FITTER

NSQF LEVEL - 4

1st Year

TRADE THEORY

SECTOR : CAPITAL GOODS & MANUFACTURING

(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 : Capital Goods & Manufacturing

Duration : 2 Years

Trade : Fitter - 1st Year - Trade Theory - NSQF Level - 4 (Revised 2022)

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National Instructional Media Institute
Post Box No.3142
Guindy, Chennai - 600 032
INDIA
Email: chennai-nimi@nic.in
Website: www.nimi.gov.in

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 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 comprising various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Fitter - 1st Year - Trade Theory NSQF Level - 4 (Revised 2022) in CG & M Sector under** under Annual pattern. The NSQF Level - 4 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

Addl.Secretary / Director General (Training)
Ministry of Skill Development & Entrepreneurship,
Government of India.

New Delhi - 110 001

PREFACE

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

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

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

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

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

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

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

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

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP **(Trade Theory)** for the trade of **Fitter** under the **CG & M** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

Shri. P.K. Radha Krishnan	-	Senior Instructor Govt ITI, Kerala
Shri. T. Gopalan	-	Assistant Training officer Govt ITI, Ambattur, Chennai
Shri. U. Abdul Kadar	-	Junior Training officer Govt ITI, Guindy, Chennai
Shri A. Vijayaraghavan	-	Assistant Director of Training (Retd) ATI, Chennai - 32.

NIMI COORDINATORS

Shri. Nirmalya Nath	-	Deputy Director, NIMI, Chennai - 32.
Shri. V. Gopala Krishnan	-	Manager NIMI, Chennai - 32.

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

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

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

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the course of the **Fitter** 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 - 4 (Revised 2022) syllabus are covered.

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

Module 1	Safety
Module 2	Basic Fitting
Module 3	Sheet Metal
Module 4	Welding
Module 5	Drilling
Module 6	Fitting Assembly
Module 7	Turning
Module 8	Basic Maintenance

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 **Fitter - 1st** Trade Theory NSQF LEVEL - 4 (Revised 2022) in Construction. The contents are sequenced according to the practical exercise contained in NSQF LEVEL - 4 (Revised 2022) syllabus on TradeTheory 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 at least one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

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

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

Sl.No.	Learning Outcome	Exercise No.
1	Plan and organize the work to make job as per specification applying different types of basic fitting operation and Check for dimensional accuracy following safety precautions. [Basic fitting operation - marking, Hacks awing, Chiseling, Filing, Drilling, Taping and Grinding etc. Accuracy: ± 0.25mm] **CSC/N0304**	1.1.01 - 1.2.41
2	Manufacture simple sheet metal items as per drawing and join them by soldering, brazing and riveting. **CSC/N0301**	1.3.42 - 1.3.51
3	Join metal components by riveting observing standard procedure. **CSC/N0304**	1.3.52 - 1.3.55
4	Join metal component by arc welding observing standard procedure. **CSC/N0304**	1.4.56
5	Cut and join metal component by gas (oxy-acetylene) **CSC/N0304**	1.4.57 - 1.4.60
6	Produce components by different operations and check accuracy using appropriate measuring instruments.[Different Operations - Drilling, Reaming, Taping, Dieing; Appropriate MeasuringInstrument - Vernier, Screw Gauge, M icrometer] **CSC/N0304**	1.5.61 - 1.5.78
7	Make different fit of components for assembling as per required tolerance observing principle of interchange ability and check for functionality. [Different Fit - Sliding, Angular, Step fit, 'T' fit, Square fit and Profile fit; Required tolerance: ±0.04 mm, angular tolerance: 30 min.] **CSC/N0304**	1.6.79 - 1.6.89
8	Produce components involving different operations on lathe observing standard procedure and check for accuracy. [Different Operations - facing, plain turning, step turning, parting, chamfering, shoulder turn, grooving, knurling, boring, taper turning, threading (external 'V' only)] **CSC/N0110**	1.7.90 - 1.7.107
9	Plan & perform simple repair, overhauling of different machines and check for functionality. [Different Machines - Drill Machine, Power Saw, Bench Grinder and Lathe]N/A	1.8.108-1.8.114

