is still hot hold the dolly directly under the groove and tap down the ridges that will have developed on either side of the groove. This will not only drive down the ridges but will also bump up the gouged metal.

4 If the gouge is a long one this process will have be repeated several times to raise the whole length of the gouge. Only heat as much of the gouge as can be worked before the metal cools.

Filing the repair area: The damaged body panel has been bunbed and pulled as level and smooth by body file. A body file can be used to locate any remaining high and low spots. High spots will be scratched more than flash surfaces. The scratch pattern created by the file identifies any low spots. Then pick up the low spots and bump down the high spots. This process ensures that the repair area is ready for body filler.

Working aluminium panels: Aluminium is used for a variety of automatic pends such as hoods fenders and roof panels. Aluminium is natural resistance to rusting and corrosion is its primary advantage. Aluminium is much softer than steel. It also melts at a lower temperature and readily distorts when heated. Aluminium body and frames fare 1.5 to 2 times as thick as steel parts. When these aluminium parts are damaged, aluminium harder or stiffer to the touch because of work hardening.

Working aluminium with hammer and dolly: Straightening aluminium with hammer and dolly is basically the same process as steel. Except the following two:

- The hammer-off-dolly method is generally recommended for aluminium panel straightening. Because aluminium is less ductile than steel.
- When the aluminium panel is sandwiched between hammer and dolly the aluminium alloys bend much more quickly it is better to use many light strokes than a few heavy bows.

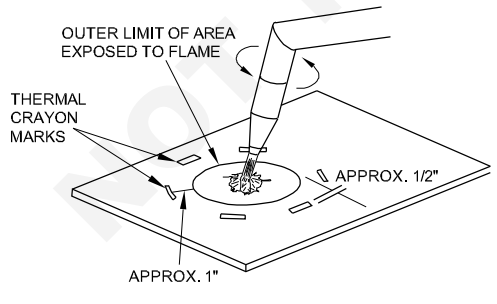
Straightening aluminium with a hammer: The separate set of tools should be used on steel and aluminium. When hammer picking alumonium work slowly and methodically. Raising small dents with a pick hammer or pry bar is an excellent way to repair aluminium panels. Be careful not raise the panel too far, stretching the soft aluminium. Spring hammering with hammer and spoon is an excellent way to unlock stresses in high pressure areas in aluminium. The spoon destributes the force of the blow over a wider area of the soft aluminium.

Filing and grinding aluminium: Aluminium is so soft, reduce the hand pressure on the body file while filling on the aluminium part. Soft aluminium cuts much more easily than steel. Use a file with rounded edges to avoid scratching gouge the metal.

Grinding must be done very carefully on aluminium panels. A coarse grit disc on a high speed grinder can quickly burn through the soft metal. The heat from the grinding operation can also quickly warp the panel, grinding small area and feather lighting should be done with a dual action sander or an electric polish machine that rotates at less than 2500 rpm. Use #80 or #100 grit paper and a soft, flexible backing pad.

Straightening aluminium by heat shrinkage: Without the use of heat, the aluminium may be cracked when straightening force is applied on aluminium sheet. Before attempting to straighten aluminium heat the damaged metal with a gas torch (Fig 17) it is easy to apply too much heat, because aluminium does not change color with high temperature. Heat control if very important because aluminium melts early. Use the following method to straight the aluminium.

Fig 17

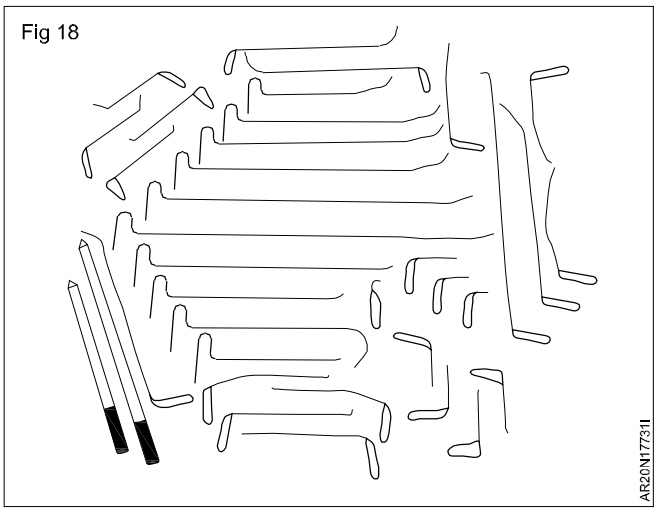


- Apply a temperature - sensitive paint in a circular pattern around the area that will be exposed to the flame.
- Heat the area moving flame constantly
- Stop heating when the pair color changes, the surface temperature at the center of the heated area will be between 750°-800°F. A lack of caution will result in melted sheet, also shrink spot must be very slowly quenched to avoid distorting the panel by excessive construction.

Paintless dent removal: Paint less dent removal involves removing small dents using spealized tools, long picks soft, faced hammers, plastic blocks and other as need equipment, pointless dent removal only works with very small dents that do not damage, the finish. Mark the small dents with crayon, place a bright light to one side of the panel so that light reflects off from the side to help make the dents more visible use a large hook attached to bottom of a hood in a paintless repair. The hook allows you to pry upward on the bottom of the hood right under small dents. Push up on the panel while watching for pushing action of the pick. The metal will flex upward at the point of the pick. More pick until it is next to the ding or dent. Then slowly pry up on the dent. Circle around larger dents to work than out a little at a time. (Fig 18)

Start with point of impact point. Slowly pry up the damaged area. On the larger areas use a flat blade pick rather than a pointed one. Tap down pressure areas while prying up low tension areas. To lower high spots next to small during, place a plastic dolly or dowel over the high spot. Very light taps from a plastic hammers or mallet will face the high spot down without damaging the paint film. Light careful blows front ting metal dolly will also lower the perimeter of dings without requiring repainting.

Fig 18



Refinishing material

Objectives: At the end of this lesson you shall be able to
- **state the different type of refinishing material**
- **state the masking method.**

Primer - Sealer: Primer - sealer provides a scaling film between the primer - surface and the top - coats. Sealers are desirable for some works and are not used for others. For example, if you apply enamel over lacquer, use a sealer first. This prevents the lacquer from bleeding through the enamel and giving the top coats a spotty appearance. Also if enamel primer surfaces was used and the topcoat is to be lacquer then a sealer should be applied before the lacquer.

If you apply lacquer over enamel, sealer is also recommended. If apply enamel over enamel or lacquer over lacquer, a sealer is not generally required if there are sand scratches present and they are not wet sanded away, then a sealer often is used it kinds to prevent the sand scratches from showing through the top - coats.

If you building up the under coat from bare metal the sealer is applied last. For example you may decide to use primer then to fill in the sand scratches, you use primer surfaces, finally the primer - sealer is applied over the primer surfaces to obtain the best possible colour holdout.

Top coats: In the vehicle painting process after the guide coat finishing area that has been sanded to remove the guide coat it is very smooth and ready to take the top - coats. Top coat paint is sprayed by the paint spray gun on the surface of the vehicle panel evenly after the top - coat finishing if need clear - coat also applied on the top - coat surface.

Paint material types: Lacquer based automotive paints due to fast drying process and thin body, these paints flow smoothly. These are following paint materials.

- Acrylic lacquer
- Enamel paint
- Waterborne enamels

Paint Classification

- Urethane paints
- 2 - Pack paint

Automotive paint is made out of 5 components

Pigments - Prime pigments to impart colour and opacity

Binder (resin) - a polymer often referred to as resin forming a matrix to hold the pigment in place.

Extender - Larger pigment particles added to improve adhesion strengthen the film and save binder.

Solvent (Thinner) - Either an organic solvent or water is used to reduce the viscosity of the paint for better application water borne paints that use volatile organic compounds such as the hydrocarbons which are harmful to the atmosphere.

Additives: It is used to modify the properties of the liquid paint or dry film.

There are two types of car paint materials in the market, waterborne of solvent based.

Lacquer: At the automotive assembly plank, the lacquer is sprayed on the metal surface. To achieve the high gloss the lacquer finish must be rubbed out. This process is called compounding. After the lacquer has dried sufficiently.

Enamel: Enamel paint that air dries to a hard usually glossy, finish used for coating surface that are outdoors or otherwise subject to hard ware or variations in temperature. The term of enamel paint is used to describe oil - based covering products. However recently many latex or water based paints have adopted the term as well most enamel paints are alkyd resin based. Some enamel paints have been made by adding varnish to oil - based paint. Enamel paint also refers to nitro - cellulose based paints nitro cellulose enamels are also commonly known as modern lacquers.

Categories of enamel paint

- Floor enamel
- Fast dry enamel
- High temperature enamel
- Nail Enamel
- Epoxy enamel, Polyurethane enamel
- Wood and building enamel

Water Based Paints: It contains filter, pigments and binder all dissolved in water. Their low level of volatile organic compound (VOC) made it a go - to paint after the new VOC regulation. This makes them environmental friendly paint with minimum to zero harmful effects on human health. Quality of water based paints have 100 percent acrylic binders that makes the paint especially durable and very flexible latex paint adheres well to a variety of interior and exterior surfaces.

Types of water based paints

There are two types of water based paints

- Acrylic
- Latex

Water is the ingredient that accounts for most of the benefits of latex paint as well as a few of the disadvantages. Water based paints becomes difficult to use when temperature fall below 50 degree Fahrenheit. The lower temperature also make it possible to see brush strokes in the final results.

Paint Pigments: A pigment is a colored material that is completely or nearly insoluble in water pigment is a material that changes the colour of reflected or transmitted light as the result of wave length - selective absorption. Pigment are used for edour paint ink, plastic fabric, cosmetic, food, and other materials.

Pigments are very fine powder that have their own colour and they are colour material for paint. Paints are mainly made of pigments and binders. Each pigments have their own chemical and physical properties.

Paint Binders: Paint is essentially composed of a binder pigment and solvent. The binder exist to hold the pigment to the surface. The binder is polymeric substance and is either dissolved in the paint or suspended it by emulsifiers.

Paint Solvents: Solvent is a material which dissolves another materials. For example when you add water to salt or sugar they dissolves in water forming solution. In other words, a solution contains a solvent in which the solute or the material is completely dissolved. This is a physical mixture, both the solvents and the solute can be separated by physical processes like distilling and evaporation.

Paint additives: Paint additives commonly used extenders include clay, silica, diatomaceous silica, calcium talc and zinc oxide additives can be used to speed up drying and improving gloss. Other additives slow drying. Additives that speed up curing and improve gloss are called hardeners. Additives that are slow drying are called retarders. Additives that are lower gloss are called flatteners.

Drying: As the paint dries a film is formed which adheres to the surface of the material to which it is being applied. On applying gloss paints the alkyd polymer cross links by an oxidation reaction with oxygen in the air once the solvent has largely evaporated.

The paint drying process corresponds to the evaporation of all solvents added to the paint in order to make it liquid or reduce its viscosity.

Hardening: The hardening of paint corresponds to the process by which main polymer of the paint it creates and hardens with all other pigments and additives which comprises the paint, creating a solid and adherent coating.

Curing: The Paint curing process corresponds both drying and hardening process curing = Drying + Hardening.

Physical curing paints correspond to the set of paintings where the main resin is already formed to cure the paint is only required to evaporate the solvent input into the painting itself chemical curing paints correspond to the set of paints where the main resin is created through chemical reactions between various compounds, in this type of cure is necessary both drying and hardening process.

Type of curing process

- Hot air curing
- Radiation curing
- Curing by electrical process

Flash: Flash points are determined experimentally by heating the liquid in a container and then introducing a small flame just above the liquid surface the temperature at which there is a flash/ignition is recorded as flash point.

The lowest temperature at which a liquid gives off sufficient vapour to form an ignitable mixture with the air near the surface of the liquid or within a container. Painting material with flash point below 100°F (38°C), such as most solvents and solvent borne coating are considered dangerous. The standard method for flash point is defined in ASTMD3941.

Paints, linseed oil, mineral oil - flash point - 141 - 199°F (61 - 93°C)

Paints oil base, neats foot oil flash point (III - B) - 200°F (93°C above)

Retarder: In painting a retarder is a substance, usually added to water, used to slow the drying time of acrylic paints, giving more time for blending or layering highlights.

Accelerator: It is an liquid additive which is used in small quantities with 2k hibernate hardeners to achieve rapid through curing, it may be used with normal or medium solids (ms) or high solid (hs) system for air drying or storing and accelerates the through curing of 2k primers, top coats and clear lacquers, significantly reducing solving times - offering increased through put and energy - saving in the workshop.

Paint Catalyst: A catalyst is a chemical which makes a chemical reaction go faster but is not itself used up in the reaction in paints. Catalysts speed up the formation of polymers from the resin. Cobalt or manganese naphthenate are used in gloss paints to accelerate the polymerisation of the alkyd resin.

Paint adhesion: In the paint and coating industries, paint adhesion testing is often used to determine, if the paint or coating will adhere properly to the substrates to which they are applied. There are several different tests to measure the resistance of paints and coatings from substrates cross cut test, serape adhesion, pull off test and other tests carried out.

Paint adhesion promoter: Rust - olesom adhesion promoter is fast drying clear primer that helps paints adhere to polyolefin surfaces such as automotive plastics vinyl, trim bombers, fiberglass and more adhesion promoter features an advanced spray system that allows you to spray at any angle.

Paint blending solvent: Blending solvent is a specially formulated solvent to assist in dissolving the dry edges of freshly sprayed 2k clear coat blending properties enable the job to be confined to a spot repair.

Paint toners: Pigments, colorants or toners, as they are called in the market, are actually finally ground particles, which produce a specific nuance. The paint can be toned individually, by hand or at a paint store, with the help of a machine, by adding a certain amount of pigment.

Paint primers and sealers: Sealer is designed to be used prior to or in place of a primer, sealers are special primers designed to perform some of these functions - provide good adhesion, recondition poor substrates such as crumbly old concrete tiles.

Sealers are not porous and what that means is that it will resist absorbing moisture, whereas primer can absorb moisture and get trapped in the primer. A good 2k sealer creates a moisture tight sealed barrier between the prepared surface and the top coat.

Self-etching primer: Self-etching primer is a rust preventive coating that etches and primes in one coat. Self etching primer features an advanced spray system that allows you to spray at any angle, even upside, down for those hard to reach areas.

UV Primer: UV primer is an innovative primer surfaces that uses UV radiation to cure, allowing painters to sand in as little as 2 minutes after application. This high build primer is suitable for a wide range of substrates and comes in a convenient aerosol package, making it easy to use and spray.

Primer Surface: When burshed or sprayed to metal or fiber glass surfaces this high build, rust resistant sand able formula will hide sanding scratches and quickly fills uneven surfaces improves top coat adhesion and appearance.

Epoxy Primer: Epoxy primer refers to sealer that is a non - porous finish. Epoxy primer not only offer excellent adhesion to metals, but also serve as a proper base for extra under coat products and top coats paint. Epoxy primer can be used over fiberglass, plastic or the black iron phosphate coating. This primer ability of an epoxy primer to resist corrosion is related to its thickness. The thicker the epoxy primer layer, the better the protection. This primer can also be used on cracks and dents its banding capacity is excellent and produces a good surface finish.

Sealers: Sealer paint can be used as a substitute for a primer or before the primer is applied to the base surface. The main purpose of sealer paint is to provide good adhesion between the substrate and the new paint or the primer.

Prep solvent paint Materials: The 3m prep solvent 70 is a low VOC water based solvent that works well for removing grease oil wax, and silicon from surfaces before coating. It can be used to clean metal painted surfaces and primed metal before applying paint or primer on them.

Paint Flattener: Flattener additive can be used to flatten any catalyzed cross/single stage colour. Achieve any of the established gloss levels flat satin and semi-gloss or custom match for desired degree of gloss. It can be added to existing catalyzed ready to spray intermix colour, eliminating the need to formulate any additional cross/fire @ intermix colour qualities.

Flattener additives are versatile enough to be used in both national rule and VOC regulated areas.

Fish eye Eliminator: Fish eye eliminator is a special liquid additive that is formulated to allow epoxy systems to flow out on silicone or oil contaminated substrates, including existing epoxy and urethane floors.

The additive decreases fish eye and or crater ring by lowering the surface tension of the product to which it is added. This helps prevent beading of the liquid on the contaminated substrate.

Flex Agent: Flex additive has been recognized as an additional operation and or material necessary, when refinishing flexible parts such as bumper covers. Some paint manufactures have minimized or eliminated the need for flex additive in the clear coated portion of a base coat/ clear coat system.

Anti-chip coating: 3m Anti - chip coating - water based is available in 2 colours it can be used for under body wheel arches, front and rear valences, body sills, new ports and repaired panels. This anti - chip coating is fast over paintable, has excellent rust prevention properties, excellent flexibility and non-sag.

Features 3m water based Anti-chip coating

- Water based under body coating.
- Fast over paintable 30 minutes up to at least 72hrs (without sanding with all usual paint system, including water based.
- Excellent stone chip, weathering and corrosion resistant.
- High performance
- Fast drying
- Excellent sag resistance
- Sound deadening
- Temperature resistant - 25°C and + 130°C
- Available in black and gray colours

Metal Conditioner: It is a liquid phosphoric acid based product that effectively cleans the metal surface and removes rust. It is also used when only a simple metal treatment is required prior to painting. Rust removal is accomplished quickly due to the deep penetration and dissolving of the surface soils.

Paint Stripper: Chemical strippers are used to remove the paints by spreading on the surface of the metal sheet by using disposable brush. Generally not to brush in multiple directions and to apply thickly.

Best paint stripper

- Citric - strip paint and varnish striping gel
- Max strip paint of varnish stripper
- Eco - Friendly - Dumont chemicals smart strip advanced paint of varnish remover
- Excel blades K11 Paint remover

- Porter - Cable paint remover gun
- Fashion paint removes
- Sunny side ready strip paint and varnish remover
- Super remover - paint stripper
- Sunny side 2 - minute remover gel

Tack Cloth: Tack cloth work great for dust removal on auto body during painting process and galaxy tack cloth 12 patch works as perfect for wiping down items right before paint on the metal surface.

Different types of body fillers

Plastic body fillers: Filler materials are particles added to resin or blinders (plastic, composites, concretes that can improve specific properties. The two largest segments for filler materials use is elastomers and plastics.

Types of plastic fillers

- Calcium carbonate
- Keolin
- Magnesium hydroxide (talc)
- Walla stone
- Glass
- Nano fillers

Polymer foam beads: Other fillers - concrete filler materials include gravel, stone are used to reduce the cost of concrete. Robars are used to strengthen the concrete.

Light body filler: Light weight body filler is used to fill the dents of the vehicle surface after accident repair. The product has unique microsphere technology that helps fill the dent faster and reduce the weight on repair panel.

Fiber glass reinforced body fillers: It provides for fiberglass repair of small holes, dent and rust outs (upto ½") repair without the need for backing strips, fiberglass mat or fibreglass resin. This is reinforced body filler already contains the short, interlocking fibreglass strands, making it twice as strong as standard body filler and also much easier to use during vertical repairs when the filler can drip down the surface and cause extra work.

The filler is easily mixed and also features a fast drying formula that is sand able in as little a 20 minutes saving you time on auto body repair.

Cream Hardeners: The hardener is easy to use by simply mixing with fillers, pushes and glazes. The cream hardener changes colour during mixing to indicate, when the desired consistency has been achieved. The cream hardener is a hardening agent it is designed to work with all fillers pushes and glazes.

Fiberglass resin: Fiberglass resins are essentially polyester resins and they are used for many different purposes. They are mainly used as a casting material, a wood filling, an adhesive and for auto repairs. The excellent adhesive properties and durability of the fibreglass resins make them an extremely use full construction material.

Glazing putty: Glazing and spot putty is easy to use dries fast and stays durable. Ideal for filling pinholes in body filler and covering auto body scratches, paint chips and minor lings.

Polyester glazing putty

Polyester,glazing putty is elastic and very easy to sand. Polyester putty is re - spray able with all lacquer s0;tms and resistant to chemicals and water influences. Mo tip polyester putty can be applied in layer.s with a thickness upto 2 centimeters .

Applying body filler

Clean the body surface to be fill the body filler.

Rough up the surface without removing a significant amount of primer.

Clean the sanding dust so the surface would be nice and clean for the filler to adhere to

Before applying body filler, see the gap between the body panel and the piece of spring steel.

Prepare the body filler with mixing hardeners and apply the right amount of hardener and make sure mix it through with the filler .

Apply the mixed filler to the area needing it.

After applying the filler use the spring steel again to even out the surface and remove the excess filler.

Lets the panel sit outside in the sun for the filler to cure or use the heat lamp to curing process. Usually this takes about 10 -15 minutes .

After filler was ready lightly sanded over the area to get an idea.

If the two spots in the surface still exist requiring more filler.

Apply a little more filler than sand off a large amount to get a surface even.

Apply guide coat to the filler so can see the high and low spots and then sand and check the surface

Final check how the finished area looked.

Preparation surface for filler

Inspect, remove, store and replace exterior trim and molding.

Soap and water wash entire vehicle , use appropriate cleaner to remove contaminants

Inspect and identify substrate, type of finish and surface condition, develop a plan for refinishing a total product system.

Remove paint finish

Dry or wet sand areas to be refinished.

Feather edge broken areas to be refinished.

Apply suitable metal treatment or primer.

Mask trim and protect other areas that will not be refinished.

Mix primer, primer - surfacer or primer sealer

Apply primer onto surface of repaired area

Apply two - component finishing filler to minor surface imperfections.

Dry or wet sand area to which primer - surfacer has been applied

Dry sand area to which two - component finishing filler has been applied.

Remove the dust from area to be refinished, including cracks or mouldings of adjacent areas.

Clean area to be refinished using a final cleaning solution.

Remove with a tack rag, any dust or link particles from the area to be refinished.

Use the personal safety devices during surface preparation.

Ingredient

An ingredient is a substance that forms parts of a mixture and is used to prepare a specific paint materials. Ingredient are purported to make them better than competing products.

Characteristics and application of body filler and putties

Putty and body fillers are filling material that is used to provide a right and perfect level to the surface and also filler hollows , craters, cracks , dents and imperfections that may contain the surface .

Characteristics of polyester body putty

Soft is a 2 component poryester quick filler.

High degree of fineness.

Pore free surface and fire featheredging capabilities

Thixotopically adjusted.

Homogeneous and smooth surface spreading.

Surface dry hardening and great dimensional stability.

Easy sanding properties.

For use on steel surfaces only.

Not for use on zinc and aluminium surfaces.

Application

Putty is used for filling in deep uneven areas and dents on motor vehicle body work in the area of

cars, lorries and buses and railway vehicles, and for covering filling and fiber putty.

Characteristics of body filler

High degree of finishing.

Excellent adhesion

Quick drying

Reduce the repair time.

Durable coverage

Multi substrate

Universal application

Deep filling properties

Ideal for large repairs

Application: Body filler are used for filling in deep uneven areas and dents, dings on automotive body surface.

Mixing filler

Take filler mixing board and clean it with clean cloth.

Select the body filler and open the filler container tin.

Pour the\body filler on the mixing board.

Add the hardener with body filler as per recommended specific ratio.

Temperature	Working time
100°F	3 - 4 minutes
85°F	4 - 5 minutes
77°F	6 - 7 minutes
70°F	8 - 9 minutes

Mix the body filler with hardener with scraping/folding motion using a clean spreader.

Ensure body filler is well mixed and ready for apply.

Apply the body filler on the metal surface and spread over by spreading operation.

Kneading the hardener

Squeezing the tube of hardener back and fourth with your finger to mix the material to harden.

Mixing and spreading body filler

Clean the body surface to be body filler spreading.

Sanding the surface and clean the sanding dust from the body surface. Ensure the body surface S. easy for apply body filler.

Select the suitable contour premium body filler.

Place the body filler mixing board on the table and wipe it with clean cloth.

Open the body filler container tin cover.

Mix the body filler with paint mixing stick.

Bring out body filler from the tin with help, of paint mixing stick and drop it on the filler mixing board.

Add the hardener with body filler.

Well mix it with harder by rotating body filler by filler surface pad.

Spread over the body filler on the metal surface and level it properly by filler surface pad.

Ensure body filler is properly levelled and allow it to dry as per filler manufactures instruction.

Sand it over the body filling area for smoothen it.

Grating and sanding body filler

Grating the filler: A good RO.T is one inch of hardener for every golf ball amount of filler. Never stir the filler to mix.

Filler and hardener should mixed together with a scraping and folding motion using a clean spreader and mixing board, string will introduce air into the filler increasing the risk of pin holing. Once mixed, use a clean spreader to apply the filler to the panel.

Choose the correct size of spreader for the task.

First application will require a firm, thin, tight spread of the material to work itself into the tooth of the sanded substrate for mechanical adhesion.

Once this is accomplished, the filler can be applied for build, spreading the filler as smooth as possible so as to eliminate excessive sanding once the material has cured.

Sanding and shaping

Filler grating otherwise called cheese grating is performed with the filler in a semi-cured state is used, to rough shape a panel to help the amount of sanding required to bring the panel into shape.

Care must be taken not to remove to much material at this stage, or you will be repeating steps previously taken.

Coarse

When you remove the rust and old paints on the panel surface, small hair line scratches occurred on the surface. To cover the coarse on the panel need and apply the body filler or putty on the surface.

Blow off sanding dust

After completion of body filler has hardened. This smooth the rough spots and brings the surface nearly to contour . Then sanding on the body filler filled surface to remove the excess material and for making smooth surface . During sanding the surface body filler materials dust spread over the surface and filled within the scratches . Quest should be removed by blow by air on the sanding surface. Ensure complete dust is cleaned.

Checking filler repair

After removing the dust check the surface for dent, dings and scratches on the panel surface identify the defect area and mark it.

Applying second filler coat

Prepare body filler as you need for second filler coat. Apply the body filler on the defected area by spreading body filter evenly. Ensure properly applied and levelled on the panel to cover the dent, dings and scratches.

Feathered giving body filler

Feather edge the filler and surrounding paint with a DA using 180 grit sand paper sand the area from high toward low areas from center toward outer edge, then blow with clean, dry air. Apply a skin coat of putty or glaze over the repair area. Overlapping the paint feather edge.

Applying filler to panel joint: Remove the dust and rust between the panels. The original flexibility of the joint can be perserved tapping its alternate sides. Tape is applied to one panel and them filler is applied to the other panel and the tape is pulled up removing the excess filler. Both panels are filled in the same way. After filler in both panels is cured and shaped, a sealer is forced into the paint.

Applying filler to body lines: Many cars and trucks body have sharp body lines indoors, quarter panels, hoods and other body parts. Maintaining the sharpness of these lines when doing filter work is difficult, especially in recessed areas.

One way to get straight, clean lines by hand is to fill each plane, angle or corner separately. To do this masking tape is applied along one edge. The filler is applied.to the adjacent surface. Before the filler set up, the tape is pulled off, removing excess filler from the crease or line. After the first application is dry and sanded, the opposite edge is taped. Masking tape is applied along the body line and over the filler. The adjacent surface is coated with filler. When the tape is removed and the filler sanded the result is straight even line or corner.

A sanding guide is a special tool for sanding straight special contour lines on the panels. The tool frame mounts on the panel. It has long slides that hold the sanding block for making perfectly straight cuts in the filler.

The sand block is designed in segments so that it can be shaped to match the irregular shape of the edge. After fitting the block over a good section of the panel and moving its segments to match the contour, the segments are locked in place. The block is then mounted in the guide and moved over the filler. This let you cut a straight, contoured edge in the panel quickly and easily fixed-shaped sanding blocks are also available to help sand filler in contour.

Masking Materials

Masking Paper: It is great for protecting panels, doors, glass and floors from paint spills, over - spray and splatters. It also great for a variety of surface protection jobs as well as many diy crafts. Paper masking is choice of professional painter.

Printer masking paper: Different type of and sizes of primer masking papers are used by auto body painting professionals. Primer masking begin back mask primer application area using tape and paper. For individual product instructions and applicable precautions given on product labels and associated literature for the individual product.

Plastic masking tape: Masking with plastic has over paper is speed it eliminates dust better. The majority of painters use plastic mask for most of the car and then use paper around the edges. Plastic mask saves on tape too, plus dirt can't hide like it can in the folds created paper. When you stretch the plastic tight, you leave no place for dirt or specks of whatever to hides and pop out onto your paint job.

Masking with plastic - steps: Prepare all the panels as normal would. Then cover the car with plastic, stretching

it down to within 2 inches of the type bottoms. Then use 2 inch tape to stick the plastic to the types if the tape wouldn't stick because of tyre dressing, just pass the tape around to the back of the tyre where it will stick.

Using blade carefully cut out plastic around the area to be painted.

Usually put on two full wet coats of adhesion promoter using paint gun. The rattle cans just have too much orange peel for panels.

Let it go through the booth cycle, flash and then bake for five minutes. You are now ready to paint as used. After baking your clear or after air - dry, you can damask the car.

Paint masking paper: Paint masking paper is used around the panel surface to be painted.

Tips and tricks for proper masking: Prepare the surface for masking make sure to prepare properly the mask. It should be smooth and clean dry and free from dust.

Apply masking tape under the edges around the masking area.

Use masking paper or film to cover nearby areas

Use specific products for high precision application.

Masking tape: Masking tape also known as painter's tape. It is a type of pressure sensitive tape made of a thin and easy to - tear paper and an easily released pressure sensitive adhesive. It is available in a variety of width. It is used mainly in painting to mask off areas that should not be painted. Masking tapes tend to leave residue behind, if left for the duration of paint project.

Fine line masks: N.95 particulate filtering respirators do a great job of filtering out particulate matter. But they don't absorb toxic chemical vapors. To do that you need activated carbon.

Fine line masking tape: Fine line tape is vinyl or nylon paint masking tape for fascia, rocker panels, two - tone and other multiple colours application, where critical paint break lines are required. The confirmable backing is designed for uniform stretching to help create better paint lines.

Wheel masks: Wheel masks simply hook over back of tyre and whole front of wheel is masked when dipping the car, takes second to do.

Abrasives

Abrasive materials: Abrasive is a material, often a mineral, that is used to shape of finish a work piece through rubbing which leads to part of the workpiece being worn away by friction. In short the ceramics which are used to cut, grind and polish other softer materials are known as abrasives.

There are two types of abrasives

Natural

Manufactured: Important natural abrasives such as emery corundum and diamond are used only in special types of grinding wheels and honing stones.

Abrasive grit: The grit size indicates the abrasive grade on the abrasive side of the paper. A higher grit number indicates a smaller abrasive grain and firer abrasive product. A 'p' in front of the grit size indicates that product is graded in accordance with the European standard. The grit of sand paper refers to the size of the abrasive particles bonded to the paper. The higher the grit the smaller particles and the finer the scratches left behind.

Grit ratings: The grit of sandpapers is a ratings of the size of abrasive materials on the sandpaper. The higher the grit number is equivalent to a finer. Which creates smoother surface finishes. Lower grit numbers coarser abrasives that scrape off materials much quicker.

Open and closed coat grit: Open - coated sand paper has abrasive material covering approximately 70 percent of its surface. Leaving room for saw dust to build up. Which helps prevent clogging. Closed coated sand paper is completely covered by abrasive material.

Grinding disc: Grinding disc is used to grind and remove the rust and dust particle on the surface of panel. There are many types of grinding disc.

- Straight grinding wheel
- Large diameter grinding wheel
- Grinding cup wheel
- Grinding disc wheel
- Segmented grinding wheel
- Cutting face grinding wheel

Dry and wet type sand paper: The difference between dry sanding and wet sanding is the movement used. Dry sanding requires small circles. Wet sanding uses straight lines, alternating direction between passes. Wet sanding is a process that's often used on car paint jobs, guitars and even 3D prints to give them a mirror smooth look.

Wet sanding is typically done after dry sanding to get an even finish. Unlike dry sanding wet sanding is done, not to shape a surface, but to remove the large scratches left by dry sanding.

Scuff pad: It is designed for scuffing base primed or painted surfaces prior to applying primer or paint excellent for removing light surface rust can be used wet or dry rinses clean for repeat use. Scuffing pad is designed to prepare the surface prior to painting.

Rubbing compound: Rubbing compound is a material used to restore old paint work and it acts as a new top coat of the vehicle. It also helps conceal scratches in your vehicle paint. First wash your vehicle thoroughly with soap and water. Then use sand paper and an orbital polisher to smooth down existing scratches.

Polishing compound: It is used for the finishing of painting surfaces to a high luster mirror like finish and it is giving mirror finishing and removal of more products than other ordinary polishing compound. The scratches varnish quicker with this polishing compound.

Adhesives: Adhesive also known as glue cement mucilage or paste is any nonmetallic substance applied to one or

both surfaces of two separate items that blinds them together and resists their separation.

Epoxies: Epoxy resin are characterised by their very good electrical properties and chemical resistance, good strength and low absorption of moisture.

Epoxies operates as formulator of epoxies, urethanes, and silicons. The company produces adhesives, potting, encapsulating and casting, electrically conductive resins, thermally conductive resins, UV curable illumabond epoxy doming resins trigger bond, and non - hazardous products.

Composition of paint: All paints generally have four main ingredients - pigments, blinders, solvents (liquid) and additives. Pigments provide colour and hide while blinders work to bind the pigment together and create the paint film.