SYLLABUS FOR FITTER

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
Professional Skill 212 Hrs; Professional Knowledge 37Hrs	Plan and organize the work to make job as per specification applying different types of basic fitting operation and Check for dimensional accuracy following safety precautions. [Basic fitting operation - marking, Hacks awing, Chiseling, Filing, Drilling, Taping and Grinding etc. Accuracy: ± 0.25mm] **CSC/N0304.**	1. Importance of trade training, List of tools & Machinery used in the trade. (1 hr.) 2. Safety attitude development of the trainee by educating them to use Personal Protective Equipment (PPE). (5 hrs.) 3. First Aid Method and basic training. (2 hrs.) 4. Safe disposal of waste materials like cotton waste, metal chips/burrs etc. (2 hrs.) 5. Hazard identification and avoidance. (2 hrs.) 6. Safety signs for Danger, Warning, caution & personal safety message. (1 hrs.) 7. Preventive measures for electrical accidents & steps to be taken in such accidents. (2 hrs.) 8. Use of Fire extinguishers. (7 hrs.) 9. Practice and understand precautions to be followed while working in fitting jobs. (2 hrs.) 10. Safe use of tools and equipments used in the trade. (1 hrs.)	All necessary guidance to be provided to the new comers to become familiar with the working of Industrial Training Institute system including stores procedures. Soft Skills, its importance and Job area after completion of training. Importance of safety and general precautions observed in the in the industry/shop floor. Introduction of First aid. Operation of electrical mains and electrical safety. Introduction of PPEs. Response to emergencies e.g.; power failure, fire, and system failure. Importance of housekeeping & good shop floor practices. Introduction to 5S concept & its application. Occupational Safety & Health: Health, Safety and Environment guidelines, legislations &regulations as applicable. Basic understanding on Hot work, confined space work and material handling equipment. (04 hrs.)
		11. Identification of tools &equipment as per desired specifications for marking & sawing. (4 hrs.) 12. Selection of material as per application. (1 hrs.) 13. Visual inspection of raw material for rusting, scaling, corrosion etc. (1 hrs.) 14. Marking out lines, gripping suitably in vice jaws, hacksawing to given dimensions. (9 hrs.) 15. Sawing different types of metals of different sections. (6 hrs.)	Linear measurements- its units, dividers, calipers, hermaphrodite, centre punch, dot punch, prick punch their description and uses of different types of hammers. Description, use and care of 'V' Blocks, marking off table. Measuring standards (English, Metric Units), angular measurements. (04 hrs.)
		16. Filing Channel, Parallel. (5 hrs.) 17. Filing- Flat and square (Rough finish), (08 hrs.) 18. Filing practice, surface filing, marking of straight and parallel lines with odd leg calipers and steel rule. (5 hrs.)	Bench vice construction, types, uses, care & maintenance, vice clamps, hacksaw frames and blades, specification, description, types and their uses, method of using hacksaws.

		19. Marking practice with dividers, odd leg calipers and steel rule (circles, ARCs, parallel lines). (4 hrs.)	Files- specifications, description, materials, grades, cuts, file elements, uses. Types of files, care and maintenance of files. Measuring standards (English, Metric Units), angular measurements. (04 hrs.)
		20. Marking off straight lines and ARCs using scribing block and dividers. (4 hrs.) 21. Chipping flat surfaces along a marked line. (9 hrs.) 22. Marking, filing, filing square and check using tri square. (9 hrs.)	Marking off and layout tools, dividers, scribing block, -description, classification, material, care & maintenance. Try square, ordinary depth gauge, protractor- description, uses and cares. Uses, care & maintenance of cold chisels- materials, types, cutting angles. (04 hrs.)
		23. Marking according to simple blueprints for locating, position of holes, scribing lines on chalked surfaces with marking tools. (8 hrs.) 24. Finding centre of round bar with the help of 'V' block and marking block. (2 hrs.) 25. Joining straight line to an ARC. (08 hrs.)	Marking media, marking blue, Prussian blue, red lead, chalk and their special application, description. Use, care and maintenance of scribing block. Surface plate and auxiliary marking equipment, 'V' block, angle plates, parallel block, description, types, uses, accuracy, care and maintenance. (03 hrs.)
		26. Chipping, Chamfering, Chip slots & oils grooves (Straight). (08 hrs.) 27. Filing flat, square, and parallel to an accuracy of 0.5mm. (07 hrs.) 28. Chip curve along a line-mark out, keyways at various angles & cut keyways. (1 hrs.) 29. Sharpening of Chisel. (2 hrs.) 30. File thin metal to an accuracy of 0.5 mm. (3 hrs.)	Physical properties of engineering metal: colour, weight, structure, and conductivity, magnetic, fusibility, specific gravity. Mechanical properties: ductility, malleability hardness, brittleness, toughness, tenacity, and elasticity. (04 hrs.)
		31. Saw along a straight line, curved line, on different sections of metal. (12 hrs.) 32. Straight saw on thick section, M.S. angle and pipes. (8 hrs.)	Power Saw, band saw, Circular saw machines used for metal cutting. (03 hrs.)
		33. File steps and finish with smooth file to accuracy of ± 0.25 mm. (12 hrs.) 34. File and saw on M.S. Square and pipe. (10 hrs.) 35. File radius along a marked line (Convex & concave) & match. (12 hrs.)	Micrometer- outside and inside - principle, constructional features, parts graduation, reading, use and care. Micrometer depth gauge, parts, graduation, reading, use and care. Digital micrometer. (03 hrs.)