Types of paint: Paint manufactures manufactured in various types of paint for various work (painting jobs). They are as follows

- Oil paints
- Enamel paint
- Emulsion paint
- Cement paint
- Bituminous paint
- Aluminium paint
- Anti corrosive paint
- Synthetic rubber paint

Impact of paint: The impact of paint diverse. Traditional painting materials and processes can have harmful effects on the environment including those from the use of lead and other additives. Measures can be taken to reduce environmental impact including accurately, estimating paint quantities. So waste is minimized and use of environmentally preferred paints coating painting accessories and techniques.

Paint components on plastic and rubber parts: Although plastic and rubber can now be produced in all colours and with a matt or a glossy surface, in many cases they still have to be painted. On the one hand, plastics must be painted for aesthetic reasons.

The solvents absorbed by the plastic material, when it is cleaned must be removed completely before the coating is applied otherwise they will cause a build up of vapour pressure between the plastic and the coating, ultimately reducing the adhesion. The risk of solvent popping and pin holing is also increased.

Top coats and undercoats must contain the right amount of plasticiser. Too little and coatings usually crack under mechanical strain. A perfect refinish on plastic components is the result of skillful workmanship, correct preparation and the exact choice of colour. Standex offers refinishers many useful aids for precise colour matching. Always refer the technical data sheet and other latest information on the paint component on the plastic and rubber parts.

Paint techniques: Auto body painting is usually done by a professional auto body shop, the test requires all kinds of special equipments and safety precautions.

Materials required for refinishing work

- Plenty of 1200 & 2000 grit wet and dry sand paper
- Electric or air powered sander
- Masking tape
- Newspaper (For masking off)
- Air compressor
- Paint spray gun
- A buffer
- Paint thinners
- Face masks
- Safety glasses
- Under coat
- Top - coat
- Clear coat lacquer
- Dust extractor

Wash the car and hose down the surrounding area. If you plan to paint something with detail on specific areas of the car, block off those areas with masking tape and masking paper.

Use the power sander to strip away the old paint using circular motion you may have to manually sand the corners and other tricky areas. Go from front to back and make the surface as smooth as possible, the smoother it is the better the paint finish. After sanding, wipe down the whole vehicle completely. Dust sand paper remnants, and other debris will cause imperfections in the vehicle.

Mix the primer with the thinners. Apply the primer, working from the roof down it might take 2 - 3 coats to cover the car surface completely.

Assume 10 minutes per application and 20 minutes of drying time.

When dry, the primer will be powdery on the surface, so use 2000 grit sand paper to smooth and wipe it down.

Clean the spray gun and wipe down the primed surface with a rag slightly dampened with thinners (Note: If you apply too much thinner to the rag the thinner will strip the primer you just applied)

Apply 3 - 4 coats of the paint with the same sweeping strokes.

Again, each coat will take about 10 minutes to apply and 20 minutes to dry. Before applying the final coat, go over the car one last time with sand paper followed by a clean rag to get rid of any final residue.

Apply the clear coat lacquer.

Remove the masking tape with the lacquer is still wet

(Note: if you find any problem areas, sand them with the 2000 grit wet and dry sand paper and re - spray)

Once everything is dry, buff the whole thing with a soft buffer, using a circular motion. Be careful not stay in on spot too long, it could ruin the finish.

Plastic repairing

Objectives: At the end of this lesson you shall be able to
- **identify and explain the difference between two major type of plastics used in automobile**
- **identify unknown plastics**
- **repair minor cuts and cracks in plastics using adhesives**
- **repair gauges, tears and punctures in plastics by a chemical bonding process**
- **describe the keys to good plastic welding and welding repair sequence.**

Introduction to plastic repair: The term plastic refers to a wide range of materials synthetically compounded from crude oil, coal, natural gas and other natural substances. Plastic is much lighter in weight than sheet metal. Now a day's more and more plastic is used in automobile manufacturing. Plastic parts of vehicle is bumpers, fender extensions, fender aprons, faces, grille openings, stone shields, instrument panels, trim panels fuel lines, door panels, quarter panels and other engine parts. Plastic parts are used to fuel saving and weight reduction of the vehicle.

The new reinforced plastics are almost as strong and rigid as steel. Plastic parts are also corrosion resistant. Auto mobile manufactures are increased the use of plastic in their new products like, floor parts, windows fans, steering shaft, springs, wheels, and other mechanical components.

Increasing the use of plastic has resulted in how approaches to collision repair, the plastic parts can be repaired more economy that they can be replaced. The plastic cuts, cracks, gauges, tear and punctures are all repairable or reformed back to their original shape after distortion.

Types of platics: There are two types of plastics are used in automotive construction. That are as follows

1 Thermos plastics

2 Thermosetting plastics

Thermos plastics: It can be repeatedly softened and reshaped by heating with no change in their chemical make up. Thermos plastics are weidable with a plastic welder or they can be adhesively repaired.

Thermosetting plastics: It is undergoing a chemical change by the action of heating, a catalyst or ultra violet light. They are hardened into a permanent shape that cannot be altered by reapplying heat. Thermosets are usually repaired with flexible parts repair materils. In general, chemical adhesive bonding is used to repair themosetting plastics and welding is used for thermoplastics. Table 1 and Table 2 contains additional information on types of automotive plastics and their repair methods.

Plastics safety

Working with plastics and fiberglass requires you to think about safety at all times. Resins and related ingredients can irritate your skin and stomach lining. The curing agent or hardener can produce harmful vapors.

Read the following safety points before using any of these types of products.

- Read all label instructions and warnings carefully.
- When cutting, sanding, or grinding plastics, dust control is important.
- Wear rubber gloves when working with fiberglass resin or hardener. A long-sleeved shirt with buttoned collar and cuffs is helpful to prevent sanding dust from getting on your skin. Disposable paint suits will keep dust away from clothes.
- A protective skin cream should be used on any exposed areas of the body.
- If the resin or hardener comes in contact with your skin, wash with borax soap and hot water or alcohol.
- Safety glasses are a necessity at all times.
- Always work in a well-ventilated area.
- Wear an approved respirator to avoid inhaling sanding dust and resin vapors.

Plastic Identification

There are several ways to identify unknown plastics. One way to identify plastics is by the international symbols, or ISO codes, that are molded into the parts. Many manufacturers use these symbols. The symbol or abbreviation is formed in an oval on the back of the part. One problem is that you usually have to remove the part to read the symbol.

If the part is not identified by a symbol, the body repair manual will give information about the plastics used on the vehicle. Body manuals often name the types of plastic used in a particular application.

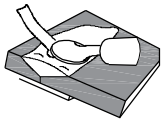
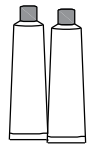
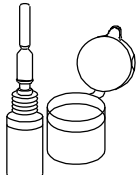
Another way to help identify a plastic part is the plastic flexibility test. To do a plastic flexibility test, use your hands to flex and bend the part and compare it to the flexibility of samples of plastic. Use the repair material that most closely matches the characteristics of the part's base material.

Table - 1 Common Automotive Plastics Identification Table

Identifying	Chemical composition	Typical usage	Common or trade names	Suggested repair method	Repair tips
PUR (RIM, RRIM	Thermoset Polyurethane	Bumper covers, front and rear body panels, filler panels	Elastoflex, Bayflex Specflex (Reaction Injection Molding)	Weld with urethane rod (5003R1) or Uni-Weld (5003R8)	Do not try to melt the base material; just melt rod into the V-groove
TPU (TPUR)	Thermoplastic Polyurethane	Bumper covers, soft filler panels, gravel deflectors, rocker panl covers	Pollethane, Estane, Roylar, Texin, Desmopan	Weld with urethane rod (5003R1) or Uni-Weld (5003R8)	
TPO, EPM, TEO	Polypropylene+ Ethylene Propylene	Bumper covers, valence panels, fascias, air dams,	TPO (Thermoplastic Olefin), TPR (Thermo-plastic rubber)	Weld with Uni-Weld (5003R8) or TPO Blended Gra rod (5003R5)	Use adhesion promoter before applying filler or coating
PP	Polypropylene (polyolefin)	Bumper covers, deflector panels, interior moldings,	Profax, Oreflo, Marlex, Novolen, carlona	Weld with Uni-Weld (5003R8) or Polypropylene Black rod (5003R2)	Use adhesion promoter before applying filler or coating
PC + PBT	Polycarbonate + Polybutylene Terephthalate	Bumper covers (Ford)	Xenoy (GE)	Weld with Polycarbonate clear rod (5300R7) or Uni-Weld (5003R8)	Preheat groove before welding with polycarbonate rod.
PPE + PA (PPO + PA)	Polyphenylene Ether + Polyamide	Fenders (Saturn, GM), exterior trim	Noryl GTX (GE)	Weld with Nylon (5003R6), Uni-Weld Ribbon (5003R8), two-part epoxy system, or instant adhesive	Preheat groove before welding with nylon rod. Use fiberglass mat with instant adhesive.
ABS	Acrylonitrile Butadiene Styrene	Instrument clusters, trim moldings, consoles, armrest supports, grilles	Cycolac (GE), Magnum (Dow), Lustran (Monsanto)	Weld with ABS White rod (5003R3) or repair with insta-weld instant adhesive	Instant adhesive works great on ABS.
PC + ABS	Polycarbonate + Acrylonitrile Butadiene Styrena	Door skins (Saturn), instrument panels	Pulse (Dow), Bayblend (Bayer), Cycoloy (GE)	Weld with Polycarbonate rod (5003R7), ABS rod (5003R3), two part epoxy, or instant adhesive	Preheat groove before welding. Use fiberglass mat with instant adhesive.
UP, EP	Unsaturated Polyster, Epoxy (Thermoset)	Fender extensions, hoods roofs, decklids, instrument housings	SMC, Fiberglass, FRP	Repair with two-part epoxy system (2020 or 2021) or polyester resin and glass cloth	The material cannot be repaired with the welder
PE	Polyethylene (polyolefin)	Inner fender panels, valences, spoilers, interior trim panels	Lacqtene, Lupolen, Dowlex, Hostalen	Weld with Polyethylen Opaque whilte rod (5003R4)	Use adhesion promoter before applying filler or coating
PC	Polycarbonate valence panels	Interior rigid trim panels,	Lexan, Merlon, Calibre	Weld with Polycarbonate clear rod (5003R7)	Preheat groove before welding.
PA	Polyamide	Radiator tanks, headlamp bezels, quarter panel extensions, exterior trim finish parts	Nylon, Capron, cleanese, zytel, Rilsan, Vydyne, Minion	Weld with Nylon Opaque white rod (5003R6) or Uni-Weld (5003R8)	Preheat groove before welding especially on radiator tanks

Identifying	Chemical composition	Typical usage	Common or trade names	Suggested repair method	Repair tips
TEEE	Thermoplastic Ether Ester Elastomer	Bumper fasicas (Bonneville SSE, Park AVe., 91-'96 Vette front), rocker panel covers (Camaro & Firebird)) or	Bexloy V (DuPont)	Weld with Uni-Weld (5003R8) or two-part epoxy system (2000 or 2020)	
PET	Polyethylene Terephthalate + Polyester	Fenders (Chrysler LH)	Bexloy K (DuPont), Vandar (Hoechst)	Weld with Uni-Weld (5003R two-part epoxy system (2020 or 2021)	
EEBC	Ether Ester Block Copolymer	Rocker cover moldings fender extensions ('91-'96 Deville)	Lomod (GE)	Weld-with Uni-Weld (5003R8) or two-part epoxy system (2010)	
EMA	Ethylene/ Methacrylic Acid	Bumper covers (Dodge Neon)	Bexloy W (DuPont)	Weld with Uni-Weld (5003R8)	

Table 2 Plastic Repair Quick Reference

Repair Method							
		A	**B**	**C**	**D**	**E**	**F**
Step 1	**Identify Plastic**	Thermoster Polyurethane	ABS, Polyurethane Nylon, Polycarbonate	PP, TPO, TEO, TPE PE, or Other	ABS, SMC Fiberglass, PC Blend	SMC, UP, FRP Fiberglass	ABS, SMC Fiberglass, PC Blend
Step 2	**Clean**	Clean part with soap and water and plastic cleaner					
Step 3	**Repair**	Thermoset Urethane Weld 	Thermoplastic Fusion Weld 	Uni-Weld FiberFlex 	Insta-Weld Adhesive 	Two-Part Epoy Adhesive 	Rigid Plastic Repair Kit 
Step 4	**Fill**	Grind and apply filler to match the harness of the substrate					
Step 5	**Prime**	Prime with flexible primer, then seal with sealer					
Step 6	**Paint**	Apply topcoat with flex additive					

Symbol & Type	How to Identify	Typical usage	Suggested Repair Methid	Repair Tips
PUR (RIM, RRIM Thermoset polyurethane	Usually flexible, may be yellow or gray, bubbles and smokes when attempting to melt	Flexible bumper covers (esp, on domestics), filler panels, rocker panel covers, snowmobile cowls	Method A with urethane rod or Method C with Uni-Weld Fiber flex	Do not try to melt the base material! Just melt the rod into the V-groove like a hot melt glue.
SMC, UP, FRP Fiberglass	Rigid, polyester matrix reinforced with glass fibers, sands finely	Rigid body panels, fenders, hoods, deck lids, header panels, spoilers	Method E---two-part epoxy repair with fiberglass reinformcement	Use backing plate over holes, layer in fiberglass cloth for extra strength and to approximate thermal expansion
ABS (Acrylonitrile Butadiene Styrene)	Rigid, often white, but may be molded in any color, sands finely; very pungent odor when heated	Instrument panels, grilles, trim moldings, consoles, armrest supports, street bike fairings	Method B with ABS rod (500R3) or Method D Insta-Weld adhesive repair, or Method E Two-Part epoxy repair	Weld repairs may be backed with epoxy for extra strength
EEBC (Ether Ester Block Copolymer	Flexible, off-white in color, similar in appearance to PUR (Lomod by	Rocker cover moldings, bumper extensions ('91-'96 DeVille)	Method C with Uni-Weld Fiber Flex (5003R10)	-do-
EMA (Ethylene Meth-acrylic Acid)	Semirigid, molded in a variety of colors, unpainted (Bexloy W by DuPont)	Bumper covers (Dodge Neon first-generation base model)	Method C with Uni-Weld Fiber Flex (5003R10) or Method B with silvers cut from scrap	Sand entire bumper for refinishing, restore texture with Flex Tex (3800)
PA Polyamide (Nylon)	Semirigid or rigid, sands finely	Radiator tanks, headlamp bezels, exterior trim finish parts	Method B with nylon rod (5003R6)	Preheat plastic with heat gun before welding, mix rod completely with base material.
PC + ABS Pulse (Polycarbonate & ABS)	Rigid, sands finely, usually dark in color	Door skins (Saturn), instrument panels, street bike fairings	Method B with Polycarbonate rod (5003R7), or Methods D or E adhesive repairs	Preheat plastic with heat gun before welding with Method B.
PC + PBT Xenoy (Polycarbonate blend)	Rigid, sands finely, usually dark in color	Bumper covers (primarily Ford products, 84-95 Taurus, Aerostar, some Mercedes and Hyundai's)	Method B with polycarbonate rod (5003R7), Method C, or Method E adhesive repairs	Preheat plastic with heat gun before welding with Method B.
PE Polyethylene	Semiflexible, melts & smears grinding, usually sem-translucent	Overflow tanks, inner fender panels, valences, interior trim panels, RV water storage tanks, gas tanks	Method B with polyethylene rod (5003R4) or Method C with FiberFlex (5003R10)	Applying filler or painting is nearly impossible
PP Polypropylene	Semiflexible, usually black in color, melts & smears when grinding	Bumper covers (usually blended with EPDM), inner fenders, radiator shrouds, interior panels, gas tanks	Method X with Uni-Weld Fiber Flex (5003R10) or Method B with polypropylene rod (5003R2)	Use 1060FP Prep adhesion promoter when applying two-part epoxy filler.
PPO + PA Noryl GTX (Nylon blend)	Sem-rigid, sands finely, usually off-white in color	Fenders (Saturn & GM), exterior trim	Method B with nylon and (5003R6), or Methods D or E adhesive repairs	Preheat plastic with heat gun before welding with Method B.

Symbol & Type	How to Identify	Tyical usage	Suggested Repair Methid	Repair Tips
TEEE (Thermoplastic Ether Ester	Flexible or Semiflexible (Bexloy V by duPont)	Bumper covers (especially on domesitcs, filler panels, rocker panel covers)	Method C with Uni-Weld Fiberflex (5003R10) or Method B with silvers cut from scrap	
TPE Thermoplastic Elastomer	Semi-flexible, usually black or gray, melts & smears when grinding	Bumper covers, filler panels, underhood parts	Method C with Uni-Weld Fiber Flex (5003R10)	Use 1060FP Filler Prep adhesion promoter before applying two-part epoxy filler.
TPO, EPM, TEO Thermoplastic Olefin	Semiflexible, usually black or gray in color, melts & smears when grinding	Bumper covers, air dams, grilles, interior parts, instument panels, snowmobile cowls	Method C with Uni-Weld Fiber Flex (5003R10) or Method B with PP or TPO rod	Use 1060FP Filler Prep adhesion promoter when applying two-part epoxy filler.
TPU, TPU---- Thermoplastic Polyurethane	Flexible, sands finely	Bumper covers, soft filler panels, gravel deflectors, rocker panel covers	Method B with urethane rod (5003R1) or Method C with Uni-Weld FiberFlex (5003R10)	

Plastic repair: There are two methods of repairing palstics.

1 By use of chemical adhesive

2 By plastic welding

Plastic repair like any other kind of body repair work it is up to the repair person to determine whether it makes more sense to repair a plastic part than to replace it.

Chemical-adhesive and bonding techniques: The adhesive repair systems are two types. 1) Cyanoacrylate 2) Two-part adhesive system.

Cyanoacrylates: It is one part fast-curing adhesives used to help repair rigid and flexible palstics. It is often used as a filler or to tack parts together before applying the fluid repair material.

Two-part adhesive system: It is consisting of a base resin and a hardener. The resin comes in one container and the hardener in another. When mixed, the ahesive cures into a plastic material similar to the base material in the part. Two-part adhesive systems most commonly used as alternative to welding for many plastic repairs.

Repairs of minor cuts and cracks: Wash the repair area thoroughly with soap and hot water. Wipe or wash the repair area clean with water and a plastic cleaner. Repair surface must be free of wax, dust and grease. Allow parts warm upto 70°F (21°C) before applying adhesives.

After cleaning prepare the crack with an adhesive bit. The bet should have two elements an acceleration an adhesive. Spray one side of the crack with the accelerating tool. Then apply the adhesive to the same side of the crack. Carefully position the two sides of the cut or crack in their original position and quickly press that together with firm pressure. Hold for a full minute to achieve good bonding strength. Then allow the repair to cure for 3 to 12 hours for maximum strength.

Repairs of gauges, tears and punctures: Wash the area thoroughly with soap and hot water. Then clean around the damaged area thoroughly with a wax, grease, and silicon removing solvent applied with a water dampened cloth, wipe the area dry. Prepare for the structural adhesive bevel the edges of the hole back about 1/4 to 3/8 inch (6.4 to 9.5mm). In this repair the beveling has left a coarse surface for good adhesion. Use a fuser grit dies to remove the paint around the repair area but very little of the urethane palstic. Blend the paint edges into the plastic. The repair material must not overlap the painted surface.

Carefully wipe of all paint and dusk. The repair area must be absolutely clean for proper bond strength if recommended by the product manufacturer use any torch with a controlled flame and develop a 25mm cone tip. Apply auto backing tape to the repair area. An aluminium foil with a strong adhesive on one side and a moisture proof backing is recommended clean the inner surface of the repair area with silicone and wax remover. Then install the tape cover the hole completely with about a 25mm adhesion surface around the edges.

Prepare the repair adhesive material on a clean flat nonporous surface, such as metal or galss, as directed by the manufacturere. Paddle the structural adhesive into the hole, use in a squeegee or plastic spreader. Two applications of the adhesive are usually required. The first application is used to fill the bottom of the hole. The cure for about an hour at room temperature or 20 minutes with a heat lamp (if the manufacturer's directions allow heat curing) before the final application of the adhesive use a fire grit disc to grind down the high spots of the application. Wipe the dust from the repair area. Mix the second application of the adhesive, squeezing the components together as before for about 2 minutes. Then apply the second adhesive mixture, paddling if into an overfill contour of the area. When the adhesive repair material has dried, establish a rough contour to the surrounding area with a #80 grit abrasive on a sanding block. The finishing sand can be done with a disc sander and a #320 grit disc. After sanding clean the dust and loose the material. Now plastic surface is read for painting.

Using the right adhesive: The service manual will recommend products and procedures for the exact type of palstic in the part.

It is important to keep in mind that there are differences amond manufacturers repair materials. When using palsstic repair adhesives, remember the following:

- Mixing product lines is not acceptable. Choose a product line and use it for the entire repair.
- Most product lines have two or more adhesives designed for different types of plastic.
- The product line usually includes an adhesion promoter, a filler product, and a flexible coating agent. Use each as directed.
- Some product lines are formulated for a specific base material. For example, one manufacturer offers individual products for use on each type of plastic (TPO, urethanes, or Xenoy, for example), regardless of plastic flexibility.
- Clean palstic parts with a plastic prep. Never use solvent-based cleaners.

A product lines might use a single flexible for all palstics, or there may be two or more flexible fillers designed for different types of plastic.

Flexible part repair

Here is a typical procedure for using a two-part epoxy adhesive to repair a flexible part, a bumper cover in this example:

1 Clean the entire cover with soap and hot water. Wipe or blow-dry. Then clean the surface with a good plastic cleaner.

2 V-groove the damaged area. Then grind about a 11/20inch (38 mm) taper around the damage for good adhesion and repair strength.

3 Use a sander with #180 grit sand paper to featheredge the paint around the damaged area, Then blow off the dust. Depending on the extent of the damage, the back may need reinforcement.

4 To reinforce the repair area, sand and clean the back side of the cover with plastic cleaner. Then, if needed, apply a coat of adhesion promoter.

5 Dispense equal amounts of both parts of the flexible epoxy adhesive. Mix them to a uniform color. Apply the material to a piece of fiberglass cloth using a plastic squeegee.

6 Attach the plastic-saturated cloth to the back side of the bumper cover. Fill in the weave with additional adhesive material.

7 With the back side reinforcement in place, apply a coat of adhesion promoter to the sanded repair area on the front side. Let the adhesion promoter dry completely.

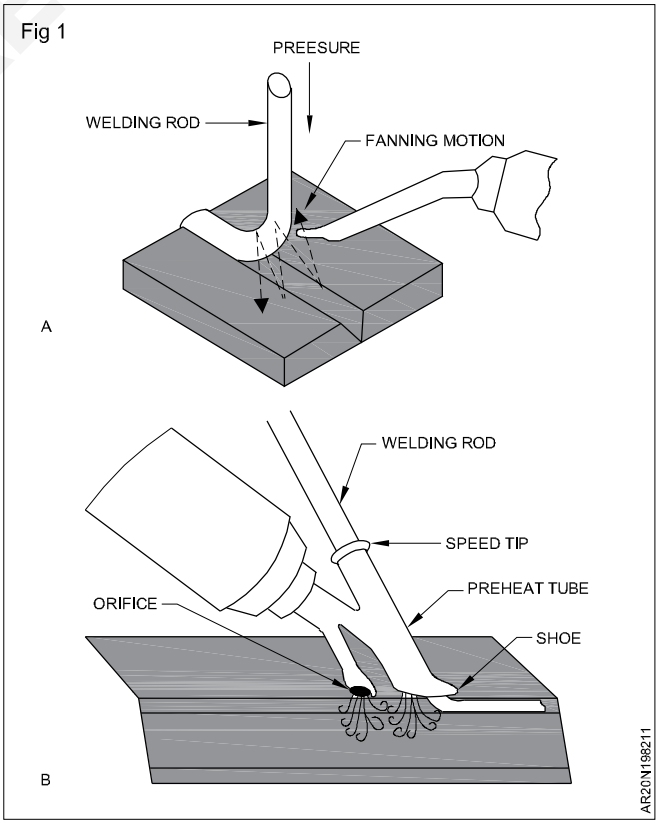
8 Fill in the area with adhesive material. Shape the adhesive with your spreader to match the shape of the part. Allow it to cure properly.

9 Rough grind the repair area with #80 grit sandpaper, then sand with #180 grit, followed by smoother #240 grit.

10 If additional adhesive material is needed to fill in a low spot or pinholes, apply a coat of adhesion promoter again.

Plastic welding: (Fig 1) Plasic welding uses heat and sometimes a plastic filler rod to join or repair plastic parts. The welding of plastics is not unlike the welding of metals both methods use a heat source, welding rod and similar techniques, joints are prepared in much the same manner and evaluated for strength.

Fig 1



When welding plastics the materils are fused, together by the proper combination of heat and pressure successful welds require that both pressure and heat be kept constant and in proper balance too much pressure on the rod tends to stretch the bead too much heat will char melt or distort the plastic with practice, plastic welding can be mastered as completely as metal welding.

Fig 1A successful plastic welding requires the proper combination of heat and pressure B. This plastic welder is equipped with a high speed tip.

Hot-air plastic welding: Hot-air plastic welding uses a tool with an electric heating element to produce hot air 232°C - 345°C that blows through nozzle and onto the plastic. The air supply comes from either the shop's air compressors or a self-contained portable compressor that comes with the welding unit. The plastic welding rod is often thicker them the panel to be welded. This can cause the panel to overheat before the rod has melted. Using smaller diameter rod can often correct such wear page problems. There are three types of welding tips are available for use with most hot air plastic welding torches.

Tacking tips, round tips, speed tips for use of tack weld, short welds, hold feed and automatically preheat the plastics check the product catalog for more information.

High-speed welding: High-speed welding incorporates the basic methods utilized in hand-welding except a specially designed and patented high-speed tip us used, which enables the welder to produce more uniform and work at a much higher rate of speed. As with hand-welding, constant heat and pressure must be maintained.

Plastic welder setup, shutdown, and servicing: The two hot-air plastic welders are exactly alike. For specific instructions, always refer to the owner's manual and other material provided by the welder manufacturer.

Some manufacturers advise against using their welder on plastic thinner than 1/8 inch (3 mm) because of distortion. It is sometimes acceptable to weld thin plastics if they are supported from underneath while welding.

Airless plastic welding: Airless plastic welding and electric heating element to melt a smaller 1/8-inch (3 mm) diameter rod with no external air supply. Airless welding with a smaller rod helps eliminate two troublesome problems: panel warpage and excess rod buildup.

When setting up and airless welder, set the temperature dial at the appropriate setting. This will depend on the specific plastic being worked. It will normally take about 3 minutes for the welder to fully warm up.

Make sure the rod is the same material as the damaged plastic or the weld will be unsuccessful. Many airless welder manufacturers provide rod application charts. When the correct rod has been chosen, it is good practice to run a small piece through the welder to clean out the tip before beginning.

Ultrasonic plastic welding: Ultrasonic plastic welding relies on high-frequency vibratory energy to produce plastic bonding without melting the base material. Handled systems are available in 20 and 40 kHz frequencies. They are equally adept at welding large parts and tight, hard-to-reach areas. Welding time is controlled by the power supply.

Plastic welding procedures: The basic for hot-air and airless welding are very similar. To make a good plastic weld with either procedure keep the following factors in mind:

- Plastic welding rods are frequently color-coded to indicate their material. Unfortunately, the coding is not uniform among manufacturers, It is important to use the reference information provided. If the rod is not compatible with the base material, the weld will not hold.
- Too much heat will char, melt, or distort the plastic. Too little heat will not provide weld penetration between the base material and the rod.
- Too much pressure stretches and distorts the weld.
- The angle between rod and base material must be correct. If too shallow, a proper weld will not be achieved.
- Use the correct welding speed. If the torch movement is too fast, it will not produce a good weld. If the tool is moved too slowly, it can char the plastic.

The basic repair sequence is generally the same for both plastic welding processes:

1 Prepare the damaged area.

2 Align the damaged area.

3 Make the weld.

4 Allow it to cool.

5 Sand if the repair area has pinholes or voids, bevel the edges of the defective area. Add another weld bead and resend,

6 Apply a topcoat.

General welding techniques: Welding plastic is not difficult when done in a careful and thorough manner. The following guidelines cannot be stressed enough:

- The welding rod must be compatible with the base material in order for the strength, hardness, and flexibility of the repair to be the same as the part.
- Always test a welding rod for compatibility with the base material. To do this melt the rod onto a hidden side of the damaged part, let the rod cool, then try to pull it from the part. If the rod is compatible, it will adhere.
- Pay close attention to the temperature setting of the welder, it must be corrected for the type of plastic being welded.
- Never use oxygen or other flammable gases with a plastic welder.
- Never use a plastic welder, heat gun, or similar tool in wet or damp areas. Remember: Electric shock can kill.

- Become proficient at horizontal welds before attempting the more difficult vertical and overhead types.
- Make welds as large as they have to be. The greater the surface area of a weld, the stronger the bond.
- Before beginning an airless weld, run a small piece of the welding rod through the welder to clean out the torch tip.
- Consult a supplier for the brands of tools and materials that best fit the shop's needs. Always read and follow the manufacturer's instructions carefully.

Tack welding: On long tears where backup is difficult, small tack welds can be made to hold the two sides in place before doing the permanent weld for larger areas, a patch can be made from a piece of plastic and tacked in place.

To tack weld, proceed as follows:

1 Hold the damaged area in alignment with clamps or aluminium body tape.

2 Using a tacking welding tip, fuse the two sides to form a thin hinge weld along the root of the crack. This is especially useful for long cracks because it allows for easy adjustment and alignment of the edges.

3 Start tacking by drawing the point of the welding tip along the joint. Press the tip in firmly, making sure to contact both sides of the crack. Draw the tip smoothly and evenly along the line of the crack. No welding rod is used when tacking.

4 The point of the tip will fuse both sides in a thin line at the root of the crack. The fused parts will hold the sides in alignment. Then you can fuse the entire length of the crack.

Speed welding procedure: As mentioned, plastic speed welding uses a specially designed tip to produce a more uniform weld at a higher rate of speed. You must preheat both the rod and base material. The rod is preheated as it passes through a tube in the speed tip. The base material is preheated by a stream of hot air passing through a vent in the tip.

Following are some techniques essential for quality speed welding:

1 Hold the speed torch like a dagger. Bring the tip over the starting point a full 3 inches from the base material. You do not want the hot air to affect the part.

2 Cut the welding rod at a 60-degree angle. Insert it into the preheat tube. Immediately place the pointed shoe end of the tip on the base material at the starting point.

3 Hold the torch perpendicular to the base material. Push the rod through until it stops against the base material at the starting point. If necessary, lift the torch slightly to allow the rod to pass under the shoe.

4 Keep a slight pressure on the rod and only the weight of the torch on the shoe. Then pull the torch slowly toward you to start the speed weld.

5 In the first 1 to 2 inches (25 to 50 mm) of travel, push it into the preheat tube with slight pressure.

6 Once started, swing the torch to a 45-degree angle. The rod will now feed without the need for pressure. As the torch moves along, inspect the quality of the weld.

Airless melt-flow plastic welding: Melt-flow plastic welding is the most commonly used airless welding method. It can be utlized for both single-sided and two-sided repairs.

A typical melt-flow procedure is as follows:

1 With the welding rod in the preheat tube, place the flat shoe part of the tip in the V-groove.

2 Hold it in place until the rod begins to melt and flow out around the shoe.

3 A small amount of force is needed to feed the rod through the preheat tube. The rod will not feed itself and care should be used not to feed it too quickly.

4 Move the shoe slowly. Crisscross the groove until it is filled with melted plastic.

5 Work the melted plastic well into the base material, especially toward the top of the V-groove.

6 Complete a weld length of about 1 inch (25 mm) at a time. This will allow smoothing of the weld before the plastic cools.

Plastic stich-tamp welding: Plastic stitch-tamp welding is used primarily on hard plastics, like ABS and nylon, to ensure a good base and rod mix.

After completing the weld using the melt-flow procedure, remove the rod. Turn the shoe over and slowly move the pointed end of the tip into the weld area to bond the rod and base material together. Stitch-tamp the entire length of the weld. After stitch-tamping, use the flat shoe part of the tio to smooth out the weld area.

Single-sided plastic welds: Single-sided plastic welds are used when the part cannot be removed from the vehicle. To make a single-sided weld, proceed as follows:

1 Set the temperature dial on the welder for the plastic being welded. Allow it to warm up to the proper temperature.

2 Clean the part by washing with soap and hot water, followed by a good plastic cleaner.

3 Align the break using aluminium body tape.

4 V-groove the damaged area 75 percent of the way through the base material. Angle or bevel back the torn edge of the damage at least 1/4 inch (6 mm) on each side of the damaged area. Use a die grinder or similar tool.

5 Clean the preheat tube and insert the rod. Begin the weld by placing the shoe over the V-groove and feeding the rod through. Move the tip slowly for good melting and heat penetration.

6 When the entire V-groove has been filled, turn the shoe over and use the tip to stitch-tamp the rod and base material together into a good mix along the length of the weld.

7 Resmooth the weld area using the flat shoe part of the tip, again working slowly. Then cool with a damp sponge or cloth.