		36. Chip sheet metal (shearing). (3 hrs.) 37. Chip step and file. (3 hrs.)	Vernier calipers, principle, construction, graduations, reading, use and care. Vernier bevel protractor, construction, graduations, reading, use and care, dial Vernier Caliper, Digital Vernier caliper. Vernier height gauge: material construction, parts, graduations (English & Metric) uses, care and maintenance. (03 hrs.)
		38. Mark off and drill through holes. (5 hrs.) 39. Drill and tap on M.S. flat. (8 hrs.) 40. Punch letter and number (letter punch and number punch) (3 hrs.) 41. Practice use of different punches. (5 hrs.)	Drilling processes: common type (bench type, pillar type, radial type), gang and multiple drilling machine. Determination of tap drill size. (03 hrs.)
Professional Skill 97Hrs; Professional Knowledge 21Hrs	Manufacture simple sheet metal items as per drawing and join them by soldering, brazing and riveting. **CSC/N0301**	42. Marking of straight lines, circles, profiles and various geometrical shapes and cutting the sheets with snips. (12 hrs.) 43. Marking out of simple development (5 hrs.) 44. Marking out for flaps for soldering and sweating. (4 hrs.)	Safety precautions to be observed in a sheet metal workshop, sheet and sizes, Commercial sizes and various types of metal sheets, coated sheets and their uses as per BIS specifications. Shearing machine- description, parts and uses. (05 hrs.)
		45. Make various joints: wiring, hemming, soldering and brazing, form locked, grooved and knocked up single hem straight and curved edges form double hemming. (22 hrs.) 46. Punch holes-using hollow and solid punches. (5 hrs.) 47. Do lap and butt joints. (12 hrs.)	Marking and measuring tools, wing compass, tin man's square tools, snips, types and uses. Tin man's hammers and mallets type-sheet metal tools, types, specifications, uses. Trammel- description, parts, uses. Hand grooves- specifications and uses. Sheet and wire gauge. (07 hrs.)
		48. Bend sheet metal into various curvature form, wired edges- straight and curves. Fold sheet metal at angle using stakes. (6 hrs.) 49. Make simple Square container with wired edge and fix handle. (13 hrs.)	Stakes-bench types, parts, their uses. Various types of metal joints, their selection and application, tolerance for various joints, their selection& application. Wired edges. (04 hrs.)
		50. Make square tray with square soldered corner. (11 hrs.) 51. Practice in soft soldering and silver soldering. (7 hrs.)	Solder and soldering: Introduction- types of solder and flux. Composition of various types of solders and their heating media of soldering iron. Method of soldering, selection and application-joints. Hard solder- Introduction, types and method of brazing. (05 hrs.)

Professional Skill 19Hrs; Professional Knowledge 03Hrs	Join metal components by riveting observing standard procedure. **CSC/N0304**	52. Make riveted lap and butt joint. (6 hrs.) 53. Make funnel as per development and solder joints. (8 hrs.) 54. Drill for riveting. (1 hr.) 55. Riveting with as many types of rivet as available, use of counter sunk head rivets. (4 hrs.)	Various rivets shape and form of heads, importance of correct head size. Rivets-Tin man's rivets types, sizes, and selection for various works. Riveting tools, dolly snaps description and uses. Method of riveting, The spacing of rivets. Flash riveting, use of correct tools, compare hot and cold riveting. (03 hrs.)
Professional Skill 21Hrs; Professional Knowledge 04Hrs	Join metal component by arc welding observing standard procedure. **CSC/N0304**	56. Welding - Striking and maintaining ARC, laying Straight-line bead. (21 hrs.)	Safety-importance of safety and general precautions observed in a welding shop. Precautions in electric and gas welding. (Before, during, after) Introduction to safety equipment and their uses. Machines and accessories, welding transformer, welding generators. (04 hrs.)
Professional Skill 64Hrs; Professional Knowledge 16Hrs	Cut and join metal component by gas (oxy-acetylene) **CSC/N0304**	57. Making butt joint and joint-gas and ARC. (12 hrs.) 58. Do setting up of flames, fusion runs with and without filler rod, and gas. (8 hrs.)	Welding hand tools: Hammers, welding description, types and uses, description, principle, method of operating, carbon dioxide welding. H.P. welding equipment: description, principle, method of operating L.P. welding equipment: description, principle, method of operating. Types of Joints-Butt and fillet as per BIS SP: 46-1988 specifications. Gases and gas cylinder description, kinds, main difference and uses. (05 hrs.)
		59. Make butt weld and corner, fillet in ARC welding (22 hrs.)	Setting up parameters for ARC welding machines-selection of Welding electrodes. Care to be taken in keeping electrode. (05 hrs.)
		60. Gas cutting of MS plates (22 hrs.	Oxygen acetylene cutting-machine description, parts, uses, method of handling, cutting torch-description, parts, function and uses. (06 hrs.)
Professional Skill 143Hrs; Professional Knowledge 26Hrs	Produce components by different operations and check accuracy using appropriate measuring instruments.[Different Operations - Drilling, Reaming, Taping, Dieing; Appropriate	61. Mark off and drill through holes. (04 hrs.) 62. Drill on M.S. flat. (1 hrs.) 63. File radius and profile to suit gauge. (10 hrs.) 64. Sharpening of Drills. (1 hrs.) 65. Practice use of angular measuring instrument. (04 hrs.) 66. Counter sink, counter bore and ream split fit (three piece fitting). (04 hrs.) 67. Drill through hole and blind holes. (2 hrs.)	Drill- material, types, (Taper shank, straight shank) parts and sizes. Drill angle-cutting angle for different materials, cutting speed feed. R.P.M. for different materials. Drill holding devices- material, construction and their uses. (04 hrs.) Counter sink, counter bore and spot facing-tools and nomenclature, Reamer- material, types (Hand and machine reamer), kinds, parts and