8 Shape the excess weld buildup to a smooth contour, using a razor blade and/or abrasive sandpaper.

Two-sided plastic welds: A two-sided plastic weld is the strongest type of weld. When making a two-sided weld, be sure to follow these steps.

1 Allow the welder to heat up. Then clean the preheat tube.

2 Clean the part with soap and hot water and plastic cleaner.

3 Align the front of the break with aluminium body tape, smoothing it out with a stiff squeegee or spreader.

4 V-groove 50 percent of the way through the back side of the panel.

5 Weld the back side of the panel using the melt-flow method. Move slowly enough to achieve good melt-in.

6 When finished, smooth the weld with the shoe.

7 Quick-cool the weld with a damp sponge or cloth.

8 Remove the tape from the front of the piece. V-groove deep enough so that the first weld is penetrated by the second V-groove.

9 Weld the seam, filling the groove completely.

10 Use a razor blade or slow speed grinder to reshape the contour.

Repairing vinyl: Vinyl is a soft, flexible, thin plastic material often applied over a foam filler. Vinyl over foam construction is commonly used on interior parts for safety. Common vinyl parts are the dash pads, armrests, inner door trim, seat covers, and exterior roof covering. Dash pads or padded instrument panels are expensive and time-consuming to replace. Therefore, they are perfect candidates for repair.

Most dash pads are made of vinyl-clad urethane forum to protect people during a collision. Surface dents in foam dash pads, armrests, and other padded interior parts are common in collision repair, These dents can often be repaired by applying heat as follows:

1 Soak the dent with a damp sponge or cloth for about half a minute. Leave the dented area moist.

2 Using a heat gun, heat the area around the dent. Hold the gun 10 to 12 inches (254 to 305 mm) from the surface. Keep it moving in a circular motion at all times, working from the outside in.

3 Heat the area to around 130°F (54°C). Do not overheat the vinyl because it will blister. Keep heating until the area is too uncomfortable to touch. If available, use a digital thermometer to meter the surface temperature.

4 Using gloves, massage the pad. Force the material toward the center of the dent. The area might have to toward reheated and massaged more than once. In some cases, heat alone might repair the damage.

5 When the dent has been removed, cool the area quickly with a damp sponge or cloth.

6 Apply vinyl treatment or preservative to the part.

Spraying vinyl paints: Vinyl repair paints are usually ready for spraying as packaged. Because application properties cannot be controlled with thinners or other additives, air pressure is an important factor.

Using heat to reshape plastics: Many bent, stretched, or deformed plastic parts, such as flexible bumper covers and vinyl-clad foam interior parts, can often be straightened with heat, This is because of plastic memory, the tendency of a piece to keep or return to its original molded shape. If it is bent or deformed slightly, it will return to its original shape if heat is applied.

To reshape a distorted bumper cover, use the following procedure:

1 Thoroughly wash the cover with soap and hot water.

2 Clean with plastic cleaner. Carefully remove all road tar, oil, grease, and undercoating.

3 Dampen the repair area with a water-soaked rag or sponge.

4 Apply heat directly to the distorted area. Use a concentrated heat source, such as a heat lamp or high temperature heat gun. When the opposite side of the cover becomes uncomfortable to the touch, It has been heated enough.

5 Use a paint paddle, squeegee, or wood block to help reshape the piece if necessary.

6 Quick-cool the area by applying cold water with a sponge or rag.

Ultrasonic stud welding: Ultrasonic stud welding uses high-frequency movement and friction to generate heat that bonds plastic parts together. Ultrasonic stud welding is made along the circumference of the stud its strength is a function of the stud diameter and the depth of the weld. Maximum tensile strength is achieved when the depth of the weld equals half the diameter of the stud.

Reinforced plastic repair: Reinforced plastic including sheet molded compound fiber-reinforced plastic, and reinforced reaction injection-molded polyurethane parts are using in many unibody vehicles. Table 3 provides an overview of reinforced plastic repair materials. The damage that generally occurs in reinforced plastic panels includes.

- One sided damage such as a scratch or gauge.
- Punches and fractures
- Panel separation, where the panel pulls away from the metal space frame.
- Severe damage, which required full or partial panel replacement.
- Minor bends and distortions of the space frame, which can be repaired by pulling and straightening.
- Severe kinks and bends to the space frame, which require replacement of that piece along factory or by sectioning.

Depending on the location and amount of damage there are four different types of reinforced plastic repairs.

1 Single sided repair

2 Two-sided repair

3 Panel sectioning

4 Full panel replacement

Select the any of the repair method through examination of the damaged vehicle parts.

Reinforced plastic parts of the vehicle showing in Fig 2.

Fig 2

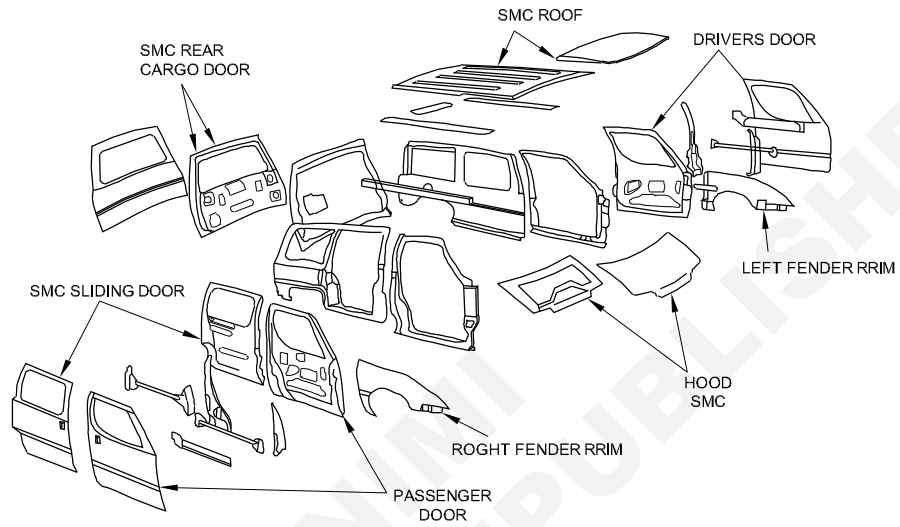


Table 3 Reinforced plastic repair material selection cart

Applicable repair product

Types of Repair	Panel Adhesive	Patching Adhesive	Structural Filler	Cosmetic Filler	Glass fiber Reinforcement
Panel replacement	X				
Panel sectioning	X		X[1]	X[1]	X
One-sided repairs				X[1]	
Two-sided repairs	X[2]	X[2]	X	X	X

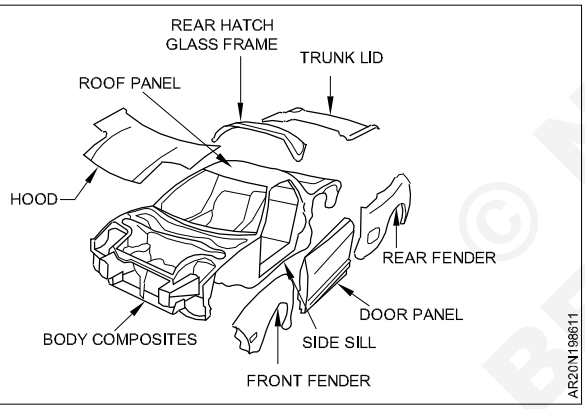
Hood, Bumber, Fender and trim service parts

Objectives: At the end of this lesson you shall be able to
- **remove and install fenders**
- **perform hood-to-hinge, hood height and hood latch adjustments**
- **remove, install and adjust decks lids**
- **remove, install and adjust the bumpers**
- **replace the grills and other plastic parts**
- **service trim pieces on the outside of body panels.**

Removal sequence of plastic parts from the vehicle: Start by removing large external parts first, if the front end has damage, you must remove the hood first. This gives more space to access rear fender belts. It also allows more light into the front to aid in finding and removing hidden bolts. Use this same kind of logic to remove other parts. Fig 1 shows the vehicle removed parts.

Hood service: The hood provides an external cover over the engine and front of vehicle before removing the hood, analyze the condition of its parts. Open and close the hood, Check the binding and bent hinges. Inspect the hood alignment with the fenders and cowed.

Fig 1

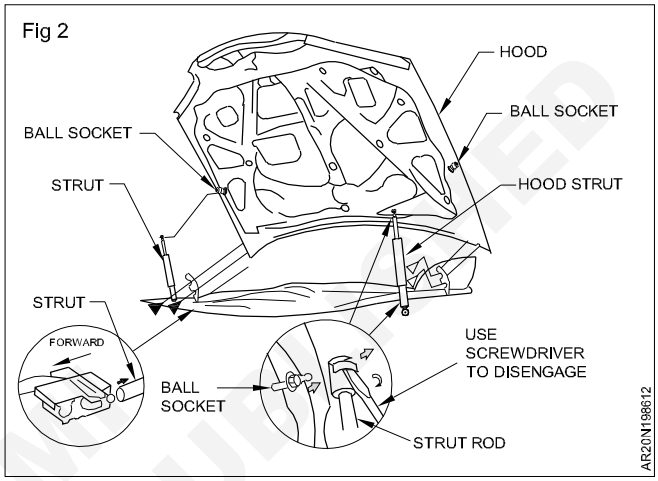


Hood removal: (Fig 2) Disconnect the hood mounting and wire connections and hoses. Hoses might run to the hood for the wind shield washer system. Use proper tools to remove the nuts of bolts connected with hood, remove the hood starts, hood hinges bolts, mark the hood hinges alignment. To mark the hood scribe alignment marks around sides of the hood hinges and on the body. You can use these marks to rough adjust the hinges and hood during reinstation.

Note the location of body shines or spacers that help adjust the hood. Fig 2 shown the typical service of how to remove hood studs.

Hood adjustment: The hood is the largest adjustable panel on most vehicles, it is adjusted at the hinges at the adjustable stops and at the hood latch. The slots at the body-to-hinge bolts allow the hood to be moved up and down. The slots at the hood-to-hinge bolts allow forward and reward adjustments to align the with the fenders and cowl.

Fig 2



The hood should align with the cowl and fenders with and equal gap between them. The front edge of the hood should be even with the front edge of the fender.

Hood hinges bolted to either the cowl or inner fender hold the rear of the hood to the vehicle. The holes in the hinges are slotted to allow the hinders to be adjusted. The front of the hood is held in place by a hood latch. The latch is used to secure the front of the hood so that it holds tightly and aligns with the fenders. Slotted holes are usually provided on the latch for alignment purposes. The safety catch is simply a spring-loaded hook or lever that engages the hood.

The bumper stops provide up and down adjustment points to set the hood height in relation to the fenders, bumper stops also prevent hood flutter during driving.

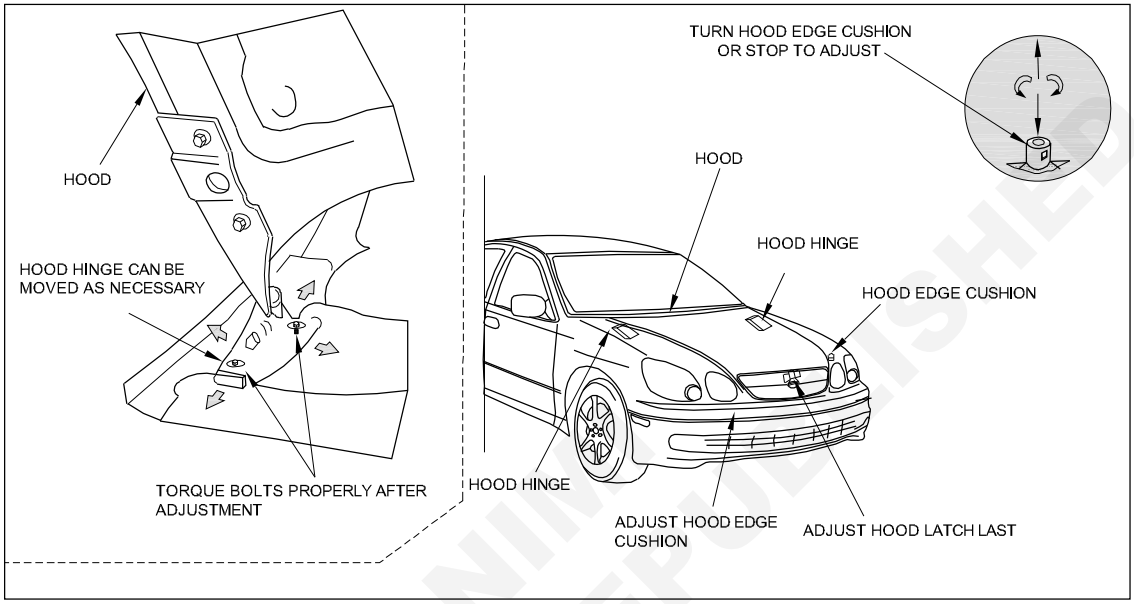
Hood-to-hinge adjustment: To adjust a hood slightly loosen the bolts attaching the hood to the hinges. Keep them tight enough to hold the hood during adjustment, but enough loose is allows to shift the hood. Now close the hood and line it up properly, shift it by hand until the gap around all sides of the hood is equal. Carefully raise the hood far enough for another technician to tighten the bolts. The front of hand must be aligning with the front of the fenders and any panel in front of the hood. Ensure sufficient clearance between the hood and cowl to allow the hood to be raised without rubbing the cowl.

Hood height adjustments: To correct the alignment of the hood up and down at the rear slightly the bolts holding the hinges to fenders or cowl. Once the rear of the hood is

adjusted to the correct height the adjustable stops must be checked. The rear stops must be adjusted to touch lightly against the hood. The front steps control the height of the front of the hood. Turn the stops in or out until the front of the hood is even with the top of the fenders. Ensure to retighten the locknut on the stop often adjustment. Hood adjustments are made at the hinges, adjust hood up or down, side to side and forward or rearward. Hood hinge adjustments control the position of the good in relation to the fender and rear hood height by loosening the hood-to-hinge bolts you can move the front end of the hood right or left or slide the hood to the front or back. Tighten them down when the hood is centered in opening. Hood stop adjustment controls the height of the front of the hood. Hood stops are usually rubber. By rotating the hood stops you can raise or lower the stops and the hood. Adjust the hood stops when it is closed.

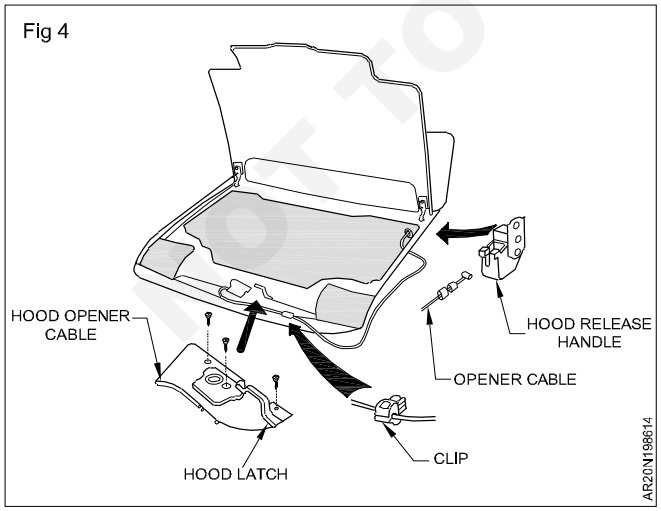
Fig 3A shows the adjusting the alignment and B shown the hood edge cushions or stops adjustment to heighten hood even with the fender.

Fig 3



Hood latch mechanisms (Fig 4): The hood latch mechanism keeps the hood closed and releases the hood when activated. Hood release mechanisms use a long steel cable running from the latch to a handle release in the passenger compartment it can be damaged in a major collision.

Fig 4



Hood latch adjustments: (Fig 5) The following steps to be covered while adjusting hood latch.

1 Remove the hood assembly from the radiator support and lower the hood.

2 Check that all the gaps around the hood are properly aligned.

3 Reinstall the hood latch and lower the hood until it engages or contacts the first latch (auxiliary latch or safety catch).

4 Attempt to raise the hood. If it does open, adjust the safety catch so that it engages. Sometimes the hook can be shifted or bent until the auxiliary latch “catches”.

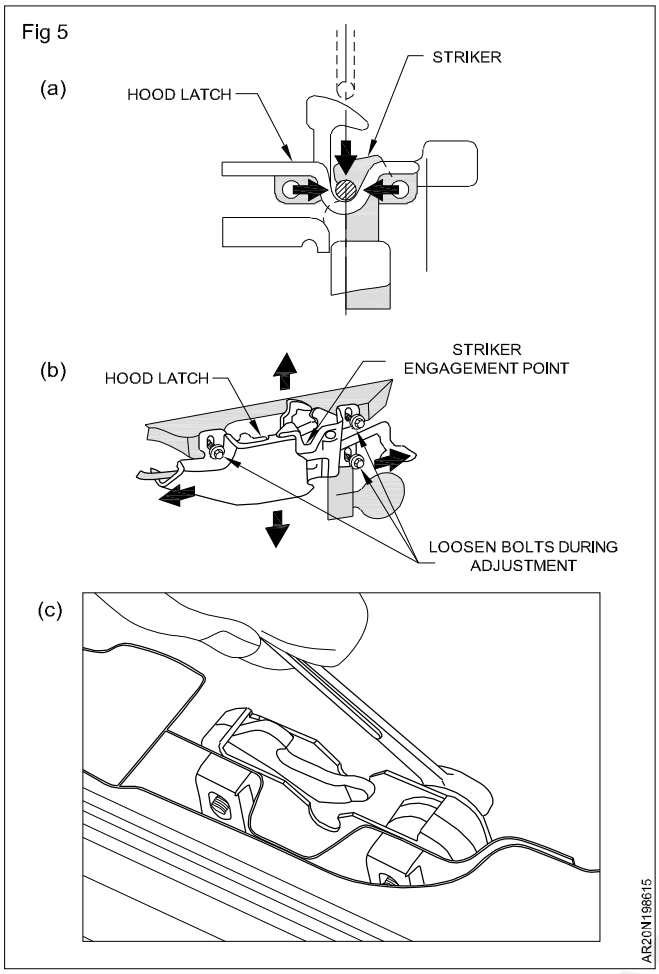
5 Lower the hood slowly. Check to see whether the hood shifts to one side or the other when it is locked. The striker bar bolted to the hood should be centered in the “U” of the latch. When the hood is latched, it should be even with the surrounding sheet metal and fit tightly.

6 Loosen the hood latch just enough to maintain a tight fit, but with enough give to allow you to move the latch.

7 Move the latch from side to side to align it with the hood latch hook. Move the latch up or down as required to obtain a flush fit between the top of the hood and the fenders when an upward pressure is applied to the front of the hood.

8 Tighten the hood latch attaching hardware.

9 Open the hood and double-check its action.



10 Close the hood. Make sure it is still at the same height as the fenders. If necessary, again adjust the bumper stops to eliminate any looseness at the front of the hood and ensure a good, tight fit.

11 Tighten the attaching hardware on the bumper stops.

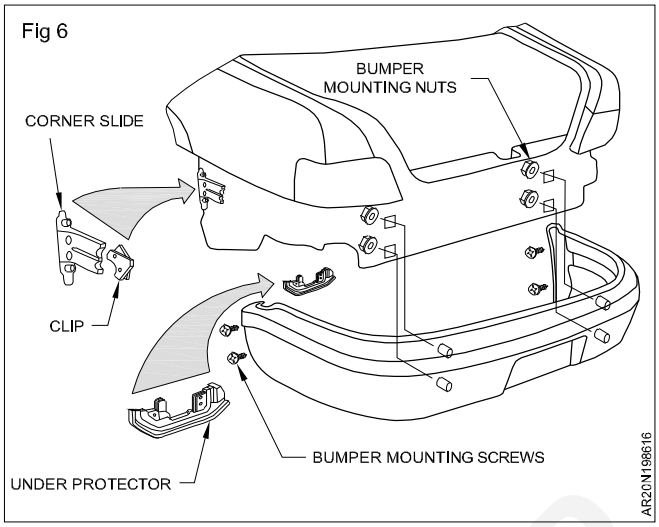
12 Check to see that the side bumper stops (if any) are in place and in good condition.

13 Make sure that the safety catch is working properly.

After adjustment, tighten the latch bolts, make sure the latch release the hood properly. Always check the vehicles service manual for specific hood adjustment procedure.

Bumper replacements (Fig 6): Remove the parking lights, wind shield washer hoses and other fitting items must be disconnected before dismount the bumper from the vehicle. Now select the new bumper and fix the bumper on the vehicle. After bolting new or repaired bumper in plate, it must be adjusted so that it is an equal distance from the fenders and front grille adjustments are made at the mounting bolts. The mounting brackets allow the bumper to be moved up or down side to side and in and out. if necessary steel shines can be added between the bumper and the mounting bracket to adjust the bumper alignment.

Fender service: Fender service is commonly needed after fronted impacts. Fenders are most common parts damaged during collisions.



Fender removel: Fluid and remove all the bolts mounting it to the vehicle. Remove the wires going to to fender-mounted lights. Fenders are bolted to the radiator core support, inner bender panels and cowl, bolts are often behind the doors, inner bender panels and under the vehicles.

With all of the bolts removed, carefully lift the fender off transfer any needed parts from the old fender over to new fender.

Installations fenders: Installation new fender in reverse order of removal. When installing fenders, hand tighten all of the bolts but don't tighten them. Leave the bolts loose enough so that can adjust the fender. While installing the fender place making or duck tape over their edges ot protect from scratches.

Fender adjustments: Fenders are bolted to the radiator core support or to the grill, to the inner fender panel in the engine compartment, and to the cowl behind the door and under the car. When these bolts are loosended, the fender can be moved for adjustment.

Start adjusting and tightening the fender bolts at the rear, next to the top of the door. Obtain the correct fender-to-door gap and the correct fender-to-hood gap. Then tighten the fender bolts, to the front of the vehicle.

Shift the fender on its bolts so that it properly aligns with other body parts. Shift the fender forward or backward until the fender, door and cowl have the correct spacing. Adjust the fender in and out so that it is flush with the door and parallel with hood. Tighten the fender bolts after the fender in alignment.

Fender shimming is an adjustment method that uses spacers under bolts, by changing shin thicknesses can be mode the position of the fender for proper alignment shins should be used only if alignment cannot be achieved without shins.

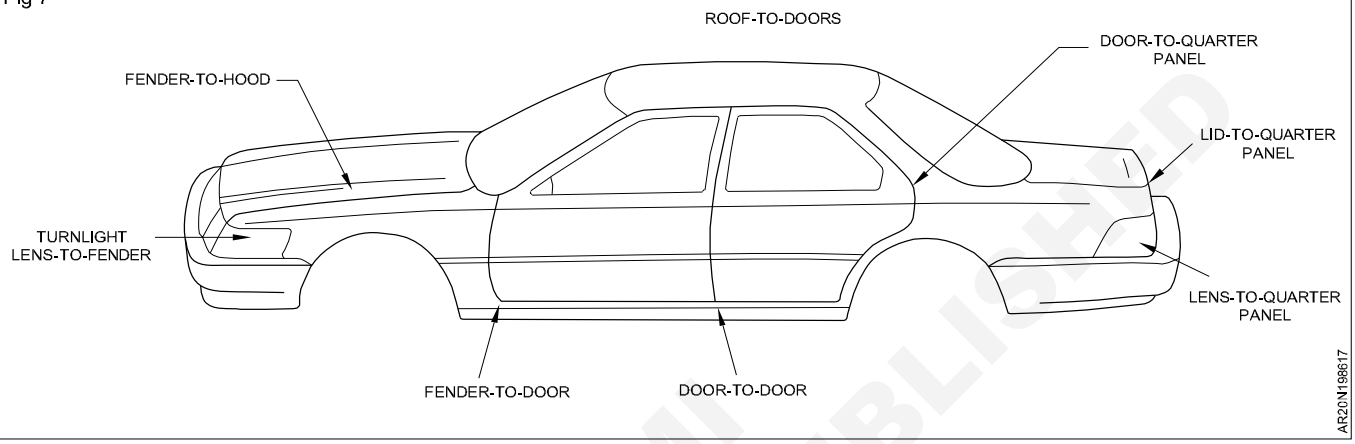
The fender and hood adjustment must be made simultaneously to achieve a satisfactory result. The gap between fender and hood should be factory specification.

Grille service: An air ratchet is handy of reaching down and unscrewing grille bolts. when installing a grille make sure all clips are undamaged and installed. Most grilles are plastic. Not to be overtighten any bolts or screw. Over tight might be crack the grille. By leaving the bolts loose can be shift and align the grille with other vehicle parts. Once it is aligned tighten the fasteners slowly.

Trunk lid adjustments: To adjust the lid forward or backward, slightly loosen the attaching hardware on both hinges. Close and adjust the lid as required. Then raise the lid softly and tighten the attaching hardware insome cases might be necessary to use shins between the bolts and trunk lid to raise or lower the front edges if the front must be raised, place the shins between the hinge and the lid in the front bolt area. To lower the front edge of the lid place the shins at the back of hinges.

Panel alignment: (Fig 7) After installing all new body parts must check overall panel alignment. Ensure the clearance between parts are equal. The gap around the parts must be with in specifications. Also check surface of the panels are even with each other.

Fig 7



Truck bed service (Fig 8): Truck beds are bolted to a full ladder frame. To remove the bed, remove the bolts on the frame. Keep track of bolt lengths and rubber mounting cushion locations. They must be re installed in their original positions.

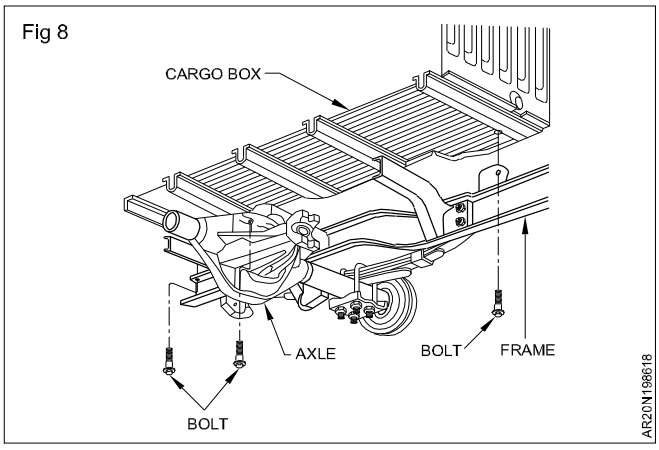
Truck tailboard mount on two hinges, A steel cable often limits how far down the tail board will open. Latches in sides of the tail gate engages strikes on the body. The handle on the outside of the tail board moves small linkage rods that run out to the latches. Adjust the tail board hinges and leave the hinge bolts loose while shifting the tail board as needed. Then tighten the hinge bolts and recheck adjustment.

Sound deadening pads: Sound-deadening pads are often bonded to the inside surface of trunk cavities and doors to reduce noise surface vibration and harshness. Sound deadening material is made of a plastic or asphalt-based material. It helps to quiet the passenger compartment by preventing the thin sheet metal panels from acting and sounding like large metal drums.

Custom body panels: Custom body panels are aftermarket parts that after the appearance of the vehicle. Many vehicle owners spend the extra money to give their vehicles a performance face lift. They have a body shop install custom parts. when you are installing custom parts, keep these following points in mind.

- Remove the lower body panel from under the front bumper.
- Place the new air dam under the front bumper and align the air dam with the wheel wells. Make sure that the front top lip of the air dam is located inside the front panel.
- Clamp the corners of the air dam to the wheel well with vise grips.
- Transfer the front body panel mounting holes with a scribe onto the air dam.

Fig 8



- Use scribe to transfer the mounting holes in the ends of the air dam to the wheel well.
- Using the recommended size drill bit, drill the rights amount of holes through the sheet metal and air dam.
- Loosely bolt the air dam in position and check it for correct alignment.
- Without overtightening them and causing part distortion securely snug down all fasteners.

Installing body trim and moldings: The variety of moldings enhance the appearance of a vehicle by hiding panel joints preventing door dings, and accenting body lines. They also help to weather proof by channeling wind and water away from windows and doors. Moldings often must be replaced due to collision damage or tim pieces or moldings can be added as a custom accessory.

Exterior moldings can be attached to the body using adhesive, self-stick backing, two sided tape, and mechanical fasteners. A variety of fasteners is used to secure moldings to a vehicle.

Removing adhesive - hold moldings: A molding tool or power knife has a thin blade that will out through the adhesive held modings. To cut off an old molding apply massing tape around the molding to protect the paint. Then adjust the tool blade depth to match the moldings size. Apply soap solution to the molding to reduce friction and cool the cutter blade, While holding the tool firmly square, begin cutting slowly from one end to the other. Sometimes a heat gun recommended to soften the adhesive before molding removed.

Installing adhesive body side modlings: Use the following procedure to install adhesive body side moldings properly.

1 Park the vehicle on a level surface. Clean the surface to molding applied.

2 Select the area to which the molding will be applied. For protection the molding should be applied to the outer most surface of the vehicle.

3 After determining the best location for the molding throughly clean the area with water and detergent. Then use a clean rag wetted with a wax and grease remover to remove waxes and silicones. Use a clean cloth for each side of the vehicle.

4 Mark the height at the rear and front of the vehicle and at each door gap. Stretch a piece of masking tape from front to rear connecting marks. Keep the tape, taut and sight along its length to ensure a straight line. Magnetic plastic tape or masking tape can also be used as a straight edge.

5 Cutting the molding to length about 3.1 mm clearance between the molding and edge of the fender cut the molding to size repeat the procedure for the rear quarter panel piece of molding. When the door is opened cut the ends of the molding at a 45° angle, using a single edge razer bladder.

6 Peel 6 inches of the protective backing paper from the cut end of the fender molding.

7 Align the molding with the top edge of the tape and lightly press against the panel. Progressing remove the backing and press the molding against the surface and along the edge of the tape.

8 Do not attempt the reposition a piece after it is applied after the whole length of molding is applied, press along the entire length with the head of hand or with roller. Repeat this process with the door moldings and the rear quarter panel moldings.

Door, roof and glass service

Objectives: At the end of this lesson you shall be able to
- **describe wind shield glass services**
- **remove and replace the door assemblies**
- **state the method of service of window regulators**
- **state the door glass replacement and adjustment**
- **state the method of rear view mirror replacement and heating elements**
- **explain the vinyl roofs repair.**

Vehicle glass technology introduction: Vehicle used glass is a transparent substance manufactured by heating a mixture of sand sodium carbonate, lime stone and other materials to a temperature of about (2400°F) 1300°C. this glass is broken out or cracked as result of a collision, air bag deployment, flying gravel.

The wind shield and back glass is considered as a structural component of the vehicle. It is important for the body shop and familiar with the various methods are used to remove and reinstall the glass. Broken glass must be removed before doing major structural repairs to the body.

Types of glass: There are two types of glass used in a modern vehicle. Both are considered as safety glass. (1) Laminated glass (2) Tempered glass

Laminated glass: This type of glass consists of two thin sheets of glass with a thin layer of clear plastic (Vinyl) between them it is used to make all wind shields and some side glass. The plastic or Vinyl material is usually clear to provide an unimpeded view from all angles. When laminated glass is broken, the plastic material helps to hold the shattered glass in place and prevent it from causing injury to passengers.

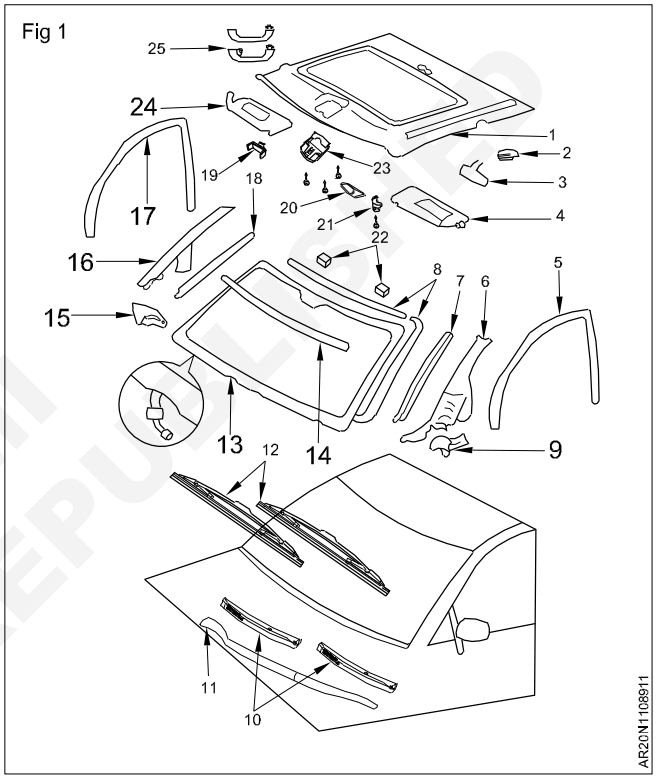
Tempered glass: Tempered glass is used for side and rear window glass. It is a single piece of heat treated glass and has more resistance to impact than regular glass of the same thickness

Note: Ant lacerative glass is used in the front wind shield only and it provides added protection against shattering and cuts during impact.

Glass service: (Fig 1) Wind shield and rear window are usually secured in place by rubber whether stripping or by an adhesive. Moldings are used on the interior and exterior of the body around the glass opening. Interior moldings around glass are called reveal moldings. These moldings are windshield wipers, cowl grille and related parts often must be removed before the wind shield will come out.