	Measuring Instrument - Vernier, Screw Gauge, Micrometer] **CSC/N0304**	68. Form internal threads with taps to standard size (through holes and blind holes). (3 hrs.) 69. Prepare studs and bolt. (13 hrs.)	their uses, determining hole size (or reaming), Reaming procedure. Screw threads: terminology, parts, types and their uses. Screw pitch gauge: material parts and uses. Taps British standard (B.S.W., B.S.F., B.A. & B.S.P.) and metric / BIS (coarse and fine) material, parts (shank body, flute, cutting edge). (03 hrs.)
		70. Form external threads with dies to standard size. (08 hrs.) 71. Prepare nuts and match with bolts. (15 hrs.)	Tap wrench: material, parts, types (solid &adjustable types) and their uses removal of broken tap, studs (tap stud extractor). Dies: British standard, metric and BIS standard, material, parts, types, Method of using dies. Die stock: material, parts and uses. (06 hrs.)
		72. File and make Step fit, angular fit, angle, surfaces (Bevel gauge accuracy 1 degree). (12 hrs.) 73. Make simple open and sliding fits. (08 hrs.) 74. Enlarge hole and increase internal dia. (2 hrs.) 75. File cylindrical surfaces. (5 hrs.) 76. Make open fitting of curved profiles. (15 hrs.)	Drill troubles: causes and remedy. Equality of lips, correct clearance, dead centre, length of lips. Drill kinds: Fraction, metric, letters and numbers, grinding of drill. (04 hrs.) Grinding wheel: Abrasive, grade structures, bond, specification, use, mounting and dressing. Selection of grinding wheels. Bench grinder parts and use. (04 hrs.)
		77. Correction of drill location by binding previously drilled hole. (04 hrs.) 78. Make inside square fit. (16 hrs.)	Gauges- Introduction, necessity, types. Limit gauge: Ring gauge, snap gauge, plug gauge, description and uses. Description and uses of gauge- types (feeler, screw, pitch, radius, wire gauge). (05 hrs.)
Professional Skill 126Hrs; Professional Knowledge 28Hrs	Make different fit of components for assembling as per required tolerance observing principle of interchange ability and check for functionality. [Different Fit - Sliding, Angular, Step fit, 'T' fit, Square fit and Profile fit; Required tolerance: ±0.04 mm, angular tolerance: 30 min.] **CSC/N0304**	79. Make sliding 'T' fit. (21 hrs.)	Interchange ability: Necessity in Engg, field definition, BIS. Definition, types of limit, terminology of limits and fits-basic size, actual size, deviation, high and low limit, zero line, tolerance zone Different standard systems of fits and limits. British standard system, BIS system. (05 hrs.)