Replacement of wind shield glass involves two different methods based on the materials used, rubber gasket installations or adhesive installations. The adhesive - type installation is further refined into two additional methods, the full cut out and the partial cut out method.

Fig 1



1	Headliner	2	Mirror cover
3	Rear view mirror	4	Sun visor
5	Front door opening trim	6	Front pillar garnish
7	Side reveal outer molding	8	Dam
9	Instrument side panel	10	Cowl louver
11	Weather-strip	12	Wiper arm
13	Windshield glass	14	Upper reveal outer moulding
15	Instrument side panel	16	Front pillar garnish
17	Front door opening trim	18	Side reveal outer molding
19	Holder	20	Lens
21	Glass Holder	22	Stopper
23	Map light assembly	24	Sun visor
25	Assist grip		

Removing wind shield molding: The locking strip fits into a groove between the glass and the pinch weld flange. The strip forces the rubber gasket tightly against the glass and flange this locking strip must be removed before the glass removed from the opening.

Adhesive - bonded wind shields also increase the overall rigidity of the vehicle, minimizing body noise and helps to keep the glass in place during a collision. Before removal of wind shield glass or rear window, the interior and exterior moldings must be removed a clip removal tool is often needed to release the clip from under the molding lip.

On the exterior of the vehicle, remove the reveal moldings and other trim. To disengage or remove the moldings from the retaining clips a special tool might be required removal moldings can also be anchored in the adhesive material. When removing the reveal moldings so that they are not bent and damaged. The garnish moldings are used on the interior face the wind shield or rear window. All of the garnish moldings should be removed.

Wind shield rubber gasket service: The following procedures are used to replace the wind shield glass gasket material.

1 Place tape or masking paper over the dash and defrost vents to protect them from damage and to keep debris from falling in the vent holes.

2 Be sure all moldings, trim, and hardware are removed

3 If the glass has a built - in radio antenna, disconnect the antenna lead at the lower center of the wind shield and tape the leads to the glass.

4 Locate the locking strip on the outside of the gasket. Pry up the tab and pull the tab to open the gasket all the way around the windshield glass.

5 Use a putty knife to pry the rubber channel away from the pinch weld inside and outside of the vehicle.

6 With an assistant, push out the windshield glass and gasket.

7 Clean the wind shield body opening with an acceptable solvent to clear the area of dirt or residual sealant.

8 If the glass was not cracked and is to be reused, do not exert uneven pressure to the glass or strike it with tools. The technician should always wear safety goggles and gloves when replacing windshield glass or rear window glass - broken or not.

9 Place the removed glass on a suitable bench or table that is covered to protect the glass. If the glass was removed to accommodate body repairs, leave the gasket and moldings intact. If the glass was replaced because it was broken, remove the associated moldings and gaskets from the glass.

10 Cracks that develop in the outer edge of the glass are sometimes caused by low or high spots or poor spot welds in the pinch weld flange. Examine the pinch weld and correct the problem if applicable.

11 Apply a double layer of masking tape around the outside edge of the glass with ¼ inch (6.4 mm) overlap on inside of the glass. This will prevent chipping or breaking the glass.

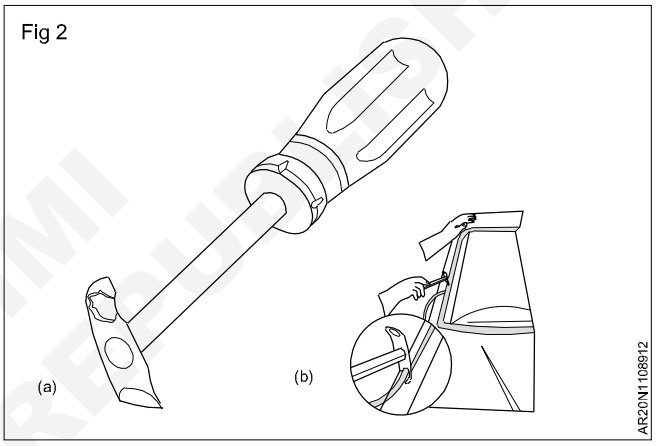
12 Install stop blocks and spacers. If the original blocks are not available, cut pieces of used gasket for blocks.

13 Carefully install the glass on the blocks center the glass and then check the gap between the glass and the pinch weld. Remove the masking tape around the edges of the glass.

14 Apply a bead of approved sealer in the glass channel and install the gasket on the glass.

15 Insert a cord (vinyl or nylon type) in the pinch weld groove of the gasket. Start at the top of the glass. The core ends should meet in the lower center of the glass. Tape the ends of the core to the inside surface of the glass (Fig 2). Squirt a soapy solution in the pinch weld groove to ease installation.

Fig 2



16 Apply factory - recommended sealer to the base of the gasket.

17 With the aid of an assistant, install the glass and gasket assembly in the body opening and center it. Slip the bottom groove over the pinch weld.

18 Very slowly pull the cord ends so that the gasket slips over the pinch weld flange. Work the bottom section of the glass in first, then do the sides, and finally the top section (Fig 15-9). Be sure to work the sections evenly, because the glass might crack if the cord ends is pulled from one side only.

19 Apply a small bead of sealer around the body side of the gasket.

20 Remove excess sealer with a suitable solvent that will not harm the paint.

21 Install the reveal and garnish moldings.

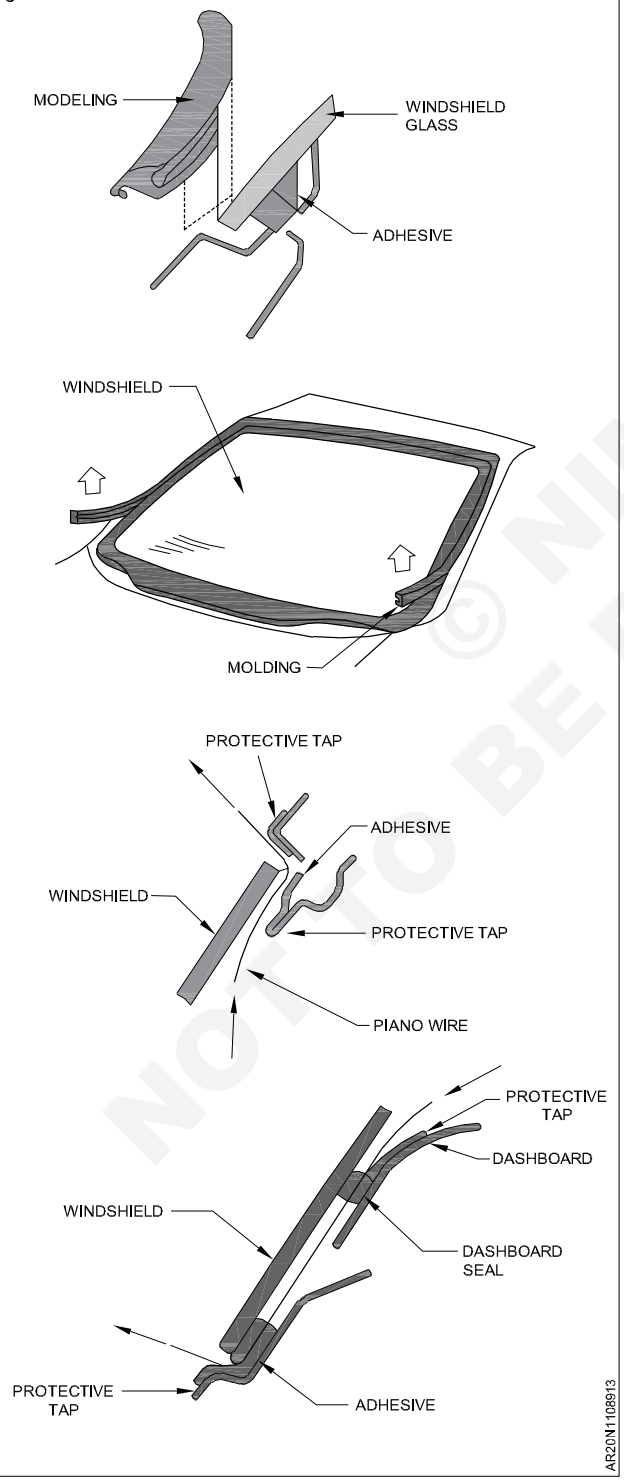
22 Check the wind shield for water leaks using a low pressure stream of water. Start at the bottom and slowly work your way up each side. Do the top last to help isolate the location of the leak.

23 Place a soapy solution in the locking strip groove and, with a tool designed for the job, replace the locking

strip. The wedge- shaped tool shown in Fig 2 spreads the groove and feeds the strip into the opening. The soapy solution lubricates the groove and makes it easier to slide the tool through the rubber groove.

Glass adhesive - full cut - out method: (Fig 3) This method involves the complete removal of the old adhesive sealer. To remove the glass, all of the old adhesive must first be cut. Several devices are available to do this: a steel wire; a hot knife; a pneumatic knife; an electric knife; or a cold, fine sharp knife. Each device has advantages and disadvantages. The pneumatic knife with a thin steel blade is preferred by many technicians.

Fig 3



Note the technique for removing the windshield on this vehicle. (A) Molding can be pulled out of the slot between the glass and vehicle body. (B) This cutaway view shows how to cut through windshield adhesive. Note the use of protective tape.

Late wind shield is secured using both a rubber gasket and adhesive. To remove this type of wind shield have to cut the old rubber gasket. Rubber reveal molding also be pulled out from between the body and glass using pliers.

Note: Wear eye protection to guard against flying bits of glass. Wear leather gloves to prevent cuts. Plastic gloves should be work to keep adhesive off skin.

Glass adhesive - partial cutout method: In the partial cutout method is to be used to install the glass, thoroughly inspect the remaining adhesive first, before attempting the procedure. There must be sufficient adhesive remaining in the pinch weld to give adequate clearance between the body and the glass. The remaining adhesive must also be tightly bonded to the pinch weld to provide a good base for the new adhesive.

If the original glass is to be reinstalled, you must remove all traces of adhesive from the glass. Use either denatured alcohol or an approved solvent to clean any residual adhesive from the edge of the glass.

To replace a wind shield using the partial cutout method, do the following:

1 Place protective coverings on the vehicle to prevent damage to the paint or interior.

2 Remove wind shield wiper arms, trim, antenna, and so on to expose the entire perimeter of glass.

3 Using a utility knife, make a cut into the existing urethane sealant around the entire perimeter of glass. Cut as close to the edge of the glass as possible.

4 Use a cutout knife or piano wire to cut out the glass, keeping the tool as close to the edge of the glass as possible. Remove the wind shield. Trim any high spots on the urethane bed to ensure a flat surface. The remaining adhesive should be approximately 3/32 inches (2.38 mm) thick.

5 Inspect the reveal molding clips for damage. Replace any clips if necessary.

6 Select an adhesive that will be compatible with the adhesive used on the body pinch welds. Refer to manufacturer recommendations for the type and amount of adhesive to use.

7 Replace the lower glass supports or spacers where applicable.

8 With the help of an assistant, position the glass in the body opening. Ensure that the gap is equal on both sides and that there is ample clearance on the top. Lower or raise the lower supports or spacers as required to get the correct placement of the glass.

9 Apply two pieces of masking tape from the bottom portion of the glass to the body 6 to 8 inches (152 to

203 mm) in from the corner. Repeat this procedure at the top of the glass.

Use a razor blade or knife to cut the masking tape strips and remove the glass. The tape strips will help to align the glass when reinstalling it.

10 Using a clean, dry, lint- free cloth, clean the surface of the urethane sealer remaining on the pinch weld. Replace the butyl tape strip in the antenna area with a new piece of butyl tape.

11 Clean the inside surface of the wind shield thoroughly with and ammonia- free, non-contaminating glass cleaner. Wipe dry with a clean, lint - free cloth or towel. Apply a uniform ½ inch (12.7 mm) wide coat of urethane primer to dry 3 to 5 minutes. Also, apply adhesive primer to the existing or remaining adhesive.

12 If the windshield contains and antenna, place a piece of butyl tape about 8 inches (203 mm) from the antenna pigtail. Do not use urethane or primer near the pigtail, because it will interfere with radio reception.

13 Apply the new, manufacturer- recommended adhesive directly over the existing adhesive.

14 Apply masking tape about ¼ inch (6.4 mm) from the outer edge of the inside of the glass on the top and both sides. This will aid the cleanup process when the glass is installed. Apply a smooth bead of the adhesive around the outer end of the glass or to the pinch weld.

15 With the help of an assistant, install the glass into the body opening. Place the glass on the lower supports or spacers with the masking tape strips properly aligned.

16 Open the vehicle front doors. Place one hand inside the opening and gently lay the glass in position. Use suction cups to control glass movement. An alternate method is to rest the glass on the lower supports or spacers. Then, one technician can go inside the vehicle and help lay the glass in position.

17 Firmly press the glass in place to set the adhesive material.

18 If adhesive was placed in the pinch weld, a dark line in the glass will indicate a sealed area. The dark line should be completely around the glass. Any light spots that appear indicate improper sealing.

19 If cartridge- type adhesive was used, the adhesive can be smoothed out along the edge of the glass.

20 Check the installation using a fine water spray. Do not use a direct flow of water on the fresh adhesive. Collect leaks by adding additional adhesive in the applicable areas.

21 Install any necessary trim and moldings and connect the antenna and/ or defogger pigtails as applicable.

22 Clean excess adhesive from the glass area or body.

23 Allow the adhesive to cure for 6 to 8 hours before moving the vehicle.

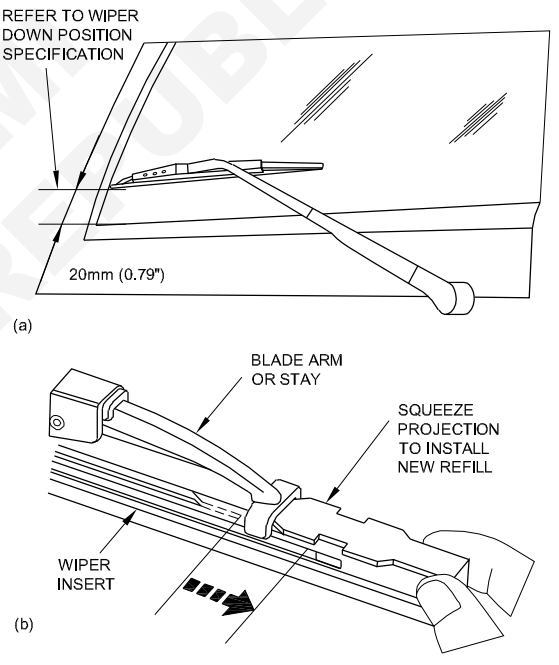
Windshield wiper service: (Fig 4A & B) The wind shield wipers must often be serviced during collision repair. The wiper arms can be held in place by spring clips or nuts. With spring clips, pinch the spring and pull for removal. You might also have to lift up on the end of a spring under the arm. This will free the arm for removal.

A special tool is available for spring tension - mounted wiper arm removal. If a nut is used, a cover over the nut must be pivoted upward or popped off. Then, you can remove the retaining nut and wiper arm.

When installing windshield wiper arms, make sure they are adjusted properly. Specs are usually given for the arms in the down position. By engaging the arm into different teeth on the drive shaft, you can change the adjustment. Operate the wipers to make sure they are adjusted correctly and do not sweep too far one way or the other.

If the wiper blades must be replaced, disengage them from the wiper arm. A small spring on the end of the blade often must be engaged into the arm. Before removing the wiper arms, you can mark their position with masking tape on the windshield to make reinstallation easier.

Fig 4



Rear and Quarter window service: The removal and replacement procedures of rear windows and side windows are similar to windshield replacement. Methods can vary slightly for different vehicle makes.

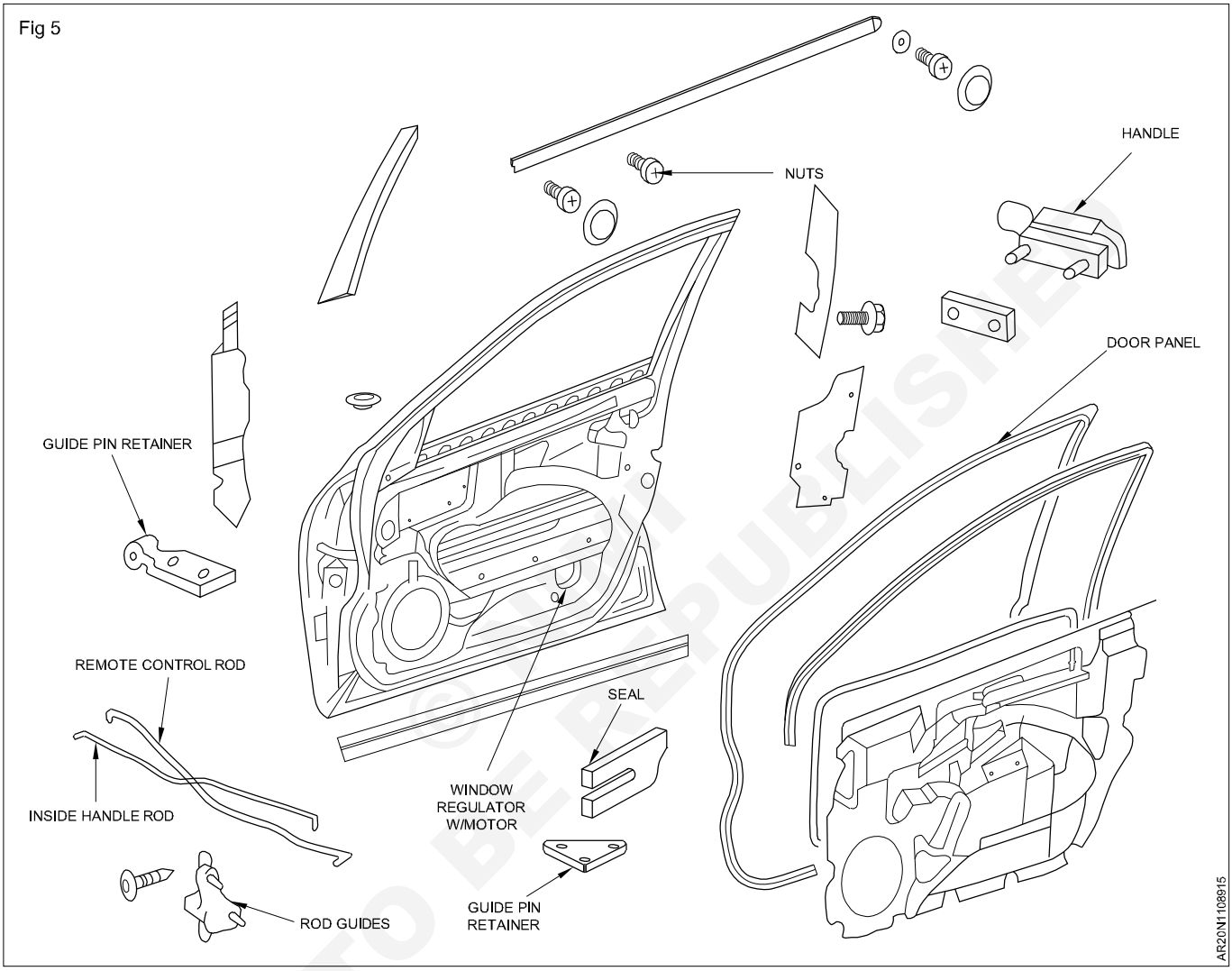
Quarter windows can be secured with rubber molding, adhesive, fasteners, of a combination of methods. After removing interior and exterior moldings, the quarter window can be removed. Again, refer to vehicle service information for details about fastener locations and procedure.

Servicing doors: Doors are the most used and abused parts of a vehicle. They are used to opened and closed many times during the lift of vehicle. Door must be strong enough to stay closed and protect the driver and

passengers from injury during a collision. In addition doors must be seal out water and wind noise to keep the vehicle interior dry and quiet. Hard top doors have the glass extending up out of the door without frame around it. The glass itself must seal against the weather stripping in the door opening.

Door construction: There are many types of door designs, (1) Framed type (2) Hard top doors. Framed doors are surround the sides and top of the door glass with metal frame. The door frame seals against the door opening. Hard top doors have the glass extending up out of the door without frame around it. The glass itself seal against the weather stripping in the door opening. The basic parts of door is as follows. (Fig 5)

Fig 5



- The door frame is the main steel frame of the door. Other parts (hinges, glass, handle, and so on) mount on the door frame.
- The door skin is the outer panel over the door frame. If can be made of steel, aluminum, fiberglass, or plastic.
- The door glass must allow good visibility out the door.
- The door glass channel serves as a guide for the glass to move up and down. It is a U- shaped channel lined with a low friction material, felt, for example.
- The window regulator is a gear and arm mechanism for moving the glass. When you turn the window handle or press the window button, the regulator moves the glass up or down.
- The door latch engages the door striker on the vehicle body to hold the door closed.
- Inner and outer door handles use linkage rods to transfer motion to the door latch. This allows you to activate the latch to open the door.
- The door trim panel is an attractive cover over the inner door frame. Various parts (inner handle, window buttons, speakers) can mount inside the inner trim panel.
- A plastic or paper door dust cover fits between the inner trim panel and door frame to keep out wind noise.
- Door weather stripping fits around the door or door opening to seal the door - to- body joint. When the door is closed, the weather stripping is partially compressed to prevent air and water leaks.
- A rear view mirror is often mounted on the outside of the door frame. A remote mirror know on the inner trim panel allows for mirror adjustment.

Manual and power regulators: Window regulators can be manually or electrically powered. Both types of regulators are very similar, the only difference being the handle crank mechanism on manual regulators and the electric motor - driven gear mechanism on powered regulators. The lift arms or mechanisms are the same for both types.

One or two lift arms can be used, depending on the make of the vehicle. If two lift arms are used in the window regulator, it is usually referred to as an X- type regulator. The X-design uses an auxiliary arm that is mounted into a cam or stabilizer channel that is adjustable. The cam adjustments allow the glass to be tilted or rocked so that it can be raised in a parallel position.

Checking door operation: Before door removal, check that the door and its related parts operate normally. Inspect the door assembly, its hinges, and the door opening in the body. Look for uneven or nonparallel gaps all the way around the door edge. Nonparallel body gaps indicate panel misalignment from structural damage, shifted panel fasteners, of worn mechanical parts (hinges or latches).

Look between the fender and door, rocker panel and door, quarter panel or rear door and front door, and between the roof rail and top of door. If you find gap misalignment, it may give you a clue about what needs to be done to repair the door, hinges, and door opening in the body.

Door sagging results when the rear of the door is lower than the front. This is a common problem that is often due to badly worn hinge pins. Without periodic lubrication the hinge pins can wear producing play in the hinges.

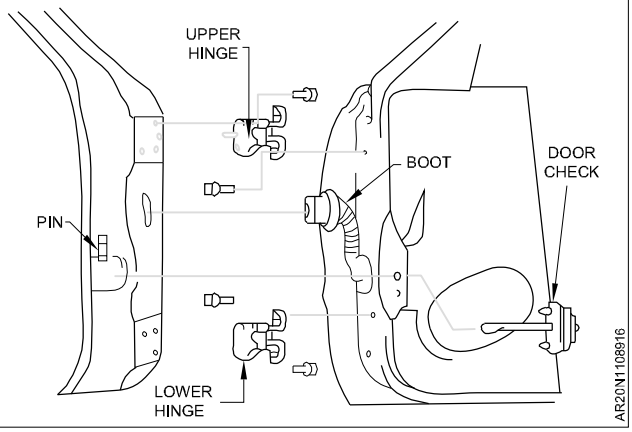
A **door hinge check** involves trying to move the door assembly up and down on its hinges. Worn door hinges should be replaced before reinstalling the door assembly.

A door operational check involves slowly opening and closing the door to check its latch, lock, hinge action, and other parameters (rattles from loose parts, squeaks from unlubricated parts, or blinding from misaligned panels). Roll the windows up and down to check for blinding or other troubles. With power windows, turn the ignition key on and activate all power window buttons. If a power window is inoperative, you want to find out now so it can be repaired while the door is apart.

Door removal: (Fig 6) Door removal is necessary for replacement or repairs. To remove the doors, must be remove the two hinge bolts or drive out the welded hinge pins. Disconnect wiring going into the door frame and other wiring requires complete door disassembly. Before removing the last bolt of the hinges ask a supporter to help hold the door and keep it from falling of your hand. Remove and move the door to a work bench place the door outer panel down on the work surface and prevent scratches in the door paint finish.

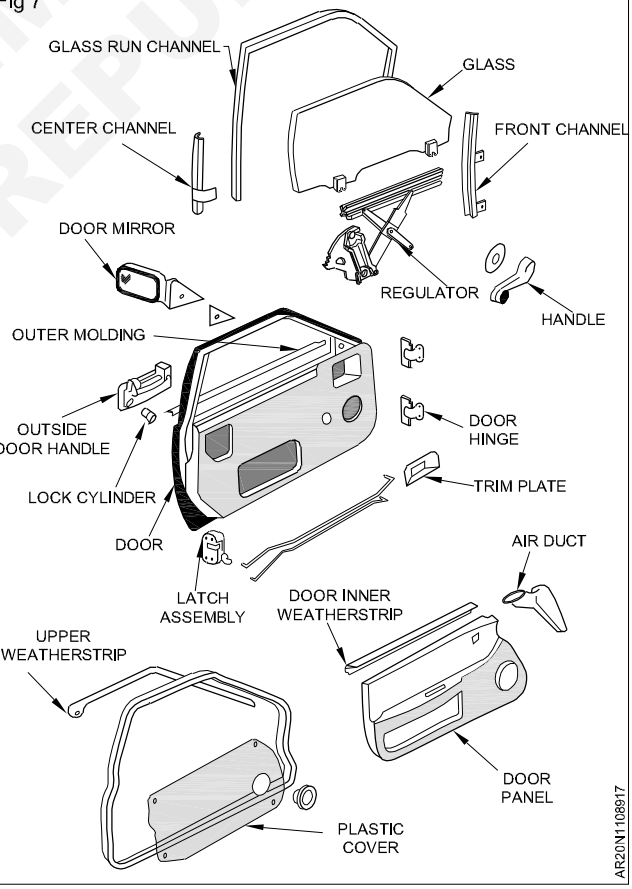
Door weather strip service: Inspect the removed door rubber weather strip for deterioration (damage). If you find damaged weather strip, remove and replace the door weather strip to prevent air and water leakage in the passenger compartment.

Fig 6



Door inner trim panel: (Fig 7) To work on parts inside the door, remove the inner door trim panel and related components. Remove the small decorative plugs over some of screws, remove the door handle and window handle. With all screws out of the door inner trim panel, have to pop out a plastic clips. Use a forked trim tool designed to remove the clips in the trim parts. Slide it between the door and panel. Then pry out the plastic clips without damaging the panel. Lift off the door inner trim panel disconnect any wires going to the panel. Remove the window regulator.

Fig 7



When replacing a door inner trim panel, check all the plastic clips are fully in the panel. They can slide out of the position and not align with the holes in the door. Read here the plastic cover back into place. Then feed wire through panel. Fit the panel over the top lip on the door

and down into position. Fit the clips and install the other parts in reverse order of removal.

Door window regulator service: The door window regulator is a mechanism for raising and lowering the door glass. It consists of a set of gears, a window crank or electric motor, and sash channels. The sash channel guides the glass as it slides up and down.

A manual window regulator operated by hand crank to turn the gears in the regulator. A power window regulator uses a small electric DC motor to spin the regulator gears. Small nuts and bolts secure the window regulator and glass guides or tracks in position. Usually the glass bolts to the upper arms of the regulator. Rivets can also be used to secure the glass to its regular.

To remove the glass unbolt it from the regulator then remove the prevent parts from sliding the glass out of the door. If the window glass was broken use the vacuum cleaner to remove all the broken glass from inside the door. Install the new glass and bolt it to the regulator. Make sure all rubber, plastic and metal washers and nut bolts and wire connection are properly fitted.

Door lock and latch service: A door lock assembly usually consists of the outside door handle, linkage rods, the door lock mechanism, and the door latch.

Door handles can be replaced by raising the window and removing the interior trim, panel, and water shield to gain access to the inside of the door. Exterior door handles are often held on with screws or bolts. A short screw driver or small, ¼ inch drive socket is often needed to remove an outside door handle.

Some causes of exterior door handle problems are:

- Work bushings
- Bent or incorrectly adjusted locks cylinder rods
- No lubrication on handle, linkage, or latch
- Worn or damaged latches

Inside door lock mechanisms are generally the pull handle type. The mechanisms are connected to the lock by one or more lock cylinder rods. Clips or bushings are used to secure the rods in place.

The door lock mechanism usually mounts through a hole in the door. A spring clip often fits over the inside of the lock to hold it in place. An arm on the lock transfer motion through a rod to the door latch.

To remove the lock, place a drop light inside the door. While looking through one of the large openings in the inside of the door, pop off the small clip holding to lock rod. Then, pry the clip off the lock. You can use a screw driver or needle nose pliers depending on the amount space around the lock. Slide the lock and washer off the outside of the door.

Electric door locks often use electric solenoids to move the linkage to the door locks. When you turn the key or press a door lock button, current flows to the solenoids in the doors. The solenoids convert the electrical energy into motion. The solenoid motion moves the lock linkages and latches. This locks or unlocks the doors.

Door reinforcements: All the doors of unibody vehicles have inner metal reinforcements at various locations. There are some other door frame reinforcements, such as at the hinge locations and the door lock plate.

Door intrusion beams are normally used inside side doors. A door intrusion beam is welded or bolted to the metal support brackets on the door frame to increase door strength.

Panel adhesive technology: Some vehicle manufacturers use structural adhesive to install door skins and other panels. These two- part epoxy adhesives are sometimes called weld - bond adhesives because spot welds can be placed through the adhesive.

Weld - bond adhesive are used to add strength and rigidity to the vehicle body. They also improve corrosion protection in weld seams. Adhesives also help control noise and vibrations.

If adhesive are disturbed by repairs, they must be replaced. Follow recommendations in the body repair manual.

Check the body repair manual for information on the use of structural adhesives.

Replacing bonded door skins: A bonded door skin is held to its frame with a structural adhesive.

To begin removal of the damaged panel, mark the location of the old panel on the door frame. This will allow to install the new panel in the proper location on the frame.

To gain better access to the inside of the door, cut out the center area of the door skin panel. Use power shears, a cut- off wheel, or an air chisel. With the center section of the door panel cut out, inspect the door frame for damage. If the frame is damaged, should consider purchasing a new door assembly.

Use a heat gun to soften the adhesive that holds the door panel to the door frame. It will soften so that wedge a putty knife or chisel into the joint. Be careful not to damage the door frame when separating the door panel. Keep working around the flange with heat and tool until the entire panel is removed.

Clean off the remaining old adhesive with putty knife. A very thin layer of adhesive can remain on the frame so long as it is not thick enough to affect new panel installation.

A door skin adhesive mating surfaces must be clean (no grease, oil, undercoating, and so forth). Some products require to apply a primer to the surfaces before the adhesive. This will ensure a strong adhesive bond between the door skin, any remaining adhesive, and the door frame.

Apply a liberal amount of new adhesive in a continuous bead around the frame flange. Place the new panel down into place. Align the reference marks so that the new panel is positioned properly. Use clamping pliers and light pressure to secure the panel in place as the adhesive cures. Allow the adhesive to cure for the time suggested by the manufacturer before moving the door.

Replacing SMC door skins: Sheet molded compound (SMC) door skin panels are becoming popular. SMC is similar to fiberglass. Many doors are now made completely of SMC, except for steel door intrusion beams and steel lock and hinge reinforcements.

To replace and SMC door skin, proceed as follows.

1 Cut away the center of the skin. Air shears work well because you can easily control the cut - depth. If you use a saw, be careful not to hit or cut internal door parts.

2 To remove the remaining door skin, heat the bonded areas with a heat gun. Apply pressure with a pry bar or chisel to remove the rest of the material. Be careful not to damage the door flange.

3 Sand the door frame to remove all remaining adhesive. Clean the bonded areas of the replacement door skin with soap and water. Allow it to dry. Sand the bonding areas to expose the SMC fibers. Wipe dry with a clean cloth.

4 Apply a bead of two - part adhesive to the door frame flange.

5 Set the door skin on the door frame and lightly clamp it. Do not squeeze too tightly. You want to leave adhesive between the skin frame.

To complete the job, allow the adhesive to cure, paint the door, and then reassembly it and mount it on the vehicle.

Door and door glass adjustments: If there are undamaged panels next to the door, cover their painted edges with masking tape. This will help prevent them from being accidentally scratched and knocked if bumped by the door during installation.

Door installation procedure involves reversing the removal procedure. Have someone help hold the door on the floor jack. Raise the jack until the door hinges are the same height as their bolts hole in the body. Make sure holding the door level.

Slowly slide the door hinges against their bolt holes. Wiggle and shift the door. Align the hinges to their original positions. Snug the bolts down but do not tighten them yet.

Door frame adjustment is needed to ensure that then door will close easily and not rattle or leak water and dust. This section will describe various door adjustments needed to prevent air and water leakage into the passenger compartment.

Worn door hinges will have play that allows up and down movement of the rear of the door. If the hinge pins are worn out, replace the hinges. Some hinges use bushings around the hinge pins. When these bushings are worn out, replace them. This will retighten the pin in the hinges and also readjust the door to a certain extent.

If the hinges are to be removed, scribe a line around the hinge to mark its position on the body and door. This will simplify reinstallation and positioning of the new hinge. Loosen the fender at the rear bottom edge to reach the hinge bolts.

Serving welded door hinges: Obviously, service methods are different for welded hinges. The large pin must be driven in and out of a welded hinge to service the door assembly. The bolted hinge can be easily adjusted forward, rearward, up, and down. The use of shims behind the hinge also allows the hinge to be moved as desired.

A specially designed pry bar can be used to adjust a door. The end of the bar hooks over the striker bar and a U - shaped bracket engages the latch.

As mentioned, some vehicles use a welded on door hinge that has no adjustment provisions. A pin is provided to remove the door for servicing the hinges. The half of the hinge that is to be installed on the door is predrilled to permit a bolt - on installation with tapped cages plates and bolts. The half of the hinge on the hinge pillar must be rewarded on the pillar when it is replaced.

When removing the door hinge pins, use a special spring compressing tool. The spring must be seated properly in the tool before compressing it. Otherwise, the spring can slip and cause damage or personal injury. After the pin in each high is removed, the door can then be removed from the vehicle.

To replace the welded door side hinge, first scribe the outline of the hinge of the door. Center punch the spot welds and drill and 1/8 inch (3.2 mm) pilot hole completely through the welds. The weld is then drilled out with a larger bit (about ½ inch, or 12 mm), but only deep enough to penetrate the hinge base to release the hinge from the panel. Next, a chisel is driven between the hinge and the base to break it free from the panel.

The new part is installed on the door by drilling the recommended size holes into the attaching holes. The holes will allow for slight adjustment on the door assembly, because the bolts are often smaller than the holes.

To remove the body side hinge, scribe the hinge position. Then use a cutting torch to cut the tabs holding the hinge together. The door sill plate and carpet should be removed or covered with an asbestos sheet to protect them from the hot slag of the cutting operation.

Using a suitable tool, such as grip - type pliers, the welds holding the separated hinge tabs are twisted or rotated to break them. Once the tabs are removed, the pillar is ground smooth and prepared to receive the new part.

To install the new hinge strap, manufacturer measurements must be transferred to the new part. First, tack weld the hinges carefully in place and then hang the door to check its fit in the door opening and with surrounding panels.

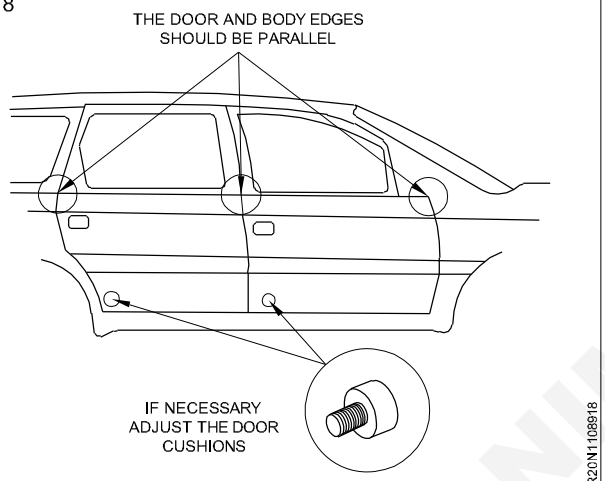
If it fits properly, the door is removed and the hinge is welded completely around the upper and lower hinge tabs. The area is cleaned properly and a paintable sealer is applied around the perimeter of the hinge. The area is then refinished to the proper color before the door is reinstalled.

Bolted door hinge adjustment: Doors must be accurately adjusted so that they close easily and do not rattle or leak. Basically, the door hinges must be adjusted to hold the door in the center of its opening when closed. The door striker must be adjusted to engage the latch smoothly.

Doors must fit their openings and align with the adjustment body panel (Fig 8). The rear door must be adjusted to fit these body lines and the opening. Once the rear door is adjusted, the front door can be adjusted to fit the rear door.

Next, the front fender can be adjusted to fit the door. On hardtop models, the windows can then be adjusted to fit the weather stripping.

Fig 8



The window adjustment starting from the front and working toward the back. The front is adjusted to fit the front door pillar and the front window is then adjusted to it. The rear door window is adjusted to the front window rear edge and opening for the rear - door assembly.

Door glass service: Various methods are used to attach the door glass to the window lifting.

- Bolt - through or rivet method
- Adhesive or bonding method
- Sash channel method

The framed door and hard top door types normally use one piece of door glass. The bolt through method utilizes bolts and nuts, that have plastic or rubber gaskets to prevent direct contact with the glass. Bolt are used to attach the lift channel or brackets to the glass. The bolts are inserted through the glass or clips bonded to the glass. The use of adhesive is another method of securing the lower lift bracket to the glass. The sash channel method of attaching glass to lift channels uses the sash channel. A rubber seal or tape is put on the lower edge of the glass. Then channel is positioned and tapped onto the glass by using a rubber mallet. Usually the edges of the channel can be squeezed slightly for and even tighter fit.

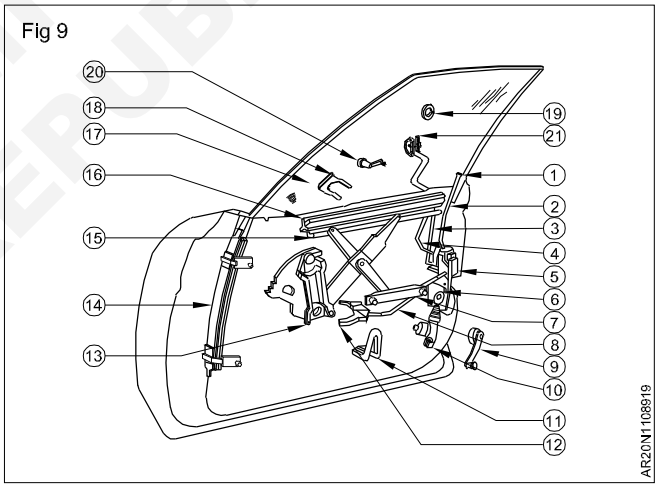
The method for removing and servicing door glass. Vary the door glass is secured in a channel with either bolts, rivets or adhesive. Some hard top doors require the removal of the upper window stops, lower lift brackets or belts, front or rear glass run channel, upper glass stabilizers and many other parts. If the glass is to be reinstalled store it in the safe place.

After the channel has been installed on the glass, the glass and channel assembly can be positioned into the door and secured with the necessary attaching hardware. Install the lower glass stop and adjust it if necessary. Finally reinstall al the hardware and trim panels.

Door glass adjustment: A soft, rubber, weather strip gasket is used in the door opening to protect the glass when it is fully raised or closed. The window glass is adjusted by loosening nuts or bolts that hold the channels and brackets have slotted holes to control forward and rearward and high window raises adjustment. These adjustments are controlled at the bracket that is attached to the door lower sash channel or where guide attaches to the inner door panel. If the channel are too tight, apply a dry silicone spray to free up the glass room.

The hard top glass does not make the proper contact, the glass will leak water and dust, if it is tilted to far in, the door will be hard to close and the gasket can be damaged. So replace the damaged channel gasket. (Fig 9)

Fig 9



1 Inside locking rod knob
2 Inside locking rod
3 Lock cylinder to lock connecting rod
4 Outside handle to lock connecting rod
5 Door lock
6 Inside locking and to electric actuator connecting rod
7 Inner panel cam
8 Inside remote handle to lock connecting rod
9 Manual window regulator handle
10 Power door lock actuator
11 Down - travel stop
12 Inside remote handle
13 Manual window regulator

14 Glass run channel retainer

15 Lower sash channel cam

16 Lower sash channel

17 Window glass

18 Lock cylinder retainer

19 Lock cylinder gasket

20 Lock cylinder assembly

21 Outside handle assembly

Door trim panel installation: After the door and its glass adjustment, install all the door trim pieces and other parts. Reposition and press the plastic dust and wind sheet into place on the door frame make sure all holes in the plastic align with their holes.

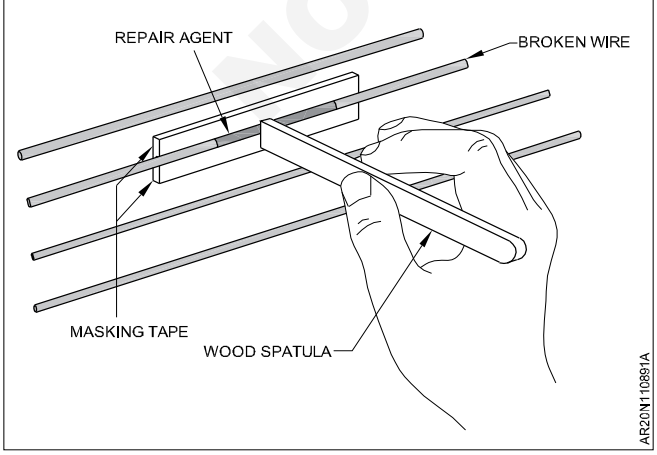
Connect wires to any lights or electric controls on the inner trim panel. Make sure all clips are properly positioned on the back of the door trim panel align these clips with the holes in the door frame ensure the clips are into the door to secure the trim panel. Install the all screws in the panel and other parts when servicing a door for a keyless entry system, all wiring harness connectors must be disconnected and reconnected carefully.

Tail gate glass service: Tailgate glass is generally secure to a regulator with screws or bolts. Removed or replacement of tailgate glass is similar to procedures presented for door glass refer the factory service manual for details.

Station wagon tailgate adjustments: The station wagons have a three - way tailgate that swings open like a door or drops down like a truck tailgate. Compact wagons are the exception. They often have a hatch back style rear gate. The three- way tailgate has a unique hinge and locking arrangement. The three-way tailgate can be operated as a tailgate with the glass fully down or as a door with the glass up or down.

Glass element repair: (Fig 10) Some heating elements built onto rear glass can be repaired when damaged. A special electrically conductive adhesive is used to bridge the gap in any breaks in the heating element. Re attach the broken antenna and heating element wires by soldering.

Fig 10



Rear view mirror service: Both outside and inside rearview mirrors can be damaged in collisions. Inside rearview mirrors normally attach to the windshield glass using a quick bond adhesive. Outside rearview mirror housings normally bolt to the door frame.

To service an inside rearview mirror, use a sharp putty knife to remove the old mirror mount. Apply heat to the mirror wedge. While it is warm, twist it back and forth with pliers. Use a single edge razor blade to scrape the area clean on the inside of the windshield. Spray clear primer where the mirror is going to be mounted. Then place a few drops of clear adhesive on the windshield glass and the mounting surface for the mirror. Press and hold the mounting pad or mirror onto the glass without moving it. Hold the mirror or metal pad tight for about a minute. This will secure the mirror or its mounting pad. Sometimes a small Allen wrench is needed to tighten a small screw that holds the mirror to its mounting pad.

If the outside rear mirror housing is damaged, the whole assembly is normally replaced. After removing the door inner trim panel, you can remove the two or three nuts that secure the outer rearview mirror to the door. Make sure you position the rubber gasket properly between the mirror housing and the door skin.

Quite often, only the rearview mirror glass is broken. You can purchase and install the mirror glass.

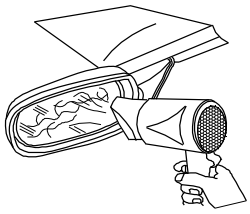
Sometimes the rearview mirror glass is held on with clips, but usually it is adhesive- bonded in place. As shown in Fig 11, use a heat gun to soften the adhesive on the broken mirror. Twist the mounting pad 30 degrees each way until it releases from the glass. Then use a putty knife or similar tool to pry off the old mirror. If the mirror has a heating element, it can be reused if still in working condition. Apply recommended adhesive to the back of the mirror and tape it in place. Allow the adhesive to cure for rest amount of time before tape removal.

Roof panel services: Roof service includes repair and replacement of roof panels. Service retractable hard top roof mechanism is very complex and designed vary. So refer the manufacturers service information to properly a retractable hard top.

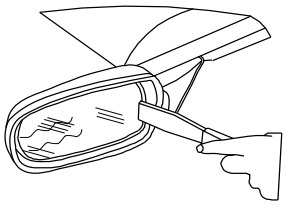
Fastened roof panel service: (Fig 12) Some roof panels are not welded with pillars. They are secured with fasteners and an adhesive. The replacement involves removing the head liner and fasteners. Then the adhesive must be pried loose to remove the old roof panel. The tip must be cleaned of old adhesive to prepare for installation of the new roof panel. Apply the head of adhesive to the matting surfaces. Then lower the new roof panel down into the adhesive. Tighten the roof panel fastener and wipe off any excess adhesive.

Convertible top service: The convertible top consists of a retractable metal form covered with canvas material. It is very complex convertible tops are often sent to upholstery service section.

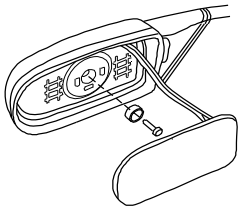
Fig 11



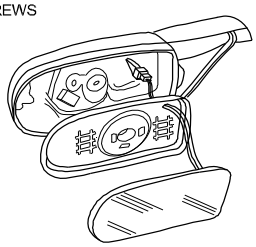
A) WARM THE GLASS WITH A HEAT GUN TO SOFTEN THE ADHESIVE



B) PRY OFF THE OLD GLASS WITH A PUTTY KNIFE



C) THE HEATING ELEMENT UNDER THE MIRROR IS NORMALLY HELD ON BY SMALL SCREWS



D) NEW MIRROR GLASS IS ADHESIVE-BONDED TO THE HOUSING

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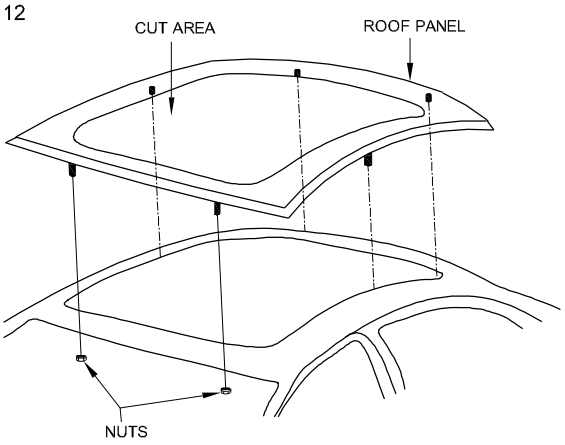
Fig 12



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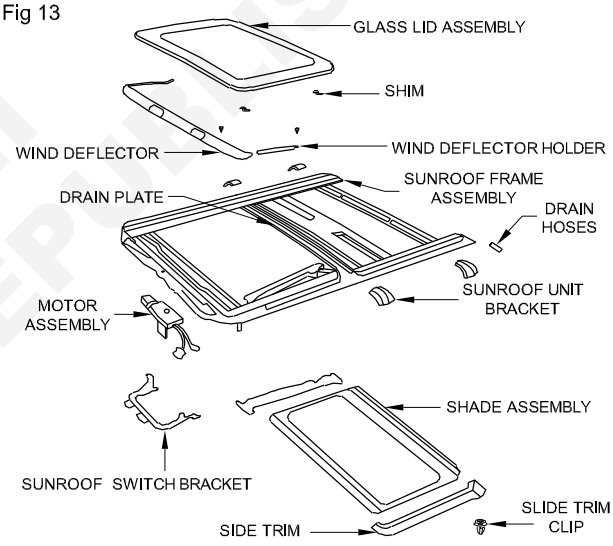
Sun roof service: A sun roof assembly typically consists of a large glass sheet, frame assembly and motor assembly for sliding the glass back into the rear of the panel roof. For replace the sun roof refer the service information for particular make and model of the vehicle. Service manual guide the repair or replacement of glass sheet. (Fig 13)

Fig 13



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Passenger compartment parts

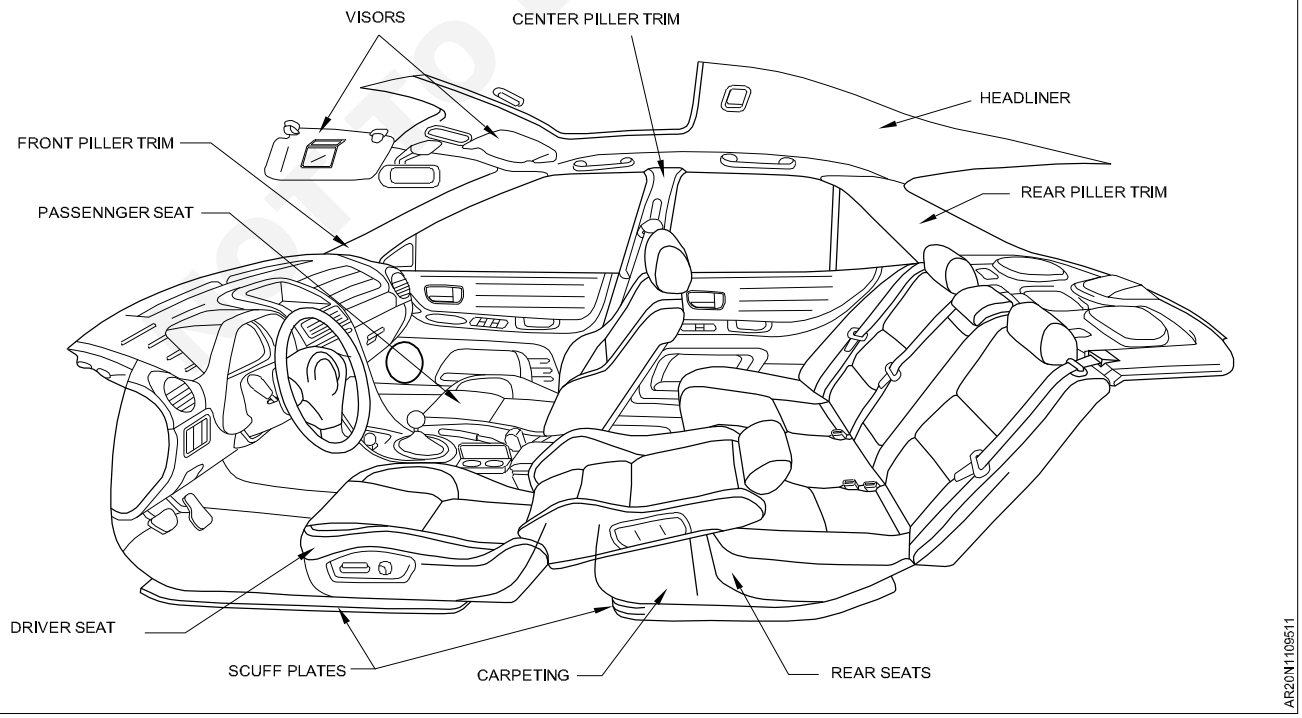
Objectives: At the end of this lesson you shall be able to
- **identify the major parts passenger compartment**
- **remove and replace passenger compartment trim pieces**
- **explain the parts of power and manual seat assemblies**
- **service front and rear seats**
- **remove and install a head liner**
- **state the methods of fastening interior parts**
- **find and rectify the air and water leakage.**

Passenger compartment service: During the major vehicle accident, the interior and exterior of passenger compartment often damaged and must be repaired. Passenger compartment damage results damage the wind shield, dash, seats and door trim can cause by deployment of the air bags and other damages, cracked plastic, bent seat frames. With side hits the door pillars and doors can be smashed into the passenger compartment and damaging removed and replace or repair the damaged parts.

Major parts of passenger compartment: The interior of passenger compartment is a multitude of new fastening method, power seats sound systems and navigation systems has added to the cost and complexity of repairing interior damage. The major parts of a passenger compartment is include as follows.

- The **dash assembly,** which includes the dash panel or cover, instrument cluster, heating and air- conditioning vents, stereo, and related parts.
- The **instrument cluster,** which fits in the dash assembly and normally contains the warning and indicator lights, gauge, and speedometer head.
- The **seat assemblies,** which include the seat tracks, seat cushion, headrests (seat motor transmission assembly. Heating elements, and so forth)
- **Interior trim,** which includes the upholstery as well as the plastic panels, covers, and moldings that fit over the pillars, headers, rockers, and other unattractive parts in the passenger compartment.
- The **steering column assembly,** which uses a long steel shaft to transfer steering wheel rotation to the steering gear assembly. The steering gear transfers this motion to the front wheels.
- The **headliner assembly,** which is a cloth or vinyl cover for the inside of the roof panel. It sometimes has grab handles, trim for interior lighting, and a sound deadening backing.
- **The carpeting,** which is a woven fabric cover, often with a sound deadening backer, that fits over the floor panels. (Fig 1)

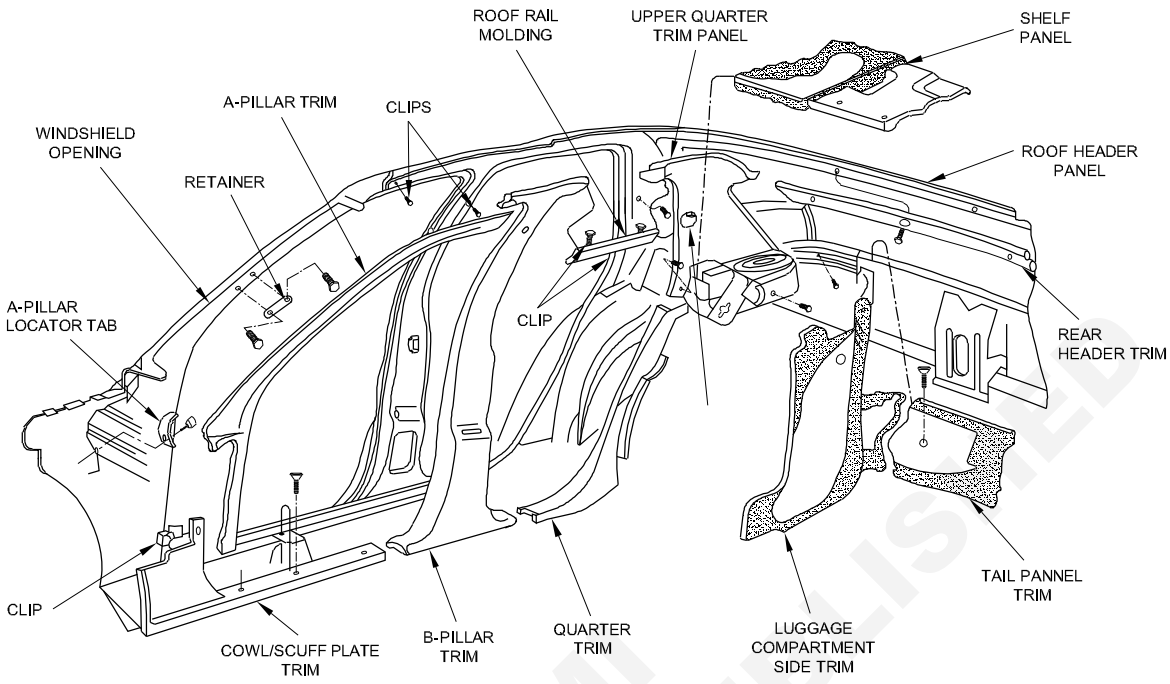
Fig 1



- **Weather stripping,** which surrounds the door openings to prevent air and water leakage around the doors.

Interior trim: Various of trim panel also called interior trim panel are used in the passenger compartment for appearance and safety. The major interior trim panels as follows (Fig 2).

Fig 2



- **Pillar trim panels,** which fit over the upper section of the A-, B-, C- pillars. The A- pillar trim fits next to the sides of the windshield. The B- pillar trim covers the center pillar on a four - door sedan. The C-pillar trim, also called quarter trim, covers the area on the sides of the back seat.
- The **dash panel,** which fits between the A-pillars, or windshield pillars, to hold the instrument cluster, air conditioning system vents, passenger side air bag, glove box door, stereo and other items.
- **Door trim panel,** which are padded trim pieces that fit over the door frames. They include provisions for arm rests, inner door handles, stereo speakers, and other parts.
- **Glass trim panels,** which fit over the edges of the windshield and back glass.
- **Sill plates,** or scuff plates, which cover the rocker panels and hold the edges of the carpeting.
- **Cloth-, vinyl-**, or leather - covered visors, which swing down to block the sun from the upper area of the window glass.

Interior trim service procedure: Servicing interior trim pieces is finding how they are fastened or held in the vehicle. Always refer to service information for the specific vehicle to disassembled. Follow these basic rules to servicing trim pieces.

- Make sure all metal screws are removed hidden areas before popping out plastic clips.
- Be careful not to break brittle plastic trim pieces. Do not use excessive force, which cound bend or even break the panel. Use a forked trim tool to reach behind trim pieces to pry out all plastic clips. Pulling force should be applied to or near the head of the clip. This will avoid trim panel breakage.
- Disconnect the battery before disconnecting any wires in the passenger compartment. This will prevent a possible short circuit that could quickly burn up wiring.
- Keep all fasteners organized in plastic bags or cans. This will help you keep track of their locations and speed reassembly.
- Use a logical sequence of trim panel removal. Usually one trim piece overlaps and helps hold an adjacent panel. Remove the top trim piece first.

Roll bars: The roll bar is steel frame work designed to protect people in a vehicle with convertible roof during a rollover accident. A fixed roll bar does not move. A retractable roll bar uses an automatic mechanism to raise the roll bar when electric sensors detect a rollover accident.

Always use a torque wrench to tighten roll bar mounting bolts to recommended specification. (Fig 3)

Seat service (Fig 4): Seats are damaged during a collision. A seat can be damaged by the inertia of it occupant by side impact intrusion into the passenger compartment. A bucket seat is a single seat for one person. A bench seat is a longer seat for several people. Both require similar servicing methods. Parts of the front seat.

Fig 3

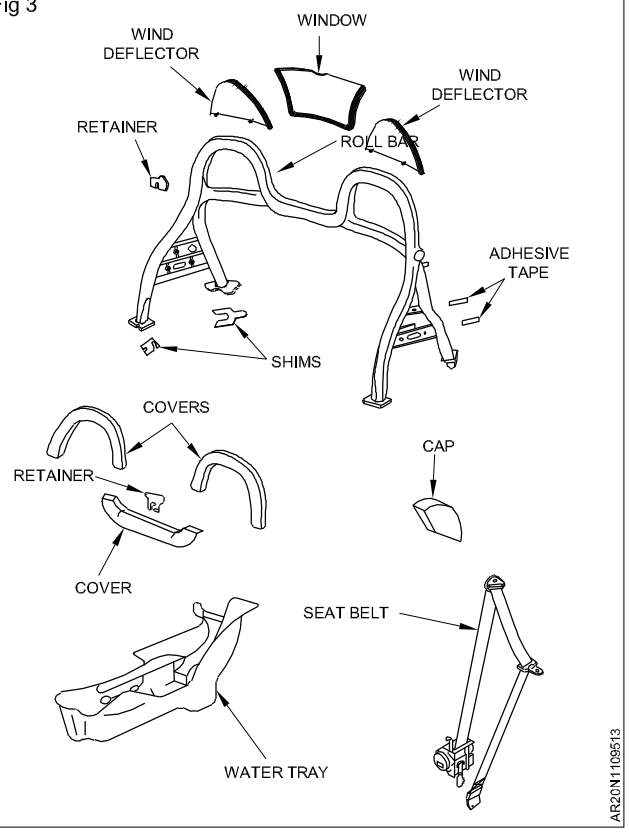
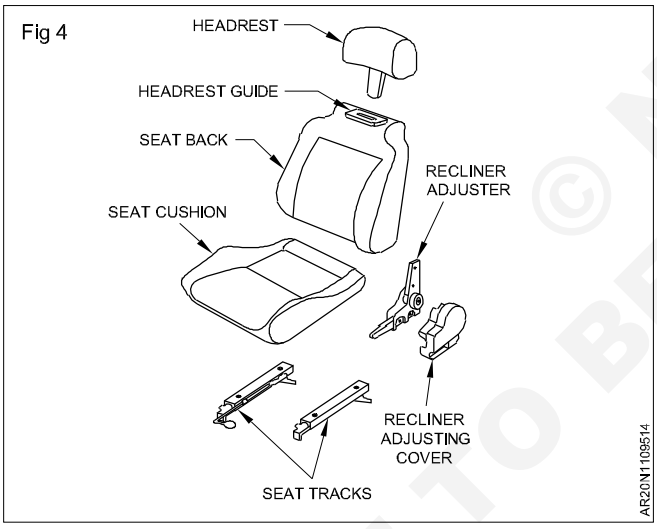


Fig 4



- **Seat cushion -** the bottom section of the seat, which includes the cover, padding, and frame.
- **Seat back -** the rear assembly, which includes a cover, padding, and metal frame.
- **Headrest -** a padded frame that fits into the top of the seat back.
- **Headrest guide -** a sleeve that accepts the headrest post and mounts in the seat back.
- **Recliner adjuster -** a hinge mechanism that allows adjustment of the seat back to different angles.
- **Seat track -** a mechanical slide mechanism that allows the seat to be adjusted forward or rearward.

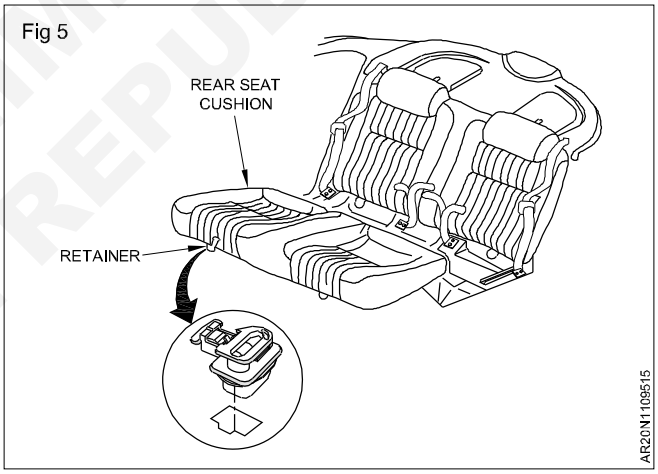
Front seat service: Seat anchor bolts are case harden cap screw that four bolts secure the seat track to the floor structure. To remove the front seat anchor bolts, slide the seat fully backward and access the front bolts. Slide the seat forward to remove the two rear anchor bolts. If you are repairing power or heated seats unplug the wiring connected with seat. Tilt the seat to gain access to the wire connectors. Carefully lift the seat out of the vehicle. Repair the damaged part of the seat with safely.

After repair install the front seats make sure all tools and items are cleaned. Lift and place the seat into the interior and position the seat reconnect the power seat wiring and anchor the seat mounting bolts by hand and then use a torque wrench to tighten the seat anchor bolts as specification.

Rear bench seat service: (Fig 5) A rear bench seat is often held in position by screws or spring loaded clips. The screws are normally at the front bottom of the seat cushion. When rear seat screws are removed the seat can pushed back and lifted up and out. After bring out the seat find the repair and rectify the damages in the seat.

After service install a seat with spring clips, place the seat into its position and push the seat down and back. This will engage most springs clip. If the seat is held by screws start then tightening.

Fig 5



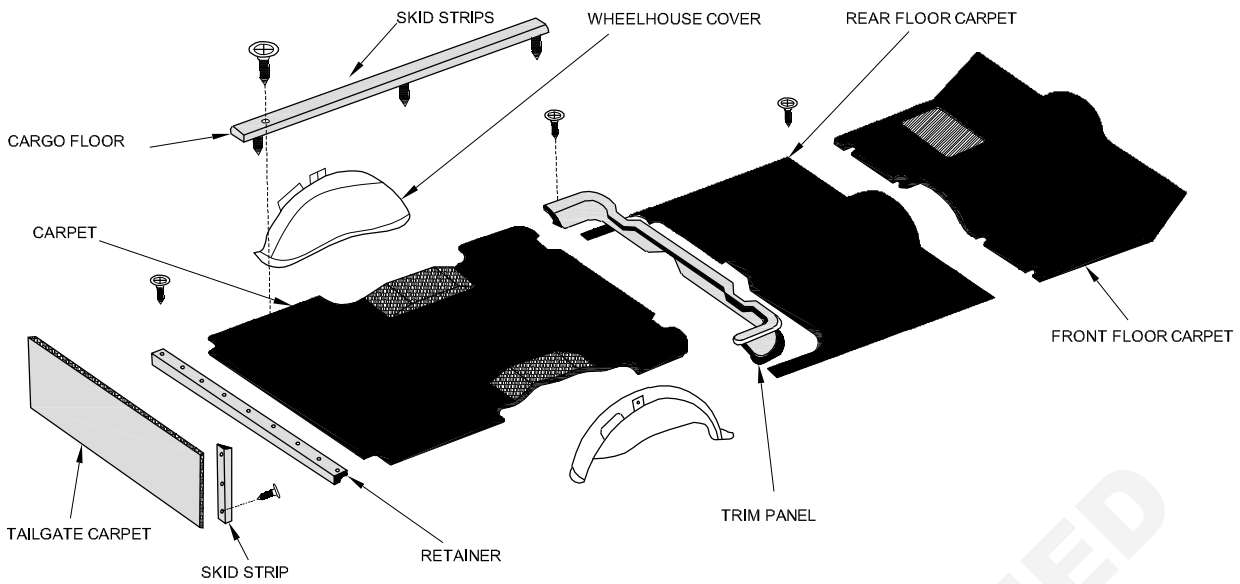
Seat cover service: The seat cover is a cloth, vinyl or leather cover over the seat assembly. The cover may be requiries replacement when it damaged. Disassemble the seat to replace the seat covers. Remove the covers and fix the new cover on the seat then be installed the reverse order of removal.