		80. File fit- combined, open angular and sliding sides. (08 hrs.) 81. File internal angles 30minutes accuracy open, angular fit. (12 hrs.)	Method of expressing tolerance as per BIS Fits: Definition, types, description of each with sketch. Vernier height gauge: material construction, parts, graduations (English & Metric) uses, care and maintenance. (04 hrs.)
		82. Make sliding fit with angles other than 90o (21 hrs.)	Pig Iron: types of pig Iron, properties and uses. Cast Iron: types, properties and usesWroughtiron:- properties and uses. Steel: plain carbon steels, types, properties and uses. Non-ferrous metals (copper, aluminium, tin, lead, zinc) properties and uses. (05 hrs.)
		83. Scrap on flat surfaces, curved surfaces and parallel surfaces and test. (04 hrs.) 84. Make & assemble, sliding flats, plain surfaces. (12 hrs.) 85. Check for blue math of bearing surfaces- both flat and curved surfaces by wit worth method. (5 hrs.)83. Scrap surfaces- both flat and curved surfaces by wit worth method. (5 hrs.)	Simple scraper- flat, half round, triangular and hook scraper and their uses. Blue matching of scraped surfaces (flat and curved bearing surfaces). Testing scraped surfaces: ordinary surfaces without a master plate. (04 hrs.)
		86. File and fit combined radius and angular surface (accuracy ± 0.5 mm), angular and radius fit. (15 hrs.) 87. Locate accurate holes & make accurate hole for stud fit. (2 hrs.) 88. Fasten mechanical components / sub-assemblies together using screws, bolts and collars using hand tools. (5 hrs.)	Vernier micrometer, material, parts, graduation, use, care and maintenance. Calibration of measuring instruments. Introduction to mechanical fasteners and its uses. Screw thread micrometer: Construction, graduation and use. (05 hrs.)
		89. Make sliding fits assembly with parallel and angular mating surface. (± 0.04 mm) (21 hrs.)	Dial test indicator, construction, parts, material, graduation, Method of use, care and maintenance. Digital dial indicator. Comparators-measurement of quality in the cylinder bores. (05 hrs.)
Professional Skill 95 Hrs; Professional Knowledge 15 Hrs	Produce components involving different operations on lathe observing standard procedure and check for accuracy. [Different Operations - facing, plain turning, step turning, parting, chamfering,	90. Lathe operations- 91. True job on four jaw chuck using knife tool. (5 hrs.) 92. Face both the ends for holding between centres. (06 hrs.) 93. Using roughing tool parallel turn ± 0.1 mm. (06 hrs.) 94. Measure the diameter using outside caliper and steel rule.(1 hr.)	Safely precautions to be observed while working on a lathe, Lathe specifications, and constructional features. Lathe main parts descriptions- bed, head stock, carriage, tail stock, feeding and thread cutting mechanisms. Holding of job between centres, works with catch plate, dog, simple description of a facing and roughing tool and their applications. (04 hrs.)

	shoulder turn, grooving, knurling, boring, taper turning, threading (external 'V' only)] **CSC/N0110**		
		95. Holding job in three jaw chuck. (2 hrs.) 96. Perform the facing, plain turn, step turn, parting, deburr, chamfer-corner, roundthe ends, and use form tools. (08 hrs.) 97. Shoulder turn: square, filleted, beveled undercut shoulder, turning-filleted under cut, square beveled. (08 hrs.) 98. Sharpening of -Single point Tools. (1 hr.)	Lathe cutting tools- Nomenclature of single point & multipoint cutting tools, Tool selection based on different requirements and necessity of correct grinding, solid and tipped, throw away type tools, cutting speed and feed and comparison for H.S.S., carbide tools. Use of coolants and lubricants. (03 hrs.)
		99. Cut grooves- square, round, 'V' groove. (08 hrs.) 100. Knurl the job. (1 hr.) 101. Bore holes -spot face, pilot drill, enlarge hole using boring tools. (9 hrs.)	Chucks and chucking the independent four-jaw chuck. Reversible features of jaws, the back plate, Method of clearing the thread of the chuck-mounting and dismounting, chucks, chucking true, face plate, drilling - method of holding drills in the tail stock, Boring tools and enlargement of holes. (02 hrs.)
		102. Turn taper (internal and external). (10 hrs.) 103. Turn taper pins. (5 hrs.) 104. Turn standard tapers to suit with gauge. (5 hrs.)	General turning operations- parallel or straight, turning. Stepped turning, grooving, and shape of tools for the above operations. Appropriate method of holding the tool on tool post or tool rest, Knurling: - tools description, grade, uses, speed and feed, coolant for knurling, speed, feed calculation. Taper - definition, use and method of expressing tapers. Standard tapers-taper, calculations Morse taper. (03 hrs.)
		105. Turn taper (internal and external). (10 hrs.) 106. Turn taper pins. (5 hrs.) 107. Turn standard tapers to suit with gauge. (5 hrs.)	Screw thread definition - uses and application. Square, worm, buttress, acme (nonstandard-screw threads), Principle of cutting screw thread in centre lathe - principle of chasing the screw thread - use of centre gauge, setting tool for cutting internal and external threads, use of screw pitch gauge for checking the screw thread. (03 hrs.)

Professional Skill 63 Hrs; Professional Knowledge 12Hrs	Plan & perform simple repair, overhauling of different machines and check for functionality. [Different Machines - Drill Machine, Power Saw, Bench Grinder and Lathe]N/A	108.Simple repair work: Simple assembly of machine parts from blueprints. (10 hrs.) 109.Rectify possible assembly faults during assembly. (14 hrs.) 110.Perform the routine maintenance with check list (08 hrs.) 111.Monitor machine as per routine checklist (3 hrs.) 112.Read pressure gauge, temperature gauge, oil level (1 hr.) 113.Set pressure in pneumatic system (2 hrs.)	**Maintenance** -Total productive maintenance -Autonomous maintenance -Routine maintenance -Maintenance schedule -Retrieval of data from machine manuals Preventive maintenance-objective and function of Preventive maintenance, section inspection. Visual and detailed, lubrication survey, system of symbol and colour coding. Revision, simple estimation of materials, use of handbooks and reference table. Possible causes for assembly failures and remedies. Installation, maintenance and overhaul of machinery and engineering equipment (10 hrs.)
		114.Assemble simple fitting using dowel pins and tap screw assembly using torque wrench. (15 hrs.)	Assembling techniques such as aligning, bending, fixing, mechanical jointing, threaded jointing, sealing, and torqueing. Dowel pins: material, construction, types, accuracy and uses. (02 hrs.)