Note: Improper seat installation could endanger the vehicle is passengers.

Carpeting service: Carpet must often be removed during major structural repairs and blood strains and tears are a common reason for carpet replacement. The major components of interior carpeting. (Fig 6)

Most carpeting's are come two or three sections. The carpets are overlap under the front and rear seats. To replace the carpeting must remove seats, seat belt anchors, trim pieces, rocker covers and other parts mounted

Fig 6

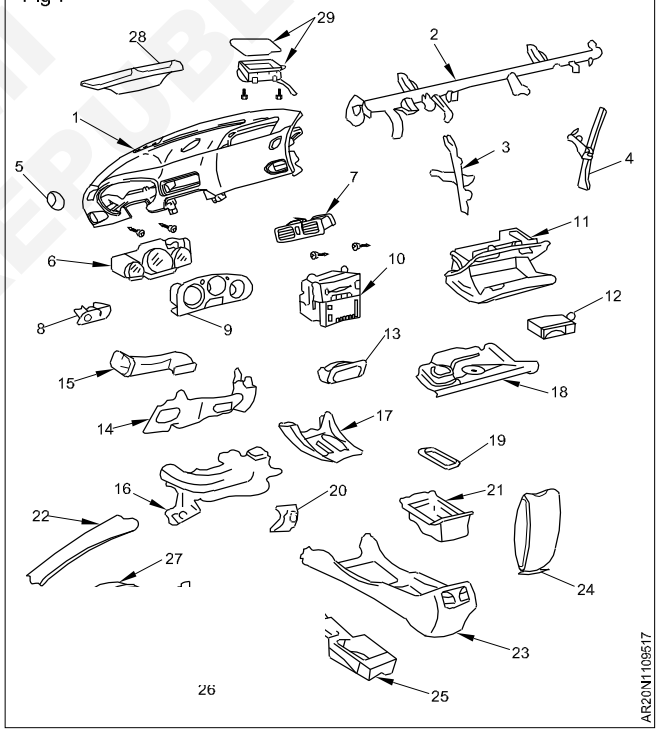


over the carpeting. After removal the new carpet is installed in the reverse order of its removal. Ensure the new carpet is properly seating and centered before installing any fasteners. Use adhesive between carpet and floor (if needed).

Dash panel service: The dash assembly includes the soft dash pad instrument cluster, radio, heater, AC controls, vents and other parts. It can damaged in a collision by air bag deployment and the impact when the dash board parts are damaged in a collision, that may be removed and replaced. If in doubt how to remove a dash assembly refer the vehicle specific service data. It will show the location and types of fasteners used to secure the dash board. You must use a specific sequence to remove dash parts. After removing the parts clean and inspect parts. If any parts are damaged or unserviceable replace the parts- then reinstall the parts in reverse as removing parts. Dash board parts are shown in Fig 7 & 8.

1 Dash panel
2 Reinforcement bar
3 No. 1 brace
4 No. 2 brace
5 No.1 side defroster nozzle
6 Instrument cluster
7 No. 2 register
8 No. 1 switch hole base
9 Cluster finish panel
10 Auto head
11 Glove box assembly
12 CD player
13 Ash tray
14 No. 1 safety pad
15 No. 7 heater duct
16 No. 1 undercover
17 Cluster finish panel
18 No. 2 undercover
19 Hole bezel
20 End pad
21 Lower rear console box
22 Front pillar garnish
23 Console box
24 Console arm rest
25 No. 1 Console box duct
26 Front door scuff plate
27 Steering column lower cover
28 Steering column upper cover
29 Lower defroster nozzle

Fig 7



Console service: Many sports vehicle uses a console between the bucket seats to house the gear shift mechanism, electrical controls, a console lid and compartment and other items. As with other trim panel, pop out plugs or covers over sudden fasteners. This will give access to the screws or bolts that secure the console. Fig 9 shows the parts of console.

Fig 8

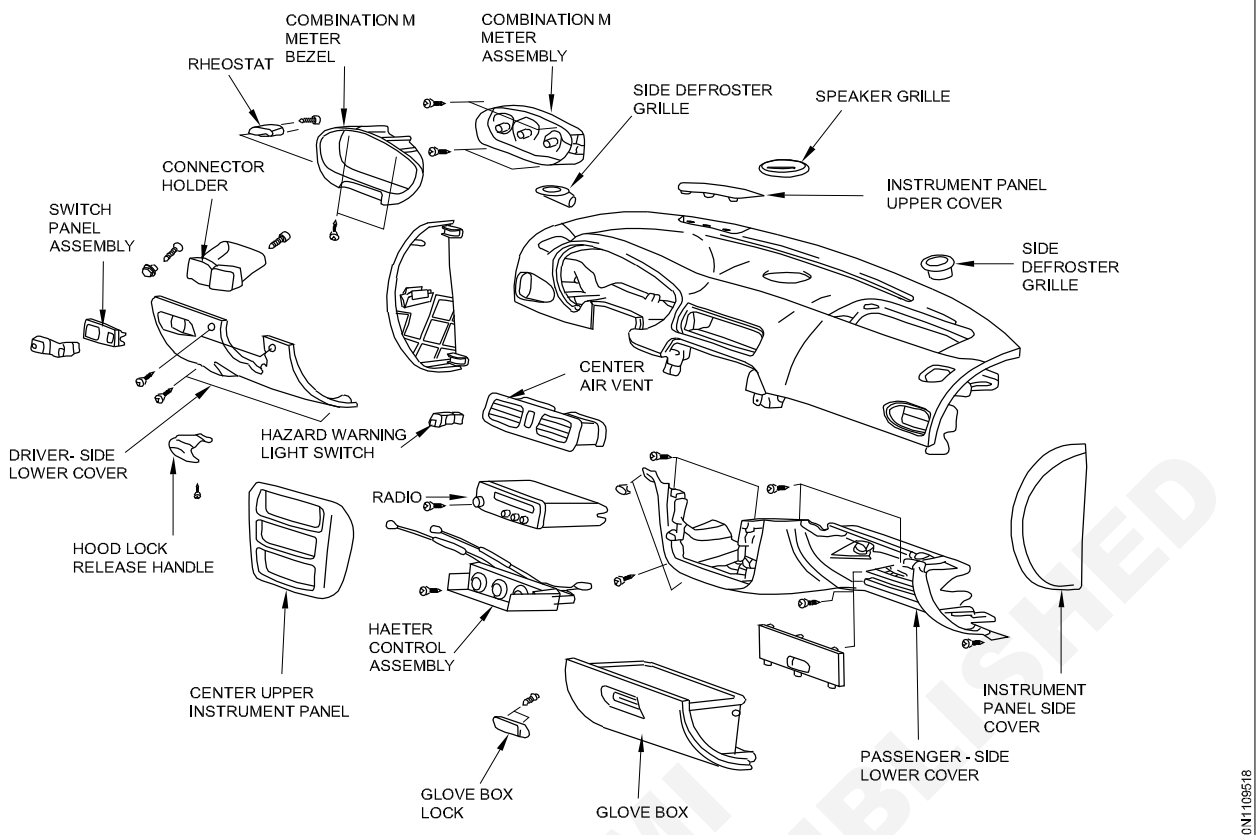
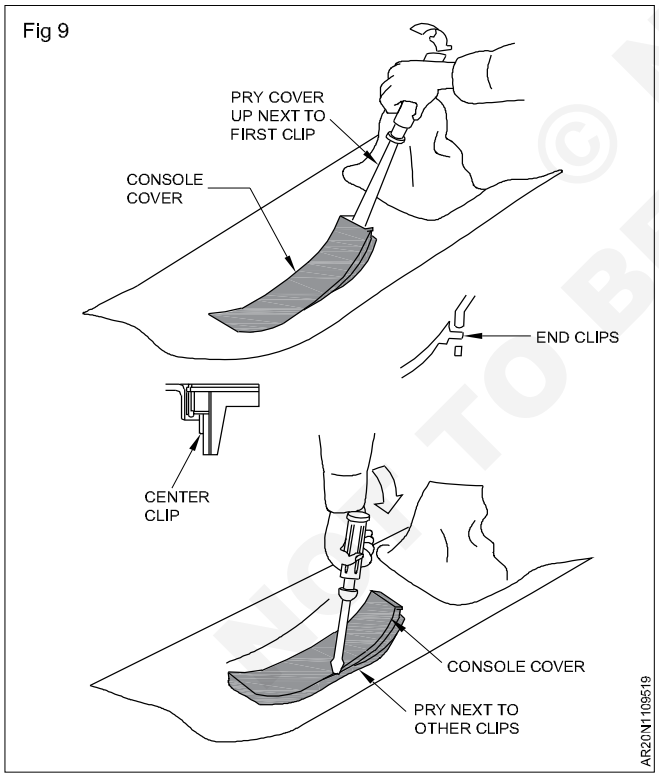


Fig 9a

Fig 9



Instrument cluster service: An instrument cluster contains the various gauge, meters, lights and similar parts. It may require service when it is damaged or parts are not working. To service an instrument cluster, first disconnect the battery. Remove the instrument panel cover. Remove the screws that hold the cluster to the dash, pull the cluster out far enough to disconnect the wires and speedo meter cable then you can lift the cluster. Replace the damaged/ defect parts.

Install the instrument cluster parts in reverse order of their removal. Connect all wires and speedo meter cable. Connect the battery cable and check the operation of all dark lights and gauge after installation.

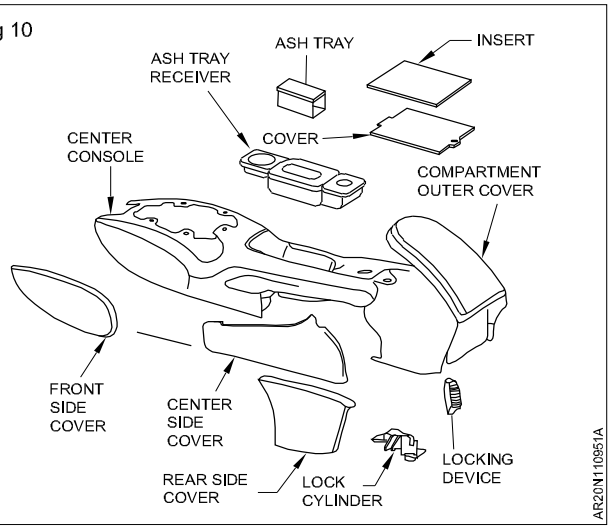
Head liner service: The head liner assembly is a cloth or vinyl collar of the roof in the passenger compartment. It can be torn or damaged during a collision. Some thick cloth or vinyl covered foam head liners are bonded directly to the roof panel. Others are thin vinyl suspended by metal rods and bonded around the edges of roof.

To service a headliner, first remove all of the trim pieces around the edges of the roof. Various screws and clips secure the trim pieces. You may also have to remove the sun visors, grab handles, and other parts for headliner service (Fig 10).

When installing a foam backed headliner, be careful not to over bend and kink it. Center it in position. Then install it in the reverse order of its removal. Again, refer to the vehicle specific service manual if in doubt.

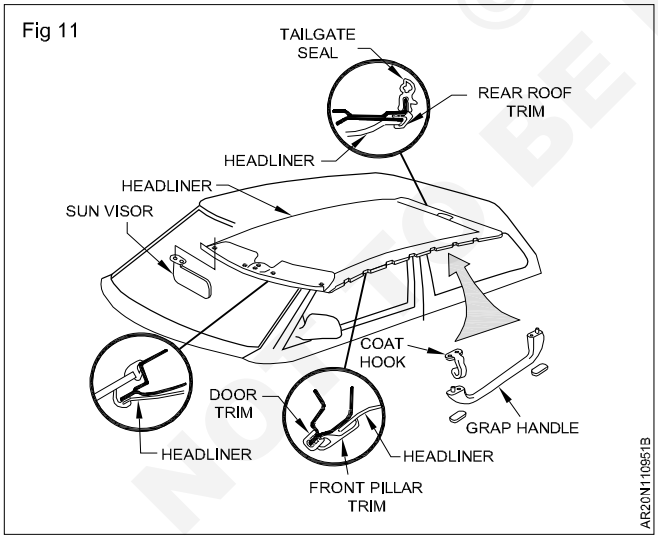
Locating air and water leaks: Water leaks are evident when moisture or rain enters the passenger compartment and collects on the carpeting. Air leaks normally cause a whistling or hissing noise in the passenger compartment while the car is being driven. Problems are often difficult to locate.

Fig 10



Checking drain hoses: The drain system routes any water that collects in the sun roof frame to the outside of the vehicle. If the drain hoses clogged with leaves and other debris. Water can leak into the passenger compartment. Air conditioning systems also have a drain hose to remove water condensation from the evaporator drains hose becomes clogged water will usually leak out onto the right floor carpeting. To clean this drain hose, raise the vehicle on a lift or on jack stand. The tip of the evaporator drain hose extends down the firewall, by pinching and opening the tip of the hose. Water leaks frequently occur at panel joints and glass to metal joints due to cracked or insufficient sealer. Dust and water leaks also occur at doors, windows, trunk lids and wind shields wherever the weather stripping becomes damaged or loose or window glass are improperly adjusted (Fig 11).

Fig 11



Wind noises: Wind noises are annoying, high - frequency swishing sounds heard when the vehicle is being driven. They are heard mainly around the door when the window is closed. This is generally due to loose, work, or improperly applied weather stripping or misaligned doors, which allows air to leak into the passenger compartment.

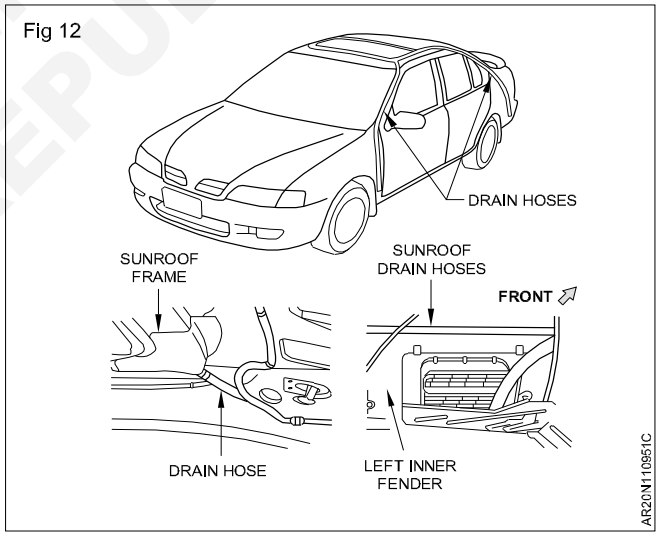
Wind noise is also produced when moving air hits a projection. This disturbance produces an eddy or swirl behind the object, thus creating a noise (the principle of flute and bugle sounds)

A loose body molding, a poorly aligned front fender, or an improperly adjusted hood are just a few causes of wind noise. If you suspect an air leaks around a rear hatch or door seal. If the door or hatch is moved in too much and is crushing the rubber seal to tightly.

Types of leak tests: The following methods are often used to locate air and water leaks (Fig 12)

- Spraying water on the vehicle
- Driving the vehicle over dusty terrain
- Directing a strong beam of light on the vehicle and checking for light leakage between the panels
- Using soapy water and an air nozzle
- Using a listening device

Fig 12

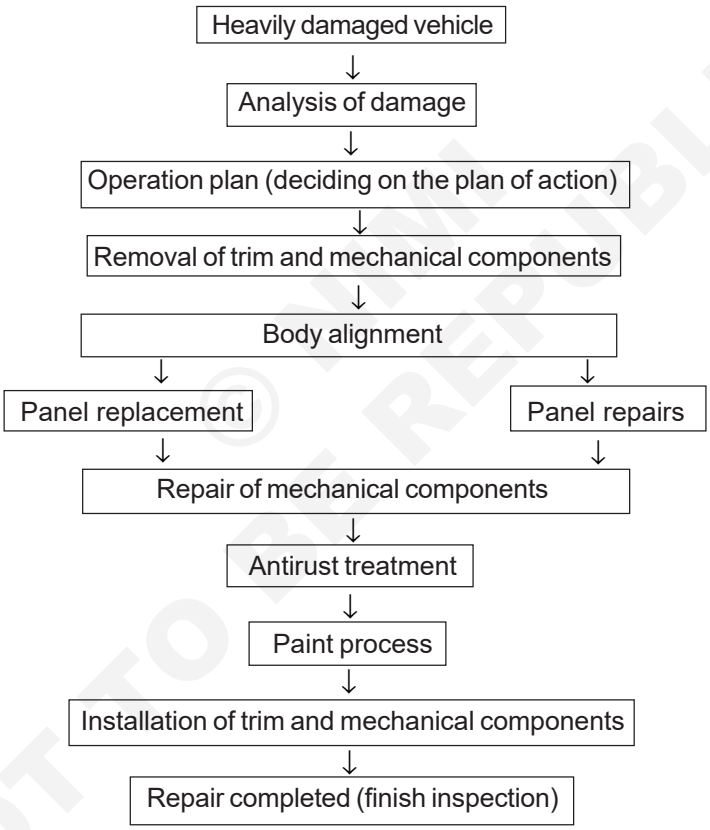


Diagnosing structural collision damage and measuring system

Objectives: At the end of this lesson you shall be able to
- **state the collision diagnostic procedure and repair process**
- **identify the condition of collision**
- **visually determine the extent of impact damage**
- **list out the various types of body measuring tools**
- **identify the vehicle impact and its effects on a vehicle.**

Vehicle body/ frame damage measurement: Vehicle body measurements involves using specialized tools and equipment to measure the location of reference points on a vehicle. These measurements are compared with undamaged vehicle. After studying damage measurements, frame straightening equipment is used to pull the frame / body back into alignment. To repair any vehicle properly diagnose the collision damage when the total damage has been determined, a repair plan can be made accident damage should be assessed carefully by measurements with the proper tools and equipments.

Vehicle collision repair process: The following is basic collision repair process



Diagnose procedure for collision damage: The following is a basic, recommended diagnostic procedure.

1 Know the vehicle construction type

2 Visually locate the point of impact

3 Visually determine the direction and force of the impact; once determined, check for possible damage.

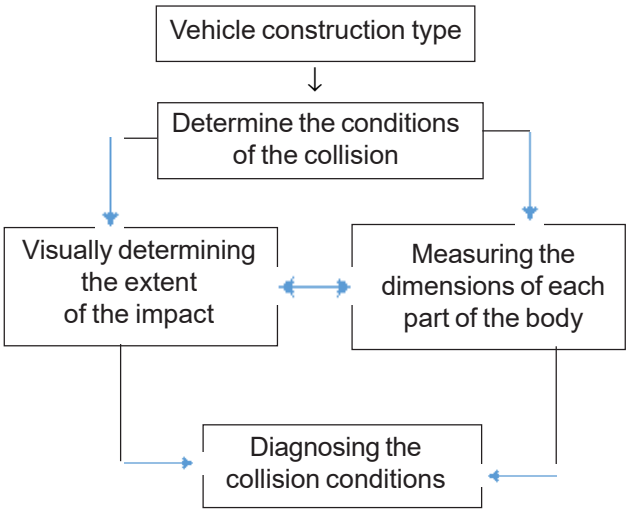
4 Determine whether the damage is confined to the body of whether it involves functional parts (wheels, suspension, engine, and so on)

5 Systematically inspect damage to the components along the path of the impact. Find the point where there is no longer any evidence of damage. For example, pillar damage can be determined by checking the door fitting conditions.

6 Measure the major components, check body dimensions (known correct body measurements of an undamaged vehicle) by comparing the actual measurements with the values in the repair manual or body dimensions chart.

7 Check for suspension and overall body damage with the proper equipment.

Vehicle damage conditions are diagnosed from the following procedure given in table



Impact and its effects on a vehicle: The body of a vehicle is designed to withstand the shocks of normal driving and to provide safety for the occupants in the event of a collision. Special consideration is given to designing the body so that it will collapse and absorb the maximum amount of energy in a severe collision, while still protecting its occupants. For this purpose, the front body and rear body are to some extent made to deform easily, forming a structure that absorbs impact energy.

During a head - on collision with a barrier at 48 kilometers per hour (km/h), the engine compartment compacts by about 30 to 40 percent of its length. However, the passenger compartment is compacted only 1 to 2 percent of its length.

When diagnosing collision damage, you must compare known good measurements with the actual measurements on the vehicle being repaired. With minor damage, this might be as simple as a visual inspection. With major damage, this will involve using complex measuring equipment.

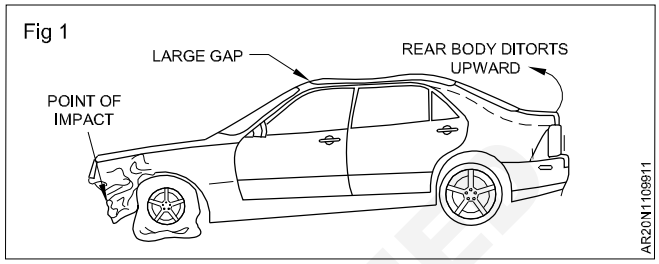
Determining the conditions of the collision: The extent of the damage differs depending on the conditions at the time of the accident. To put it another way, the damage can be partly determined by understanding how the collision occurred. To understand the circumstances of the collision, it would be necessary to contact persons directly involved or eyewitnesses. However, it is possible for the person responsible for making the estimate to get a direct response for making the estimate to get a direct response from the customer. This method of damage assessment is sometimes necessary in order to estimate the cost of the repair. Therefore, the body technician analyze the methods of repair needed.

The body technician should know the following items:

- The size, shape, position, and speed of the vehicles involved in the collision
- Speed of the vehicle at the time of the collision
- Angle and direction of the vehicle at the time of the impact.
- The number of passengers and their positions at the time of the impact.

A frontal collision where the point of impact is high on the vehicle could cause the cowl and roof to move rearward and the rear of the vehicle to move downward. Or, if the point of impact is low at the front, the inertia of the body mass could cause the rear of the vehicle to distort upward, forcing the roof forward. This would leave an excessively large opening between the front upper part of the door and the roofline. (Fig 1)

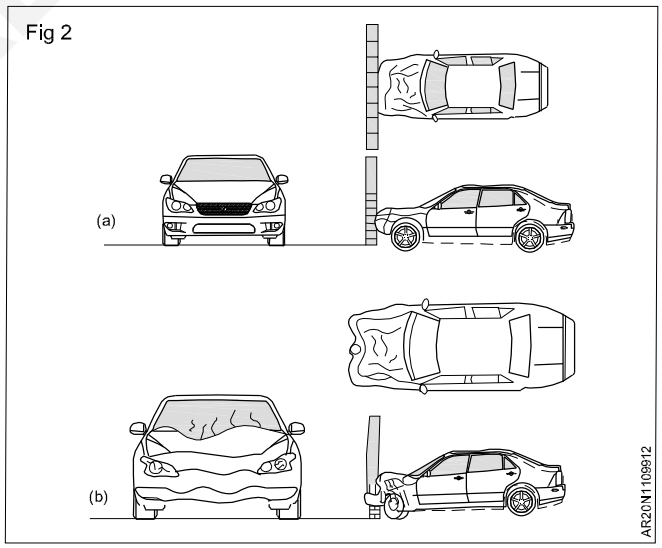
Fig 1



Even with vehicles of similar weights traveling at about the same speed, vehicle damage will vary significantly depending on what is struck, for example, a telephone pole or a wall. If the impact is spread over a larger area, such as a wall, the damage will be spread over a wide body surface area (Fig 2A).

Conversely, the smaller the area of impact, such as a telephone pole, the greater the severity of the damage in a smaller area. In this example (Fig 2B), the bumper, hood, radiator, and so forth have been severely deformed. The engine has been pushed back and the effect of the collision has extended as far as the rear suspension.

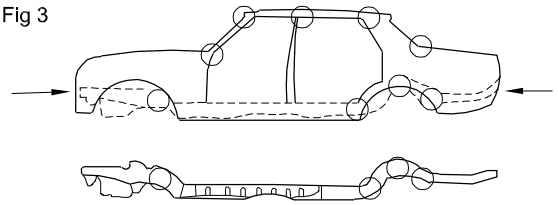
Fig 2



Influence of impact on a body- over - frame vehicle: Fig 3 illustrates a body with a perimeter frame with its built - in collapsible sections. The circled areas indicate the softer sections of the frame designed to absorb the major impact of a collision.

The body is attached to the frame by rubber mounts. The rubber body mounts reduce the effects of road shocks traveling from the frame to the body. This quiets the ride in the passenger compartment. In the event of a larger impact or collision, the bolts of the rubber mounts might bend, resulting in a gap between the frame and the body.

Fig 3



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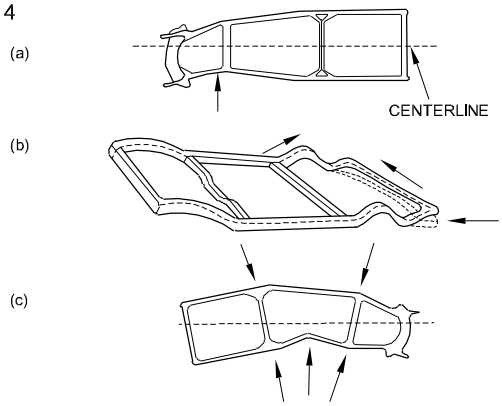
Frame deformation can be broken down into five categories:

1 **Side - sway damage (Fig 4abc):** Collision impacts that occur from the side often cause side- sway damage or a side- bending frame damage condition. Side- sway usually occurs in the front or rear of the vehicle. Generally, it is possible to spot side-sway by noting whether there are buckles on the inside of one rail and buckles on the outside of the opposite side rail.

Fig 4



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Side-sway can be recognized by abnormalities, such as a gap at the door on the long side and wrinkles on the short side. Look for impact damage obvious from the side, such as the hood and deck lid do not fit into the proper opening.

a side-sway at the front of the frame caused by a front-end collision

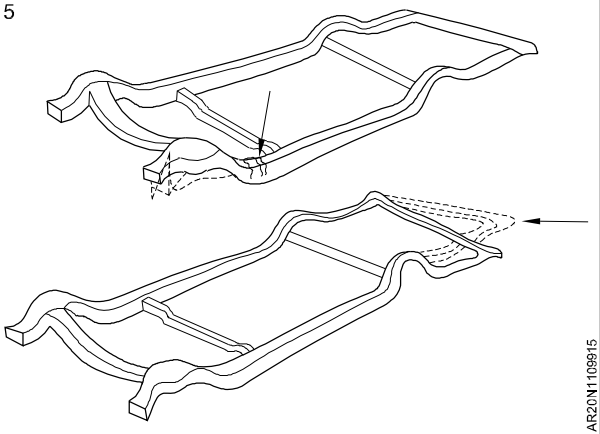
b rear side-sawy, and

c double sode-sway on the frame's outer section.

2 **Sag damage:** Sag damage is a condition in which one area often the cowl area, is lower than normal. The structure has a swayback appearance. Sag damage generally is caused by a direct impact from the front or from the rear. If can occur on one side of the vehicle or on both sides.

Sag can usually be detected visually by a gap between the fender and the door that is narrow at the top (Fig 5) and wide at the bottom. Also look for the door appearing to hang too low at the striker. Sag is the most common type of damage and occurs in most vehicles that are involved in an accident. Enough sag can be present in a frame to prevent body panel alignment even though wrinkles or kinks are not visible in the frame itself.

Fig 5



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3 **Mash damage:** Mash damage is present when any section or frame member of the car is shorter than factory specifications. Mash is usually limited to the areas forward of the cowl and rearward of the rear window. Doors might fit well and appear to be undisturbed. Wrinkles and severe distortion will be found in fenders, the hood, and possibly frame rails or horns. The frame will rise upward at the top of the wheel arch causing the spring housing to collapse. With mash damage, there is very little vertical displacement of the bumper. The damage results from direct front or rear collisions.

4 **Diamond damage:** Diamond damage is a condition where one side of the car has been moved to the rear or front causing the frame and/ or body to be out of square. The resulting shape is a figure similar to a parallelogram and is caused by a hard impact on a corner or off- center from the front or rear. Diamond damage affects the entire frame, not just the side rails. Visual indications are hood and trunk lid misalignment. Buckles can appear in the quarter panel near the rear wheel housing or at the roof to quarter panel joint. Wrinkles and buckles often will appear in the passenger compartment and/ or trunk floor. There is usually some mash and sag combined with the diamond.

5 **Twist damage:** Twist damage is a condition where one corner of the car is a higher than normal; the opposite corner might be lower than normal. Twist can happen when a car hits a curb or median strip at high speed. It is also common in rear corner impacts and rollovers.

Impact effect on unibody vehicles: The damage that occurs to a unibody car as the result of an impact can best to describe by using the cone concept. The unibody vehicle is designed to absorb a collision impact. When hit, the body folds and collapse as it absorbs energy. As the force penetrates the structure.

The centerline of the cone will point in the direction of impact. The depth and spread of the cone indicate the direction and area that the collision force traveled through the unibody. The tip of the cone is the primary damage area.

Unibodies are structured entirely from the joining of pieces of thin sheet metal, the shock of a collision is absorbed by a large portion of the body shell. The effects of the impact shock wave as it travels through the body structure are called secondary damage. This damage is toward the inner structure of the unibody or toward the opposite end or side of the vehicle. Front impact shocks are absorbed by the front body and crush zone. Rear shocks are absorbed by the rear body and crush zone side shocks will be absorbed by the rocker panel roof side frame, center pillar and door. Top impacts can result from falling objects roll over. This type of damage not only involves the roof panel but also the roof side rail quarter panels and possibly the windows.

When the vehicle has rolled over and the body pillars and roof panels have been bent, the opposite ends of the pillars will be damaged.

Collision damage sequence: The collision damage sequence on a unibody structure is as follows. (Fig 6)

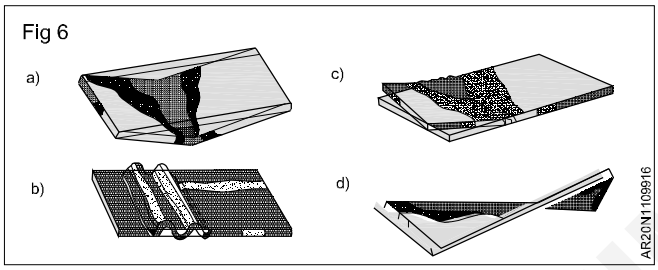


Fig 6 unibody collision damage: (A) bending, (B) crushing or collapsing, (C) Widening, and (D) twisting

1 **Bending:** In the first microseconds of impact, a shock wave attempts to shorten the structure, causing a lateral or vertical bending in the central structure. Most of the forces that broadcast impact shock to remote areas occur at this instant. Because the structure is stiff and springy, it tends to snap back to its original shape - at least momentarily. Bending is usually indicated by the height measurement being out of tolerance. This damage - similar to sag in a conventional structure - can occur on one side of the car and not the other.

2 **Crushing or collapsing:** As the collision event continues, visible crushing occurs at the point of impact. Impact energy is absorbed in the deforming structure (helping protect the passenger compartment). Remote areas may buckle, tear, or pull loose. Crush damage, which is similar to mash on body - over-frame (BOF) vehicles, is indicated by the length measurement being out of tolerance.

3 **Widening:** In a well designed unibody structure, impact forces reaching the passenger compartment cause the side structure to bow out away from the passengers (never in), distorting side rails and door openings. Widening is similar to side- sway damage in BOF vehicles and is indicated by the width measurement being out of tolerance.

4 **Twisting:** Even if the initial impact is dead center, the secondary impact can introduce torsional loads that cause a general twisting of the structure. Unibody structural twisting, like twisting of a conventional vehicle frame, is usually the last part of the collision event. It is indicated by combinations of height and width measurements being out of tolerance.

Visually determining the extent of impact damage: Damaged parts show signs of structure deformations or fractures in most cases. When making a visual inspection, stand back from the vehicle to get an overall view. Estimate the size and direction of the impact (place where impact was received). Estimate how the impact was propagated and the damage sustained.

Also investigate whether there is any twisting, bending, or slanting of the vehicle overall. Look over the entire check the presence of strain, panel joint misalignment, cracks in and peeling of the paint film, cracked undercoat and sealer, and so on.

Damage can be detected easily by finding these types of symptoms:

- Areas where the cross sections of the components were suddenly deformed.
- Parts that are broken or missing
- Gaps in strengthening materials, such as reinforcements or patches.
- Part - to - part joints that are shifted
- Corners and edges of components that are misaligned

When surveying the extent of damage to the frame components, such as side members, it is easier to locate the damage on the concave side of the component. The concave side may appear as a sharp dent or kink rather than a minor bulge that appears on the opposite side of the member.

Inspecting for damage from passengers and luggage: Passengers and luggage can cause secondary damage to the vehicle as a result of inertial during a collision. The damage will vary depending on the position of the passengers and the severity of the impact. Parts with a high damage frequency are the instrument panel, steering wheel, steering column, and seat backs. Luggage in the trunk has also been known to cause damage to the body quarter panels.