Familiarisation industrial training institute in India

Objectives: At the end of this lesson you shall be able to
- **state what is ITI and brief the objectives of ITI**
- **describe the organizational chart**
- **list out the infrastructure available in ITI**
- **explain the job opportunities and carrier development after completion of courses**
- **brief the examination pattern and soft skills.**

Introduction to ITI

Industrial Training Institutes (ITI) and Industrial Training Centers (ITC) comes under Craftsman training Scheme (CTS) to provide Vocational training in various trades functioning under Directorate General of Training (DGT), Ministry of Skill Development and Entrepreneurship, Government of India.

ITIs and ITCs are one and the same; ITIs are governed by the state/union government, whereas, the ITCs are self-financing institutions to provide same training courses as ITI's. Trade test for ITI and ITC trainees are common and the National Trade Certificate issued by the National Council for Vocational Training (NCVT) is of the same standard.

The objectives of an ITI

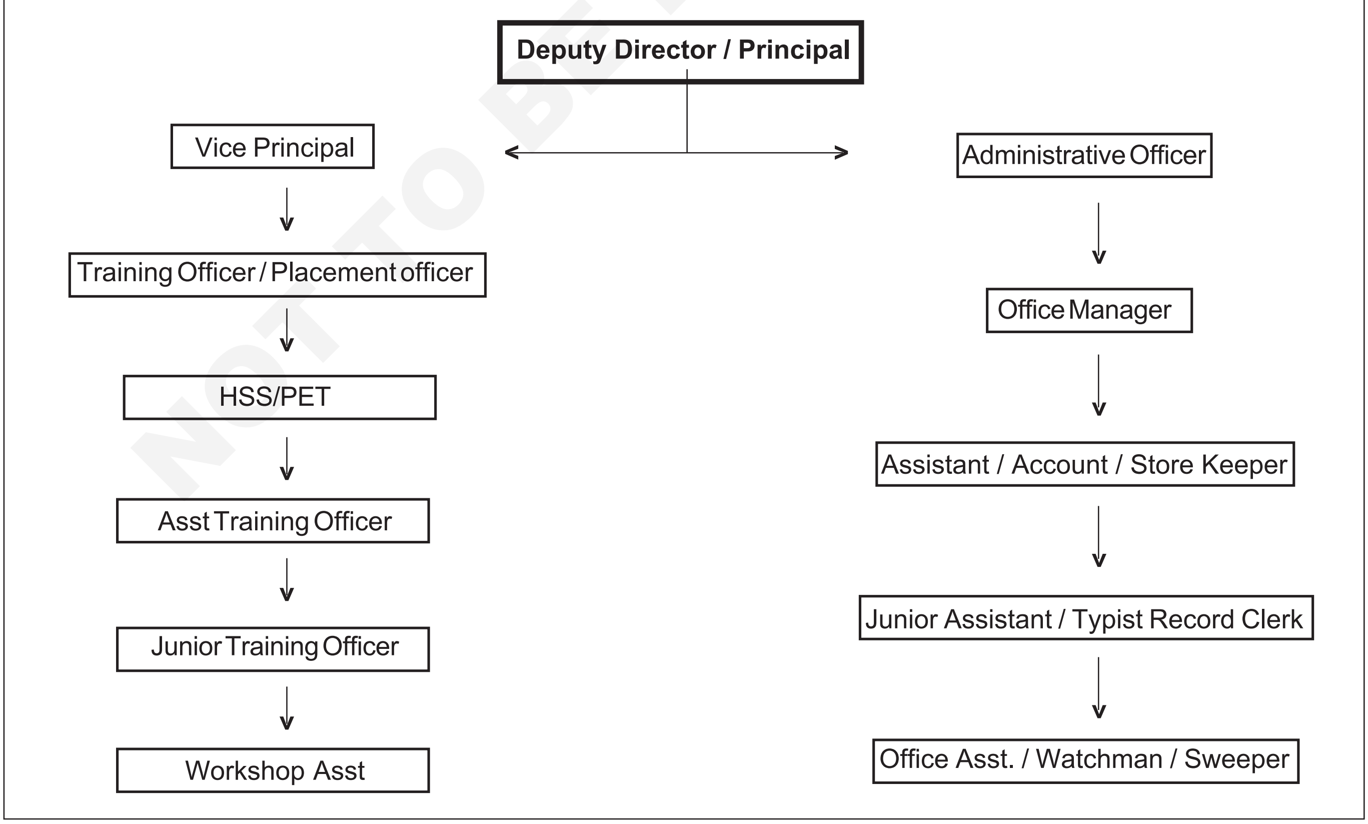
The objective of an ITI is to ensuring a steady flow of skilled workers and to reduce unemployment among the educated youth by training & equipping for suitable industrial employment and as well as for self employment.