Measurement of body dimensions: Measuring is critical to the success of any major collision repair job regardless of the type of body structure. But with unibody vehicles, measurements are vital to successful repair because the steering and suspension are mounted to the body structure. In addition, some of the suspension geometry is built into the body structure. As a result, the angles of wheel alignment (caster and camber) often have a fixed (nonadjustable) value. Body damage often seriously affects suspension geometry. The rack-and-pinion control box for the steering assembly is also mounted to a panel, resulting in a fixed relationship to the steering arms. The mechanical components, engine, transmission, and differential are all mounted directly to body members or to cradles supported by the body members (panels or integral rails).

A distortion of any of these measuring points will change steering or suspension geometry or misalign mechanical components. This can result in improper steering and handling, vibration and noise in the drive train, and excessive wear of tie rod ends, tires, rack-and-pinion assemblies, universal joints, or other drive or steering components.

Body dimensions charts: Accurate damage assessment can be made at specific points on the body using a body dimensions chart. The body dimensions chart gives measures points and measurement specifications for a specific type of vehicles. Use the chart for the specific make and model vehicle repairing. The chart information enables to use measurement tools to compare the damaged vehicle to known good measurements.

Vehicle measuring basics: In unibody construction, each section should be checked for diagonal squareness by comparing diagonal lengths. Length and width should also be compared. The center section should be used as a base when reading structural alignment. All measurements and alignment readings should be taken relative to the center section.

Start measuring in the center, or middle, section. If it is not square, then move to the undamaged end of the vehicle to find three correctly positioned reference points.

If the vehicle is not symmetrical, refer to the dimensions chart for correct measurements.

Measurement importance: In the entire repair process, a vehicle cannot be satisfactorily repaired unless all of the major manufacturing control points in the damaged area are returned to the manufacturer's specifications. To achieve this, must be

- Measure accurately
- Measure often
- Recheck all measurements

Because of the importance of measuring, many kinds of equipment have been developed and marketed by auto motive equipment manufacturers strictly for the purpose of providing the capability to measure quickly and accurately. The measuring equipment can be divided into five basic systems.

1 Gauge measuring system

2 Universal measuring system

3 Dedicated fixture system

4 Universal / laser

5 Computer/ electronic

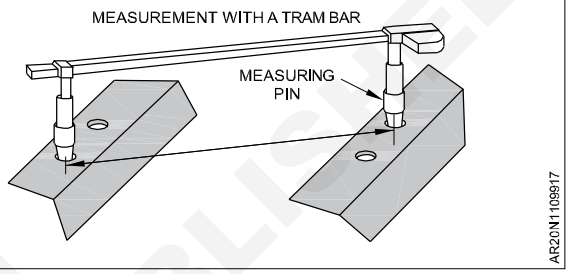
Gauge measuring system: The tram gauge, the centering gauge, and the MacPherson strut centerline gauge can be used separately. Tram gauges are scaled rods used for measurement, while centering gauges are metal rods used to check for misalignment. Supported by suspension system strut lower domes, centerline gauges allow visual alignment of the critical control points of unibody vehicles.

The tram centering and strut centerline gauges are available as a unit or as separate diagnostic tools.

Another gauge similar to the tram type is the tracking gauge. This gauge is used to check alignment of the front and rear wheels.

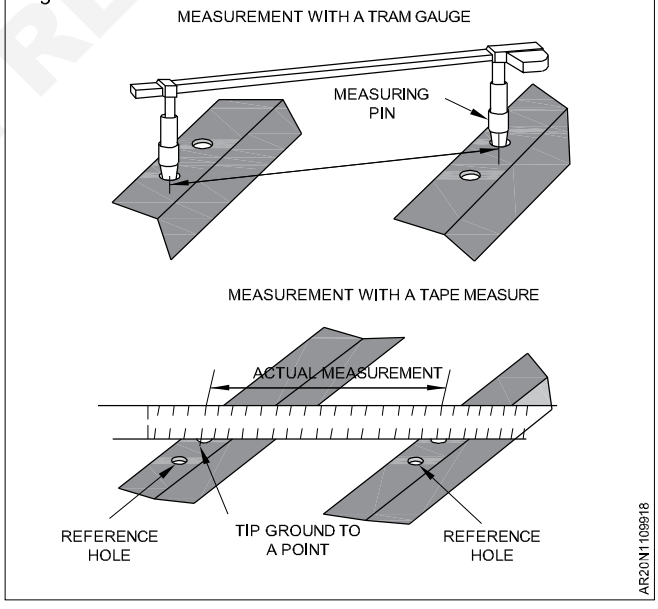
Tram gauges: (Fig 7) The tram gauge measures one dimension at a time. Each dimension must be recorded and must be cross checked from two additional control points- at-least one being a diagonal measurements. The best areas to select for tram gauge measurements are the attachment points for suspension and mechanical components because these are critical to alignment. Throughout the repair operation, critical control points must be measured repeatedly with the tram gauge in order to monitor progress and to prevent over pulling.

Fig 7



Upper body dimensioning: The upper body damage can also be determined with tracking trams and a steel measuring tape their use is basically same as they are used to do an under body evaluation (Fig 8).

Fig 8

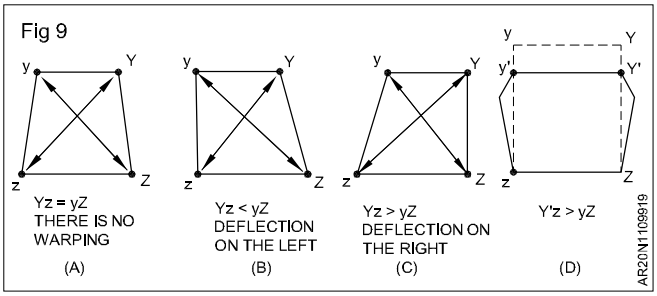


Measurement of the front body: In case of damage only the front right side or left side of the body received the impact, the left or right side will usually damage the opposite of side of impact damaged as well. Therefore the extent of deformation must be checked before premeasuring the damaged body. If any measurements are shorter or longer than specification, use frame straightening equipment to pull or push the body parts back into alignment. Backage use the tram gauge

measurements are the attachment points for suspension and mechanical components. Each dimension should be checked from two additional reference points with at least one reference point being a diagonal measurement. The longer the diamention, the more accurate the measurement. The use of two or more measurements from each reference points ensured greater accuracy.

Measurement of the body side panel: Any deformation of the side structure can be found by open and closing the door. It is important that accurate measurement be taken. The tracking tram gauge is primarily used to measure the body side panel. Compare the measurements on the undamaged side of the vehicle to the damaged side. Measure the diagonal line method. (Fig 9).

Fig 9



Measurement of the rear body: Any deformation of the rear body can be roughly estimated by appearance and irregularities evident, when the trunk lid is opened and closed. Cause of rear body damage can be water leakage and paint damage so measurements are needed to check for the probable cause.

Any wrinkle in the rear floor is usually due to buckling of the rear side member. Measure the rear body together with the underbody. In this way the straightening work can be performed effectively.

Make all measurements on the damaged vehicle at the points specified in the body manual. The amount of damage can usually be determined by subtracting the actual measurement from the specified measurements.

Digital tram gauges: A Digital tram gauge can slide to different lengths and will electronically measure its own length and show a numeric readout in inches or millimeters. Many can send a signal out to the measurement computer to help stream- line the damage measuring process.

Various type of digital tram gauges are used to measure the vehicle damage. Various rods and ends are provided with the tram gauge for measuring different points and location (Figs 10 & 11).

Centering gauges: The self centering gauges are closely related to the tram gauges, they do not measure, they show alignment or misalignment by projecting points on the vehicle structure into the auto body mechanic line of sight. They are installed at various control areas on the vehicle (Fig 12). The self centering gauges have two sliding horizontal bars that remain parallel as they move inward and outward. The action permits adjustment to any width for installation on various areas of the vehicle. After the gauges are hung on the vehicle horizontal bar will be parallel to the portion of the structure to which it is attached.

Fig 10

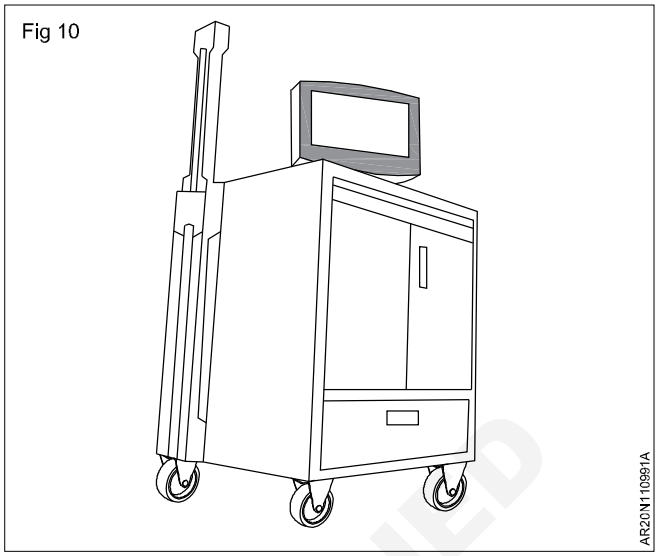


Fig 11

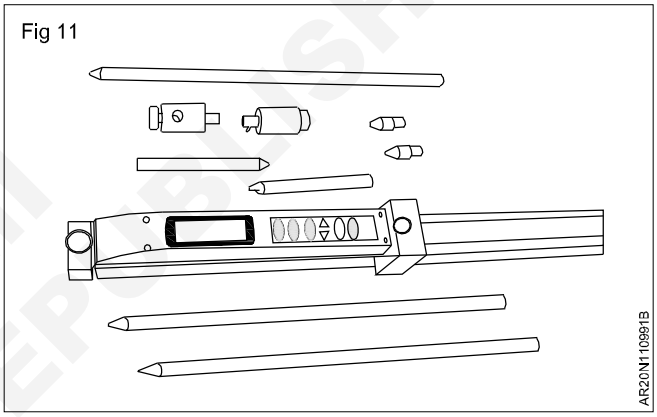
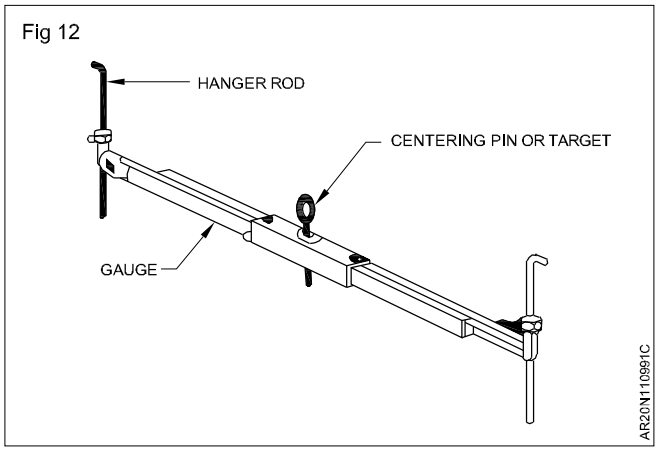


Fig 12



Keep the following points when reading and using centering gauges.

- Assuming that the centering gauges have been installed properly, correct alignment will be achieved when all the gauges are parallel and the centering pins line up in a row. This indicates that the frame or the body is level, not twisted or deformed.
- When sighting crossbars for parallel, always stand directly in the middle, scanning with both eyes. To ensure accuracy, readings should be made at the outer edge of the centering gauge, not in the middle.

- The farther one stands from the centering gauges while reading, the more accurate the reading will be. Standing close changes the line of sight to the front gauges so that an accurate reading is nearly impossible.
- Centering gauges should always be sent at the same height or plane. Different heights will change the angle of sight and give a false reading.
- It is sometimes beneficial to sight over one gauge and under another. Going to the end of the vehicle, opposite the damage, to make readings will sometimes result in a more accurate reading. This is true because you are able to read the base gauges before sighting into the damaged area. With practice and a certain amount of experimentation, you can improve the damage analysis.
- The sighting of centerline pins must be done with one eye. Since the center section is always the base for gauging, the line of sight must always project through the pins of the base gauges. Observing pins in other sections of the frame will then reveal how much they are out of alignment.
- Never attach the centering gauges to any movable parts, such as control arms or springs.

Self- centering alignment gauges are used to read three major elements of collision damage: datum, center, and zero planes. Critical measurements - the fourth major element of analysis - are handled with a tape measure and tram gauge.

Dimensional references: Two major dimensional references are indicated in all body dimension manuals: the datum plane and centerline.

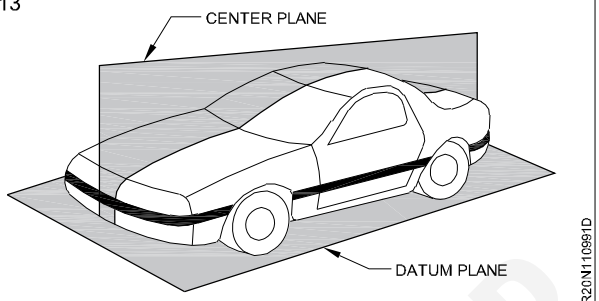
A datum line, or datum plane, is an imaginary flat surface parallel to the under body of the vehicle at some fixed distance from the underbody. It is the plane from which all vertical or height dimensions are taken by vehicle manufacturer. It is also the plane that is used to measure the vehicle during repair. The datum is normally shown on dimension charts from the vehicle's side view.

Using this line of reference, centering gauges can be strategically suspended under the vehicle from side to side at varying distances along the length of the chassis frame or uni body. First, place the base gauges at the main platform: one across the vehicle beneath the rear seat (rear torque box) and another under the cowl area (front torque box). Add two more gauges before and after the base gauges: one located at the front cross member and a second at the rear cross member. Additional gauging of the front cross member area and/ or strut tower completes the picture.

After hanging all four gauges read across the top to determine whether datum is correct. If all four gauges are level at top the vehicle is on datum. If they are not level, the vehicle is off datum. Although datum reading is obtains from centering gauges.

The center plane: The center plane or center line, divides the vehicle into two equal halves, the passenger side and the driver's side. Note how the center plane or line cuts up through the middle of the vehicle. The center plane of a vehicle allows for horizontal measurements. Whereas the datum plane allows for vertical measurements (Fig 13).

Fig 13



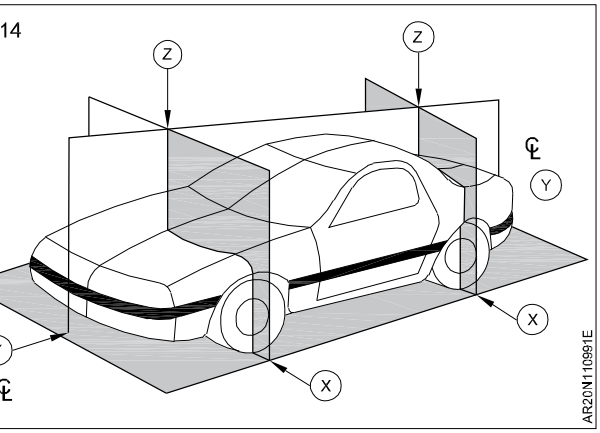
The measurement from the centerline to a specific point on the right side will be exactly the same as the measurement from the centerline to the same point on the lift side.

Zero planes: It is usually necessary to think of the vehicles as a rectangle divided into three zero plane sections. The three zero plane sections break the vehicle into three areas - front, center, and rear. The torque box location is used as the dividing line. This three - section principle is a result of the vehicle's design and the way it reacts during a collision.

The following figure shows the three vehicle planes are combined. This allows for three dimensional.

If the vehicle has a sway condition the centerline reading will be affected. Further inspection by gauging or measuring might be necessary to determine the presence or absence of these problems. Level in a zero plane means the condition in which all areas of the vehicle are parallel to on another. Level refers to parallel condition in vehicle structure only. (Fig 14)

Fig 14



Diagnosing damage: Measuring the vehicle damage by using tram gauge or digital tram gauges or self centering gauge measurements is necessary to determine the misalignment of vehicle met with an accident. After readout the damage measurement compare with vehicle specification manual data. Then find out which type of damage occurred on the vehicle types of damages.

- Twist damage
- Diamond damage
- Crushing damage
- Sideway damage

For measure the damage use the tram, self centering datum and frame gauges, start centerline gauge or universal measuring system, mechanical measuring system, or computer measuring system, computer sonic measuring system, robot arm measuring system, computerized leaser measuring system.

Although the basic methods for measuring vehicle damage are similar, the exact operating instructions for different brands of system vary. Most measuring equipment manufacturers have specific diamention charts for their equipment often displayed on a computer monitor.

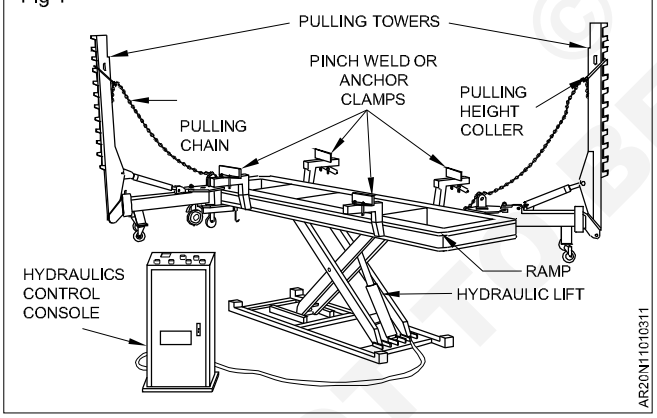
Unibody/Frame alignment

Objectives: At the end of this lesson you shall be able to
- **state the basic straightening and aligning techniques**
- **state the different types of unibody / frame straightening equipment**
- **state the unibody / frame realignment equipment**
- **state the need damaged parts of pull before their removal**
- **state the unibody / frame realignment safety**
- **state the purpose over pulling.**

Unibody / frame alignment: Vehicle with major damage must be their frame or unibody structure straightened. The frame aligning or pulling is rough and tough physical operation. If the frame or unibody is straightened exactly, panels will not fit and the wheels may not be alignable. Unibody or frame realignment involves using high powered hydraulic equipment and mechanical clamps, to bring the full frame or unibody structure back into its original shape. Accurate unibody / frame alignment positively affects safety, repair time, repair quality and the confidence to the customers.

Realignment basics: A frame machine, also called a frame rack or frame bench is a large framework with hydraulic equipment for pulling out major structural damage. Even though equipment designs and setups vary, frame straightening equipment use is similar from machine to machine (Fig 1)

Fig 1



Anchoring and pulling: Vehicle anchoring involves clamping the vehicle down so that it will not move during the straightening process.

The term pulling refers to using hydraulic realignment equipment to stretch the damaged metal back out to its original shape. The vehicle is secured and held stationary by the equipment. Then, clamps and chains are attached to the damaged area. When the hydraulic system is activated, the chains slowly pull out the damage.

Pulling direction: When realigning a vehicle, a pull force, or traction, should be applied in the opposite direction from the force of the impact. When determining the direction of a pull, basically set the equipment to pull perpendicular to damage.

The pulling and straightening process must remove both direct and indirect damage. Pulling must return all of the damaged metal back to pre-accident dimensions. To do this the equipment must reverse the direction and sequence in which the damage occurred.

Fig 2A shows frame structure is crushed straight back with no deflection. Fig 2B shows pulling or straightening involves holding the frame which chains to pull it straight back to reverse the direction of damage.

Fig 2

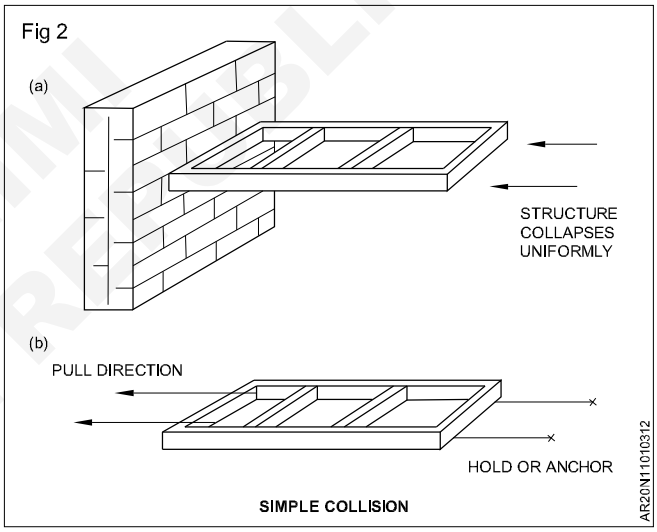
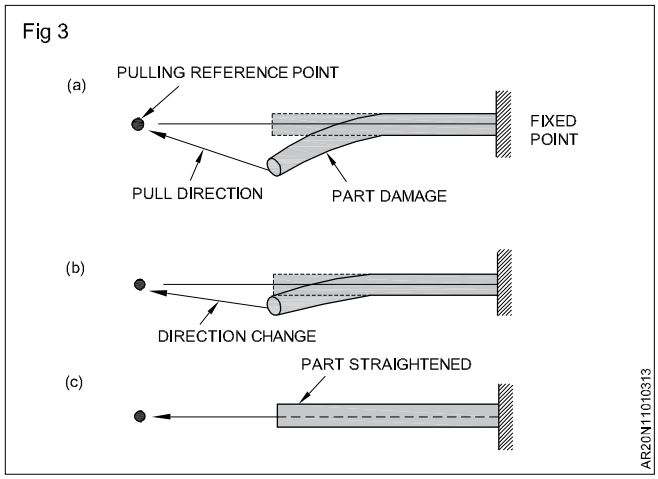


Fig 3 shows when force is applied the damage condition repaired and the bend is straightened.

Fig 3

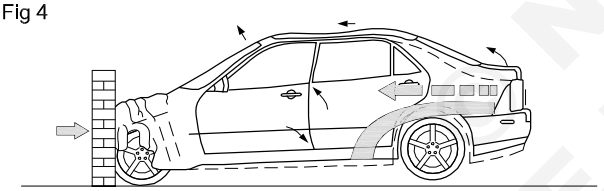


Single and multiple pulls: The single-pull method only uses one pulling chain. This method works well with minor damage on one part. A small bend in a part can often be straightened with a single pull.

With major damage to several panels, a multiple-pull method with several pulling directions and steps works best. With major damage, body panels are often deformed into complex shapes with altered strengths in the damaged areas. To after the direction while pulling divide the pulling force into two or more direction. This will allow to change the direction of the composite force - the force of all pulls combined with pull-push force, the straightening equipment is used to pull out damage, while a portable ram or blocking device pushes out damage at the time. This reduces the total force needed and restores the parts with less effort and reduced repair time. The repair of bent boxed part, such as a side member is done by clamping the surface of the bent in side and pulling. The pulling direction should be applied in straight line extending through the original position of the part.

Visualizing front-end collisions: (Fig 4) Front-end collisions result when a vehicle is moving forward and hits a stationary object or another vehicle. At the movement of impact, the parts at the front of the vehicle come to a complete stop and are crushed. The remainder of the vehicle continues to move forward from inertia forward. The door also may be smashed between the front fender and quarter panel.

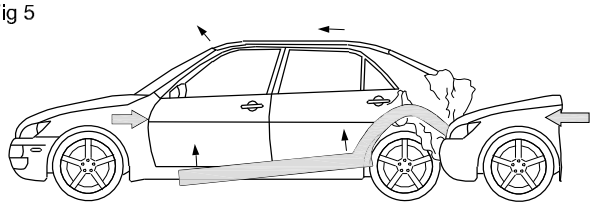
Fig 4



Visualizing rear-end collisions: A vehicle hit the rear is usually moving very slowly, the direct damage occurs to the contact points of both vehicle. As the rear-end collision continues, the first vehicle is pushed force but inertia resists movement. The rear rails and pan start to collapse forward. Their energy absorbing design also causes them to flex and deform.

During the final stages of the rear-end collision, indirect damage can flow into the roof panel and pillars. The crushing continues until the energy is spent. The roof may be forced ahead and upward roof buckling may occur. (Fig 5)

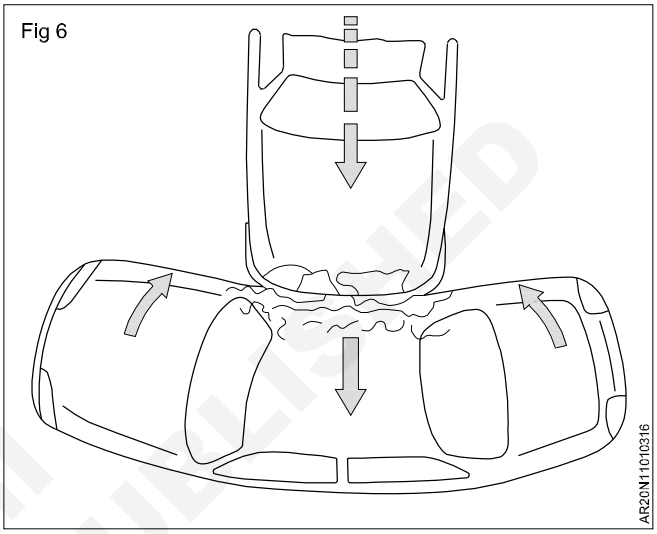
Fig 5



Visualizing a side collision: (Fig 6) During a side collision one vehicle smashes into another from the side often this accident happens, when vehicle runs a stop sign or signal and rams into the doors, fenders or quarter panel of another vehicle.

During the first stages of a side hit to the doors, the door skins are crushed inward. Steel reinforcement beams in the doors resist the initial impact. As the side hit continues, the front of the vehicle tries to move into the passenger compartment. The strength of the doors and pillars resists his intrusion.

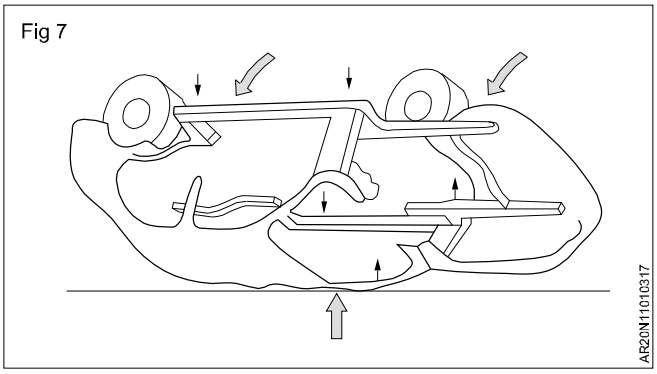
Fig 6



Impact energy pushes the passenger compartment sideways and tries to shorten and pull in on the side of the vehicle being hit. Lateral deflection continues until the hit vehicle starts to slide sideways. The collapsing of the pillars and rocker panel normally shortens the side of the vehicle hit from the side.

Visualizing rollover damage: As the vehicle rollover the front pillar and roof often hit the ground first the weight and inertia of the vehicle try to keep it moving forward. The damage is inflicted to the roof panel and one or more of the pillars. Rollover damage results when a vehicle flips over. (Fig 7)

Fig 7



Visualizing angled impacts: This types of damage often results from a side hit or a hit from an angle. When two vehicle are in different directions and collide as when both are turning corners, complex damage normally results. Lateral deflection damage also result if one vehicle is sliding sideways during the collision.

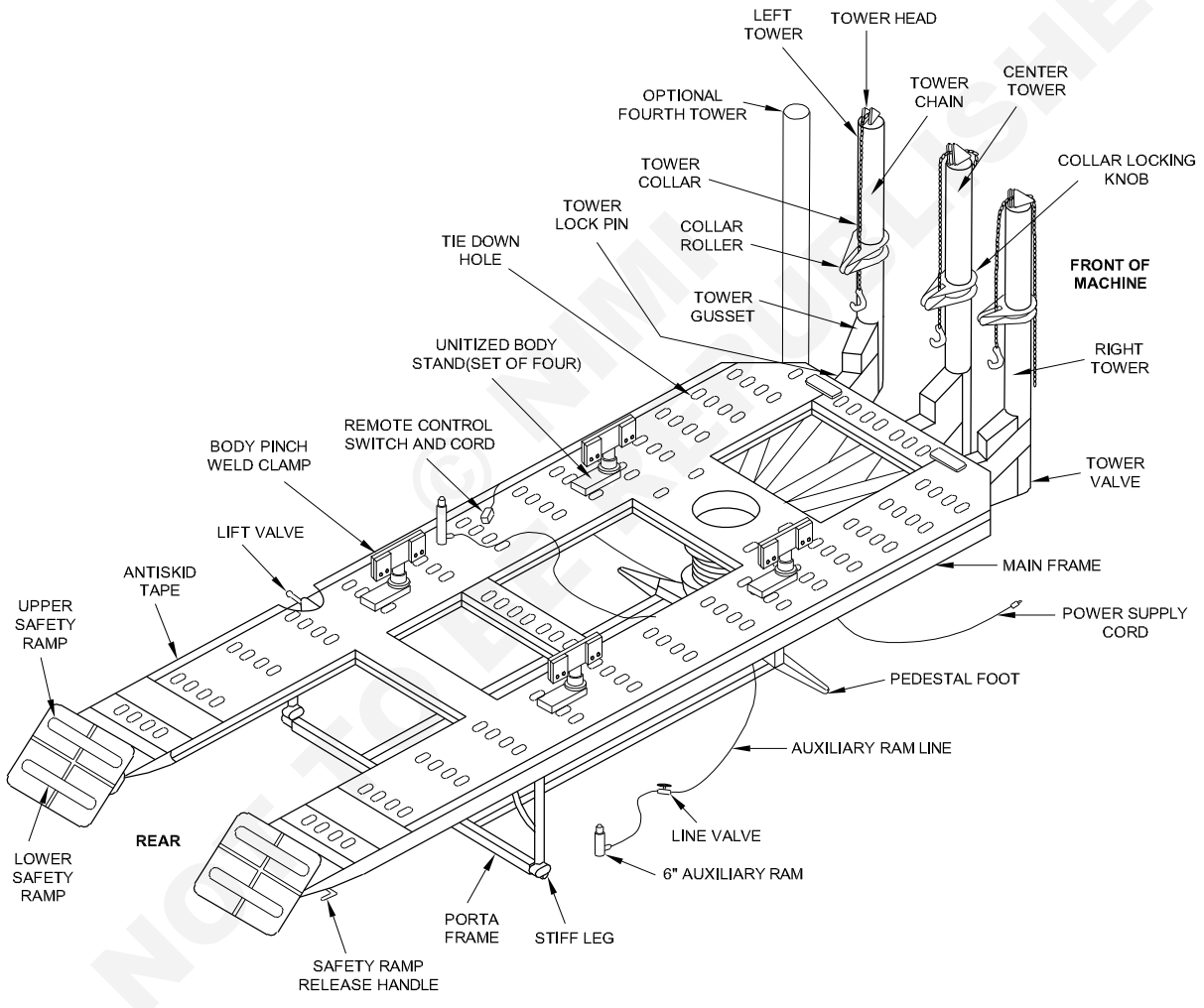
Unibody / frame straightening equipment: It is used to apply tremendous force to make the frame or body structure back into alignment. Straightening equipment includes anchoring equipment hydraulic pulling equipment and other accessories like chains, clamps. The traction direction/pulling direction force for straightening the frame/ unibody is opposite the direction that the damage was made during the impact.

Anchoring equipment holes the vehicle stationary during pulling and measuring. The anchoring system is designed to hold a vehicle solidly in place while tremendous pulling forces are applied on frame.

The pulling equipment uses hydraulic power to force the body structure back into position. The hydraulic rams use oil pressure from a pump to produce a powerful linear motion. The hydraulic oil pump is forced the oil into the ram cylinder and then ram is pushed outward with force. The pulls on the chain attached to the vehicle to remove the damage. The rams can be mounted on the pulling towers or posts or between the vehicle and anchoring system. The ram pulling posts or towers are strong steel members used to hold the pulling chains and hydraulic rams. Pins or bolts lock the tower to the rack. The tower can be rotated sideways for different pulling angles. Make sure all lock pins are securely in their holes before applying pulling power. (Fig 8)

Note: If too much pressure is applied on parts or equipment can be damages parts and serious injuries to mechanic.