The institute imparts training in engineering and non engineering two years/ one year trade courses approved by the Government of India in consultation with the National Council for Vocational Training, New Delhi.

Structure of ITI

The structure of industrial training institute is shown in the following chart 1. It may vary state to state It explain the information /order flow from higher superior officials to the ground level officials. The working hours may differ state to state. The trade master is the overall in-charge for the particular trade .the trainee has to report to trade master.

In every ITI there is a store and the incharge of the store is storekeeper for inward and outward movement of tools, equipment and consumables. The instructor will indent the training requirement for the training purposes.



Government Industrial Training Institute

Infrastructure available in ITI's

To provide 100% practical training to the trainees, tools, equipments, machineries and classroom facilities are available in ITI's. Continuous learning process/ programs are conducted in regular intervals as per the instructions given by the DGT.

The following facilities are available in ITI's

- Hostel facilities
- Libraries
- Soft skills lab/ computer labs
- High end classrooms /smart class.
- Stores
- Sports
- Wifi enabled campus.
- Industrial visit's/ Industrialist guest lecture
- Internship training on the job training
- Apprentice programs
- Campus interview etc

CTS Admission Process

Online counseling is conducted Statewide selection is made on merit basis duly following rules of reservation. The candidates exercise the option of choosing the ITI and trade of their choice.

Students between the age of 14 - 40 are admitted in Industrial Training Institutes. Admission is made during the month of August every year.

Craftsman Training Scheme Exam System

Final Trade Test is conducted on All India basis and the question papers are issued to all Trade Testing Centres on the same day by the NCVT. Passed-out candidates are issued with National Trade Certificate (NTC) under the seal and authority of NCVT by DGT, New Delhi

Job area after completion of training

This highlights the employability aspect on completion of training. The trainee should be aware of various prospects available in present market scenario along with scope for self-employment. For example a trainee with NTC engineering trade may opt for various jobs available in different industries in india and abroad.

After successful completion of training in any one of the engineering trade one can seek appointment in engineering workshop /Factories (Public Sector, Private Sector and Government Industries) in India and abroad as technician / Skilled worker.

Self employment

One can start is own factory / ancillary unit or design products manufacture and become an entrepreneur.

Further learning scope

- Apprentice training in designated trade.
- Craft Instructor certificate course.
- Diploma in relevant Engineering.

Skill competition

All India Skill Competition for Craftsmen scheme at national level was introduced to foster a healthy competition among the trainees of ITIs / ITCs

India skill competition is organized by National Skill Development Corporation., India skill competition the country's biggest skill competition is designed to demonstrate the highest standards of skilling and offers a platform to young people to show their talent at national level and international levels.

The competition is now held every year in 15 trades viz. Instrument Mechanic, Electronic Mechanic, Welder, Fitter, Turner, Machinist, Mechanic Motor Vehicle, Foundry man, Electrician, Cutting & Sewing, Computer Operator & Programming Assistant, Draughtsman (Civil), Draughtsman (Mechanical), Mechanic Diesel and Mechanic Refrigeration & Air- Conditioning.

The best trainee of each of the above trades at the State level competition competes at the All India Skill Competition.

Awards

The best Craftsmen in each of the above 15 trades at the All India level are awarded merit certificates and a cash prize of Rs. 50,000/- each. ITIs whose trainee stands first in the competition at the All India Skill Competition is awarded a merit certificate and is declared as the best ITI.

Approach on soft skills

Soft skills - refer to the cluster of personality traits, social graces, facility with language, personal habits, friendliness, and optimize that make people to varying degrees. The same can also be defined as-ability to interact communicates positively and productively with others. Sometimes called "character skills".

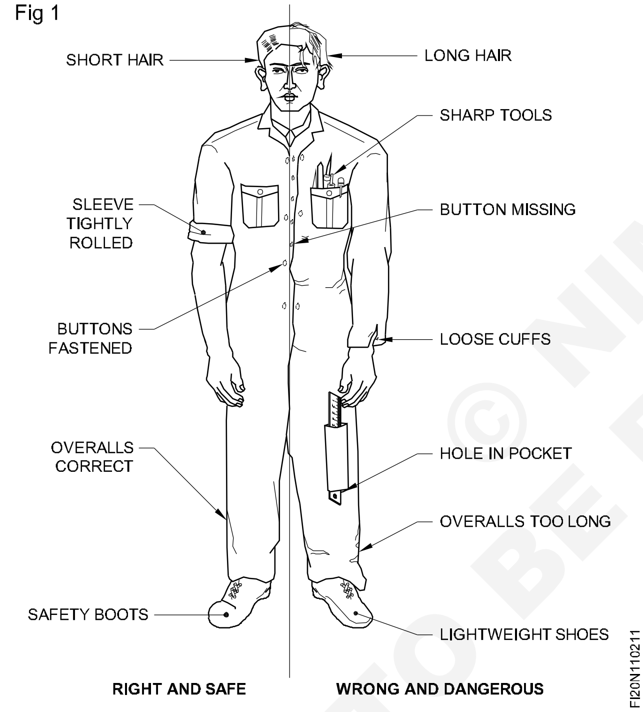
More and more business are considering soft skills as an important job criteria. Soft skills are used in personal and professional life. Hard skills / technical skills do not matter without soft skills.