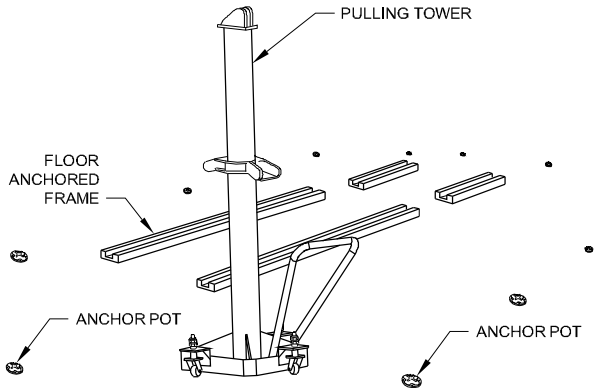
Fig 8

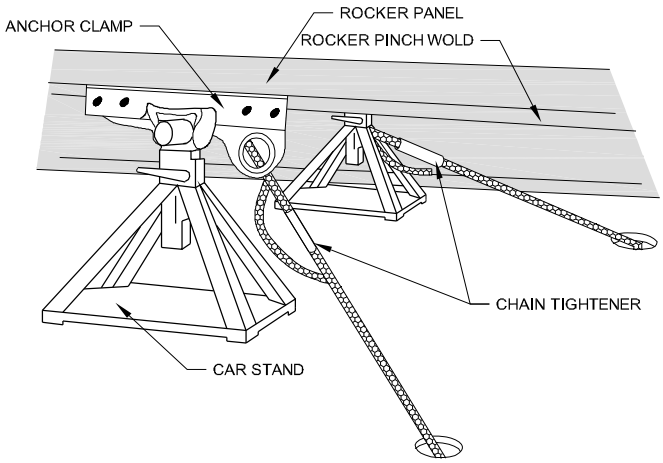


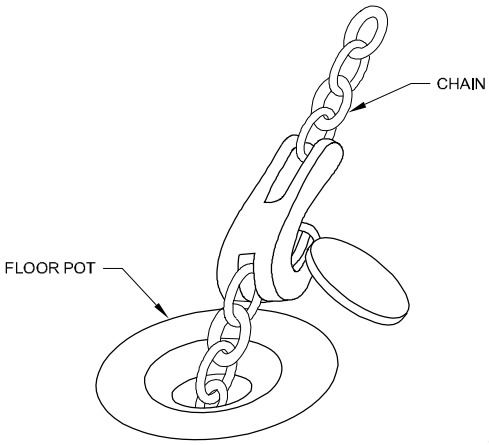
Floor straightening equipment: (Fig 9) There are two types of in floor system available are the anchor pot system and the modular rail frame system. In floor straightening system have anchor pot or rails cemented or mounted in shop floor. In this system of steel anchor rails in the floor is used to pulling, holding and balanced the vehicle in both direction during force of the pull. After the rams and other power accessories have been neatly stored away.

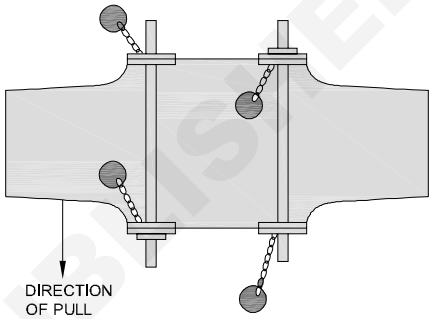
Portable body and frame pullers: Portable body and frame pullers have a hydraulic pressure system installed between the removable main frame and the mast. This type of system is designed to extract damage using chains and clamps. It is often used for repair of minor damage. However this system is used to pull only in one direction. These units are more dangerous to use than rack or floor system.

Fig 9









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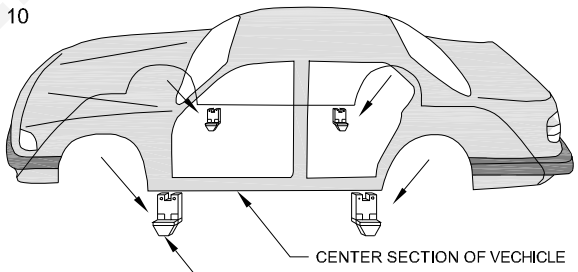
Rack straightening system: The rack straightening systems have a thick steel table to pulling and anchoring clamps are attached. Angle ramps are provided for winching a vehicle up onto the bench. This rack usually gives the positioning possibilities to pull from any angle and height. It is possible to make up pulls or down pulls. Most racks tilt hydraulically, so that vehicles can either be driven on or pulled into position with the optimal power winch.

Bench straightening systems: This system is similar to a rack straightening system. Some benches tilt, others have drive on ramps, like a rack, that can be raised or down as needed. Alignment benches are available in fixed and movable type.

Some bench-rack system have a drive on ramp with a rolling dolly system. This ram also be used as a stand while installing the vehicle on its anchoring system.

Anchoring the vehicle using pulling clamps and chains: The anchored vehicle will not make, when major structural damage is being pulled out. Pinch weld clamps are used to anchor unibody vehicles. The weld clamps are belt to the frame rack and to the vehicles pinch weld flanges along the bottom of the racker panels. Raise the vehicle off the rack a few inches with an hydraulic jack. Then position four pinch weld clamps. (Fig 10)

Fig 10



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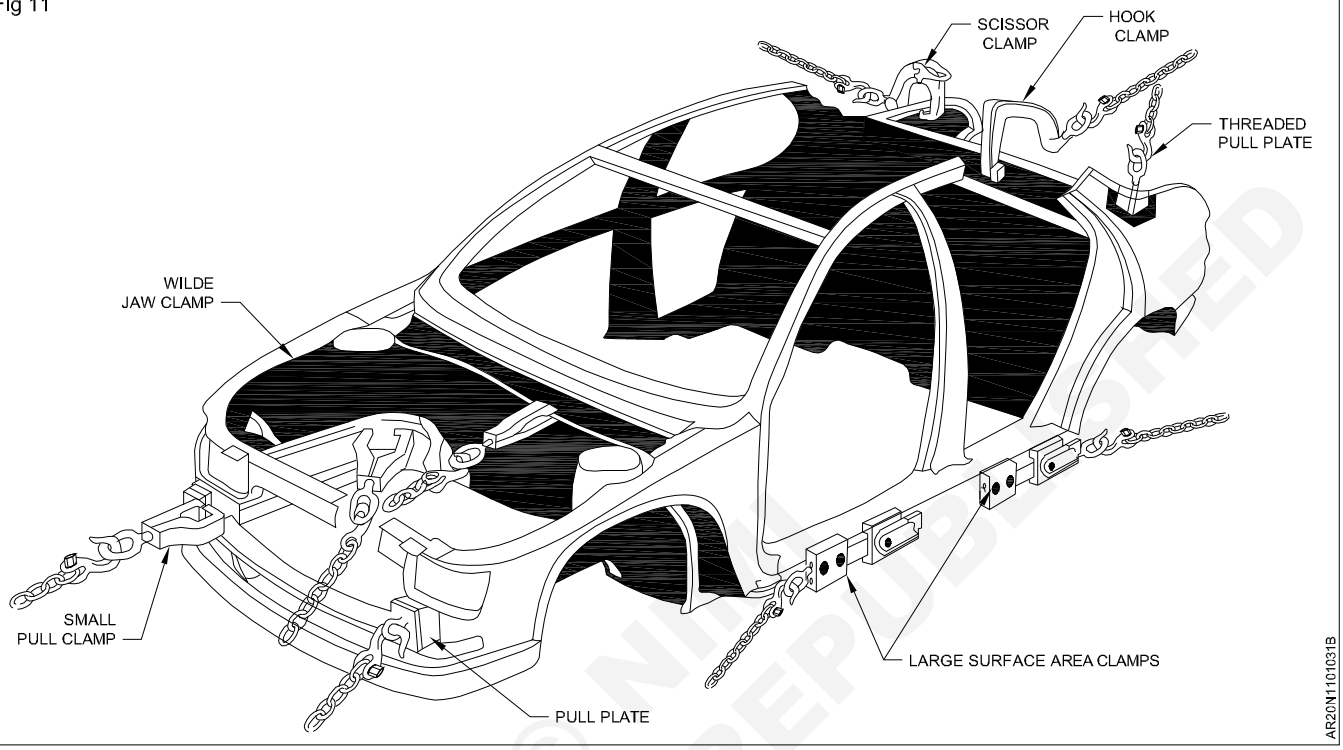
Under the outer corners of the center section of the vehicle. Lower the vehicle down into the clamps then tighten the clamp bolts on to the pinch weld flanges. Also tighten the bolts souring the anchor clamps to the rack. The special frame clamps are used to anchor a full frame vehicle.

A full-frame vehicle can be anchored by placing a suitable plug hook in the fixture holes located on the bottom of the frame rail. Blocking should be used to keep the hook in line with the frame rail. If a hard pull is to be made, it is advisable to weld a washer around the hole as a reinforcement. Make identical hookups on both sides of the vehicle.

Pulling clamps are attached to damaged area of a vehicle to accommodate pulling chains. Various pulling clamps are used to allow the frame rack to force body parts back into alignment. The pulling chains are large, high-tensile-strength chain that attach between the clamps and pulling towers. The pulling towers contain hydraulic rams for applying pulling force to the chain. They can be swiveled into different position and locked to the rack. The collars can be slid up and down on the tower and clamped to establish the height of the chain and its pulling force.

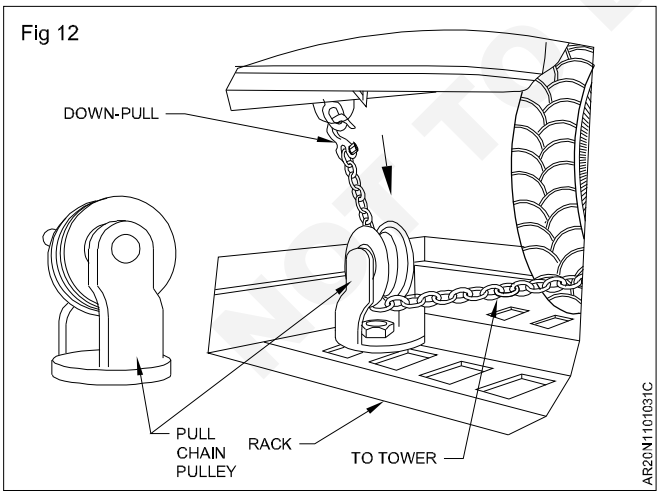
Various of change can be secured in different parts of uni body vehicle for pulling damage out a single-bolt clamp in the common set up for pulling radiator supports, flanges and other panels used minor damage. An adapter is available to allow a single-pull chain to be used with two clamps for added power. (Fig 11)

Fig 11



A chain pulley is often used to pull down from under the vehicle. The pull chain is fed through a pulley which is enclosed to the rack. (Fig 12) This allows pulling angle from the tower to be changed into a down pull

Fig 12



Other straightening accessories: Various other adapters are often supplied with frame straightening equipment. The holding devices used to clamp the parts in place so that they do not move while pulling other parts. When pulling to retain bar can be used to hold or maintain a dimension in an opening when pulling, it is an adjustable steel bar that can be slid out and locked into position.

A door aligner is designed to flex door and its hinges for correcting alignment. It is a special bar that snaps on to the door lack and striker. By pulling up or door on the handle, quickly minor door misalignment (Fig 13).

a A single holding restraint as secured across the fender aprons to hold good dimension whole pulling.

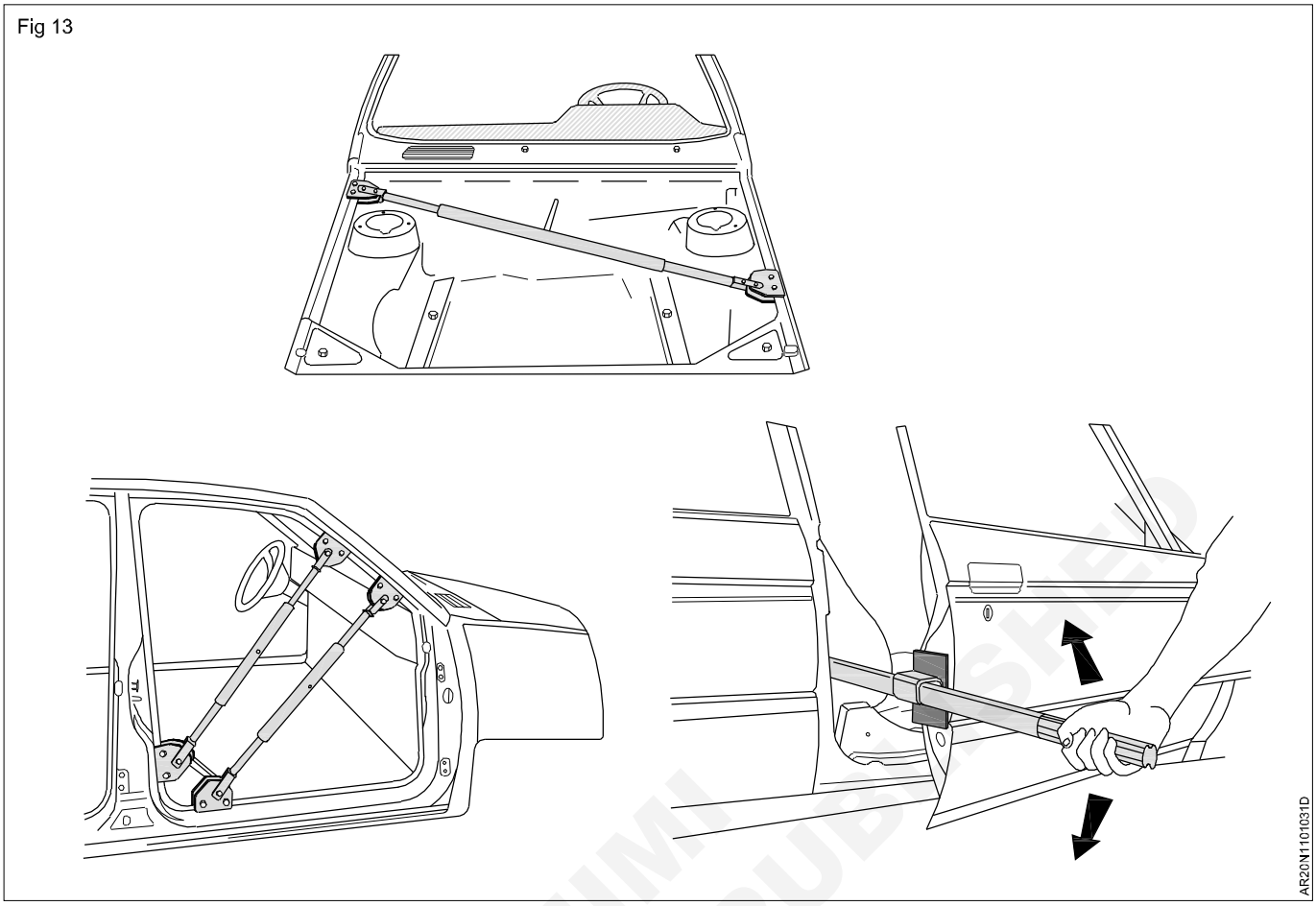
b Two restraints are used to secure the door opening dimension.

c A door aligner fits into the door lock and catch so you can flex the door up or down for minor adjustment.

When it is necessary to remove the engine or transmission mounts, an engine holder can be used to support the engine. It rests on the inner fenders and is adjustable in width. An adjustable chain hook is used to hold the chain attached to the engine. This allows you to remove engine and transmission mounts or the cradle for repair.

Portable hydraulic ram can be used to apply straightening force to hard-reach or enclosed areas on the vehicle. They are possibly the most versatile of all aligning tools. They can be used to push, spread, clamp, pull, and stretch.

Fig 13



Some pulling towards are designed to allow you to pull and push the damage at the same time. A portable power cylinder can be mounted between the damage to be pushed and the tower. It will push damage inward while pulling chains force the damage outward.

A work platform attaches to the rack so that you can stand and work on upper body areas. Many frame racks and benches come with a portable work position.

A holding device can be clamped to the rack and adjusted out to keep one area of the vehicle from flexing or moving.

A strut plate is an accessory that allows you to attach a pulling chain to the top of a shock tower. In frontal collisions, the shock towers are bent out of alignment. The strut plate can be bolted directly to the holes or studs on the top of the shock tower. A chain can then be used to apply traction to the top of the tower for straightening it.

Straightening and realigning techniques: The body on frame vehicle can usually be straightened and realigned with series of single direction pulls, single, hard pulls in one directions are fairly effective for straightening full frame vehicles. The unibody repairs demand multiple pulls, which means four or more pulling points and directions during a single straightening and alignment set up. The straightening equipment unibody structure during the pull. A single hard pull in one direction on a unibody vehicle will usually tear the metal or crack welds before the area is pulled straight.

The sequence of structure realignment procedure

1 Understand the safety considerations of the alignment equipment.

2 Analyze damage to determine which areas require unibody/frame straightening.

3 Anchor the vehicle.

4 Attach and locate pulling chains.

5 Execute the planned pulling sequence with additional clamping and alignment checks.

Unibody/Frame realignment safety: When using aligning equipment pay attention to the following items.

- Be sure to use alignment equipment correctly according to the instruction manual prepared by the manufacturer.
- Never allow unskilled or improperly trained personal to operate aligning equipment without supervision.
- Make sure the rocker panel pinch welds and chassis clamp teeth are tight. As you pull, check the clamps to make sure they are not slipping.
- Always anchor the vehicle securely before making a pull. Check that the chassis clamps and anchor bolts are tightened.

- Always use the size and grade (alloy) chain recommended for pulling and anchoring. Use only the chain and bolt grades supplied with the aligning equipment.
- Drawing chains must be securely attached to the vehicle and/or anchoring locations so that they will not come off during the pulling operation. Avoid placing chains around sharp corners.
- Before powerful side pulls are executed, apply counter supports to prevent pulling the vehicle off the straightening equipment.
- Never use a service jack for supporting the vehicle while working on or under it.
- Always use car stands for supporting the vehicle. Use only those stands recommended for the aligning equipment.
- A pull clamp can slip and cause a sheet metal tear. Prevent injuries and material damage by always using safety wires. Watch them closely while pulling.
- Never stand in line a chain or clamp. Chain breakage, clamp slippage, or sheet metal tearing can cause injury or damage. Remember, it can be dangerous to work inside the vehicle at the same time pulls are being made outside.
- Cover pulling chains with a heavy blanket or attach a safety chain. If a chain breaks, this will keep the chain from being thrown across the shop.
- Wear leather gloves to prevent hand injuries.

  Before doing any pulling work, protect the vehicle body and externally attached parts as follows.
- When welding or plasma arc cutting cover glass, seats, instruments, and carpet with a heat-resistant material. Also disconnect the battery and computer modules to protect them from welding or cutting current.
- After the initial pull, recheck the clamps. They may have rotated slightly with the initial pull and sometimes will bite into the metal, leaving some slack in the clamp tightness.
- When removing external parts (moldings and trim) attached to the body apply cloth or protection tape to the body to prevent scratching.
- If the painted surface on an undamaged part is accidently scratched mark a note to repair it. Even small flow in the painted surface may lead to corrosion and effect customer satisfaction.

Measuring when pulling: Vehicle measurement is necessary before, during and after pulling. Measurement of vehicle damage helps you determine how to pull. Measurement while pulling helps you check that you are properly pulling the damage out measurement after pulling enables to check your work.

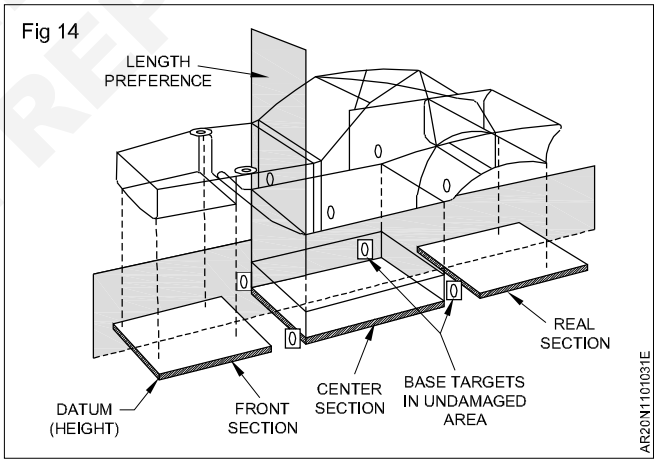
Measurements can be done with taps measures, tram bars, and electronic measuring systems. The industry trend is toward computerized laser or sonic measuring systems that give "real/time feedback" of the pulling operation. For the unibody/frame repair, the measuring equipment must show the amount and direction of misalignment.

You may have to make some general measurement with a tape measure or tram gauge. These include diagonal measurements to check for diamond damage and length measurements to check for mash damage. Try to get as good an idea as possible of where the damage beings and ends. Use all the dimension data available, including body/ frame dimension books and vehicle manufacturers manuals, or by checking against an undamaged car.

Computerized measuring system pull up the dimension data for the vehicle being repaired. Most computerized measuring systems helps to find reference points and automatically down load known good dimensions for comparison to vehicle damage measurements.

To begin measurements of frame damage with a computerized system first establish your base. Tax gets in the undamaged center section of the vehicle are normally used to establish datum plane (height) centerline (width) and body zero (length) dimensions. These three locations form the datum plane on which will of the other measurements are based, if there are more three location that are undamaged, they can also be used for set up. (Fig 14)

Fig 14



If you are measuring unibody damage with a tram gauge (Fig 15), you should write down your measurement on a copy of dimension sheet for that vehicle. This will let you compare factory dimensions and your measurements of damage.

Planning the pull: When planning the pulling process follow the following procedure.

1 Determine the direction of the pulls

2 Find out how to repair the damage in the reverse sequence from which it occurred during collision.

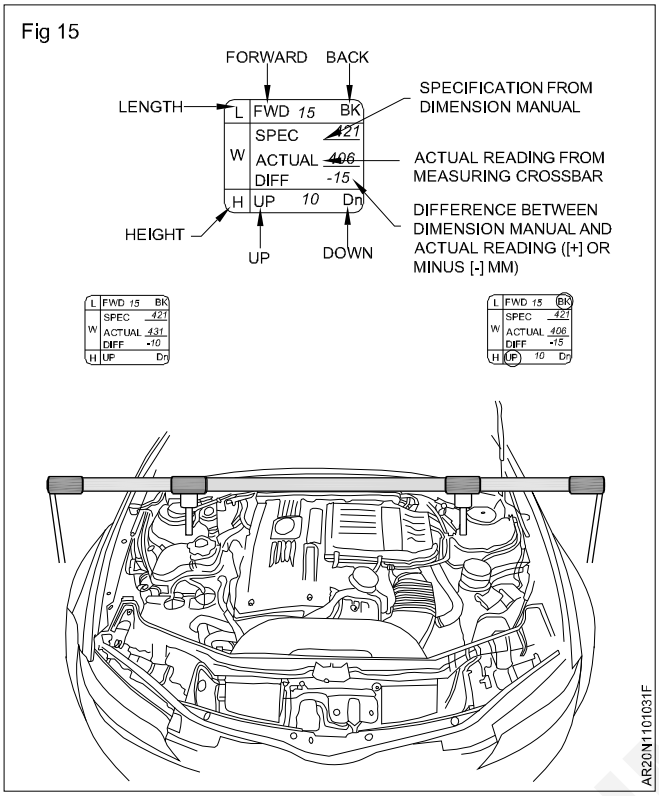
3 Plan the pulling sequence with the pulls in the opposite direction from how the damage was caused.

4 Find correct attachment points of the pulling clamps.

5 Estimate the number of pulls required to correct the damage.

6 Determine which must be removed to make the pulls.

Fig 15



In planning the repair (pulling) sequence remember the two basic guides to ensure that misalignment and damage will be corrected with minimum metal working and without further damage:

1 Repair the damage in the reverse (first-in, last-out) sequence in which it occurred during the collision.

2 Plan the pulling sequence with the pulls in the direction opposite to the damage input.

Making pulls: A single-pull setup is capable of making a simple direction pull on the damaged area of a vehicle. Single pulls are effective on primary damage to full-frame vehicle and mirror damage to unibody vehicles.

Multiple-pull setups allow you to pull and hold when damage is in several directions (length, width, and height). Multiple pulls are often required to correct major damage to unibody vehicles. Multiple-pull setup provide the ability to exert a great deal of control over any pulling task. This improves the precision with which a pull can be made. Multiple-pull setups also eliminate the need for disconnecting and moving the power posts or towers.

The multiple-pull approach accomplishes these two objectives:

1 The exact desired direction of pull can easily be achieved from three or four points at one time. This gives the control needed in the repair of modern unibody construction.

2 The use of multiple-pull points reduces the amount of force required at any single point. This reduce the risk of tearing lightweight metals. Due to the design of today's vehicle, there simply is not enough strength available in any one place to transmit sufficient force to complete a repair. Again, as in the anchoring system, the pull load must be distributed through several attaching points.

When hooking up to make a pull on a unibody vehicle, consider these pointer:

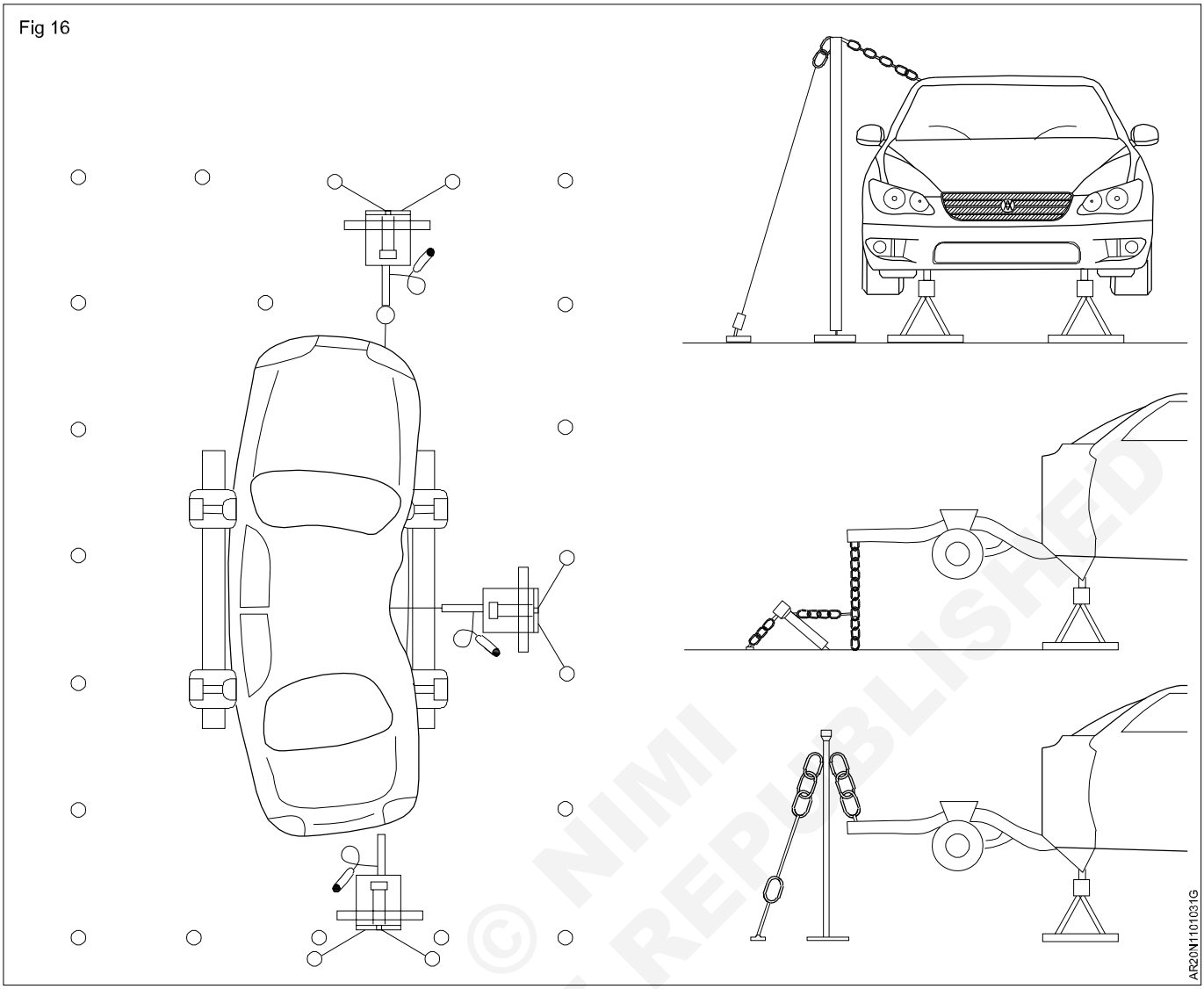
- The unitized body has made multiple anchoring is must. At least four anchors are required, one on each of the body clamps. Depending on the vehicle's construction, additional anchoring might be required.
- Always look for the possibility of more than one hook-up for both damage correction and restraints. Twin pulls and/or restraints allow twice the pull potential with less damage at the points of attachment.
- Use multiple hook-ups on structural members and on sheet metal sections to be worked. Today's metals shift, shrink and stretch quite readily. This is why an incorrect (too localized) pull can cause more damage than it removes.
- Always install an additional security chain or chains to a substantial member on the vehicle chassis.
- Treat each damaged area as individually as possible because today's cars are manufactured for isolated collapse upon impact.
- Carefully observed the "last-in, first-out" rule in areas of primary as well as secondary damage. Occasionally this principle can be violated for initial pulls, but it nearly always holds true in the "fine-tuning" phase of unibody alignment .
- Use imagination in utilizing available clamps for multiple hook-ups, including the shaping of straps and other attaching devices.
- After placing a small amount of pressure on the pulling chains, the anchor clamps will be seated, and they should be retightened to prevent slippage.

Figure 16A shows three towers are pulling out side impact damage, two stretch the vehicle length use, while another pulls it side ways. Fig 16B shows the tower is pulling upon on the roof panel. Fig 16 C shows the tower is being used to make a downward pull on the front rail Fig 16D shows the tower to pulling up on the rail.

Executing a pulling sequence: The progress toward alignment should be monitored during the pull. Because sheet metal has elasticity or flexibility, the body structure will, to a certain extent, flex back has been pulled back to its prescribed dimensions. Therefore, it is important to estimate the amount of return or flex back in advance. This is why a controlled over pull is so important.

Because of the power of the rams, the metal will begin moving as soon as the chain is taken up. Always check your dimensions frequently to prevent over pulling touch.

Fig 16



Several attempts may be needed to get the damaged area to remain in the proper position. You may have to pull and release tension to see where the panel moves when tension is released. Then repull and release to slowly moves the part or panel to within specs. Each time this is done the panel will move a little closer to the desired position. Shocking the metal in an adjacent area will help relieve stress and keep the panel moving as needed.

Make the pulls a little at a time, relieve the stress, and then take a measurement. Typically , when straightening unibody/frame damage you should work from the center section outward, achieving the following sequence.

1 Length damage removal

2 Width damage removal

3 Correction of height damage

Approach the pulling operation is determine how the metal should be moved to force it back into it original shape. How many areas could be moved at one time and in which directions. This is the key to effective pulling.

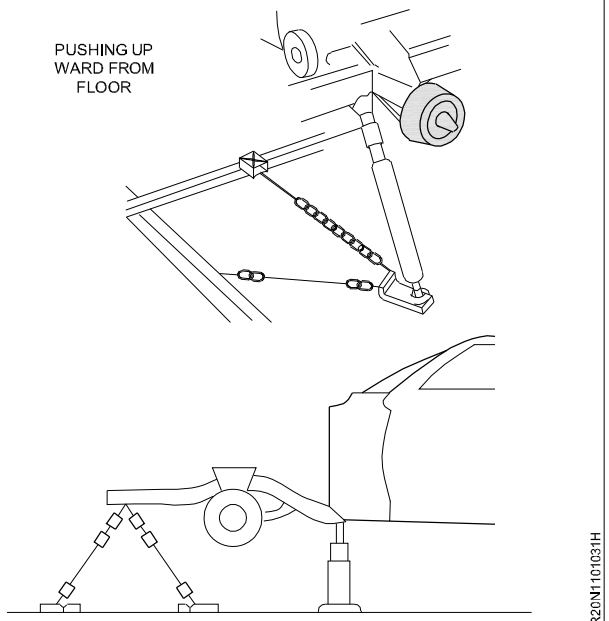
There are other basic single-pull setups when using a ram:

- For a high pull, more tubing is required. For an outward and down-pull, less tubing is needed. Another way to make a down-pull is to attach a chain between the vehicle and floor anchors. By pulling on the chain bridge, the structure is forced down.
- A horizontal pull on a rail can be accomplished by placing the ram at about a 45-degree angle.
- By adding tubing to the ram, a straight out pull on the cowl can be accomplished.
- To pull straight out at the roof line, use the ram with extension tubes.
- Upward pulls are very easy to set up, In most cases, the ram is in a vertical position. This pull setup will produce an upward and slightly outward pull.
- The same type of setup can be used at roof height by adding extensions to the ram.
- Although pushing is not used to the extent it once was in damage repair, the capability to push is still important. The vector system provides push capability from any angle around the vehicle by means of a simple triangular setup.
- It is also possible to push from underneath the vehicle at whatever angle is needed (Fig 17 A). This push setup

can be used to effectively remove sag at the cowl area (Fig 17 B).

- In most situations more than one pull will be needed to effectively repair the vehicle, for a variety of reasons.

Fig 17



The repair of a bent, closed, cross-sectional structure such as a side member is done by clamping the surface of the bent-in side and pulling. The pulling direction should be such that force is applied in the direction of an imaginary straight line extending through the original position of the part. The minor dented portion of the part can often be repaired by welding on studs and pulling them with a sliding hammer.

By bringing damaged metal back into shape, slowly and carefully, a first class, solid and safe repair to easy. Although there will be exceptions, a general rule of thumb to follow is to achieve proper length, width and height in that order.

Over pulling: Over pulling is done by pulling the damage a few multimeters beyond its original dimension, if done is a controlled way the metal until flex back slightly, when tension is released. The unibody or frame reference points until then line up properly.

If overdone, however over pulling may result is an irreversible error (Fig 18). Excessive over pulling is a mistake that can take days of work to correct. If over pulled, stretched panels cannot be shrunk, new welded panels may have to be installed, by experience overpulling and often. To prevent overpull damage, measure the progress, when pulling the damaged area.

Fig 18