Safety and general precautions in industry/shop floor

Objectives: At the end of this lesson you shall be able to
- **state the importance of safety**
- **list out the safety precautions to be observed in a industry/shop floor**
- **list out the personal safety precautions to be observed in machine shop**
- **list out the safety precautions to be observed while working on the machines.**

Generally accidents do not happen; they are caused. Most accidents are avoidable. A good craftsman, having a knowledge of various safety precautions, can avoid accidents to himself and to his fellow workers and protect the equipment from any damage. To achieve this, it is essential that every person should follow safety procedure. (Fig 1)

Fig 1



Safety in a workshop can be broadly classified into 3 categories.
- General safety
- Personal safety
- Machine safety

General safety

Keep the floor and gangways clean and clear.

Move with care in the workshop, do not run.

Don't leave the machine which is in motion.

Don't touch or handle any equipment/ machine unless authorised to do so.

Don't walk under suspended loads.

Don't crack practical jokes while on work.

Use the appropriate tools for the job.

Keep the tools at their proper place.

Wipe out split oil immediately.

Replace worn out or damaged tools immediately.

Never direct compressed air at yourself or at your co-worker.

Ensure adequate light in the workshop.

Clean the machine only when it is not in motion.

Sweep away the metal cuttings.

Know everything about the machine before you start it.

Personal safety

Wear a one piece overall or boiler suit.

Keep the overall buttons fastened.

Don't use ties and scarves.

Roll up the sleeves tightly above the elbow.

Wear safety shoes or boots

Cut the hair short.

Don't wear a ring, watch or chain.

Never lean on the machine.

Don't clean hands in the coolant fluid.

Don't remove guards when the machine is in motion.

Don't use cracked or chipped tools.

Don't start the machine until

– the workpiece is securely mounted

– the feed of machinery is in the neutral

– the work area is clear & neat.

Don't adjust clamps or holding devices while the machine is in motion.

Never touch the electrical equipment with wet hands.

Don't use any faulty electrical equipment.

Ensure that electrical connections are made by an authorised electrician only.

Concentrate on your work. Have a calm attitude.

Do things in a methodological way.

Don't engage yourself in conversation with others while concentrating on your job.

Don't distract the attention of others.

Don't try to stop a running machine with hands.

Machine safety

Switch off the machine immediately, if something goes wrong.

Keep the machine clean.

Replace any worn out or damaged accessories, holding devices, nuts, bolts etc as soon as possible.

Do not attempt operating the machine until you know how to operate it properly.

Do not adjust tool or the workpiece unless the power is off.

Stop the machine before changing the speed.

Disengage the automatic feeds before switching off.

Check the oil level before starting the machine.

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.

Safety is a concept, understand it. Safety is a habit, cultivate it.

Approach on soft skills

Objectives : At the end of this lesson you shall be to
- **state the concept of soft skill**
- **list the important common soft skills**
- **brief the employability aspect of training**
- **brief the further learning scope.**

Concept: Soft skills - refer to the cluster of personality traits, social graces, facility with language, personal habits, friendliness, and optimism that make people to varying degrees. The same can also be defined as an ability to interact communicate positively & productively with others. Sometimes called "character skills".

More and more business are considering soft skills as important job criteria. Soft skills are used in personal and professional life. Hard skills/technical skills do not matter without soft skills.

Common Soft Skills

- Strong work ethic
- Positive attitude
- Good communication skills
- Interpersonal skills
- Time management abilities
- Problem-solving skills
- Team work
- Initiative, Motivation
- Self-confidence
- Loyalty
- Ability to accept and learn from criticism
- Flexibility, Adaptability
- Working well under pressure

Job area completion of training: This highlights the employability aspect on completion of training. The trainee should be aware of various prospects available in present market scenario along with scope for self-employment. For example a trainee with NTC engineering trade may opt for:

Various job available in different industries in India and Abroad.

After successful completion of ITI training in any one of the engineering trade one can see appointment in engineering workshop/Factories (Public Sector, Private Sector and Government Industries) in India and Abroad as technician/Skilled worker.

Self employment

One can start is own factory/ancillary unit or design products manufacture and became an entrepreneur.

Further learning scope

- Apprentice training in designated trade.
- Craft Instructor certificate course.
- Diploma in relevant Engineering.

Personal Protective Equipment (PPE)

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

Scan the QR Code to view the video for this exercise

Personal protective equipment

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests and full body suits.

Categories of PPE-Small's'

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

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

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

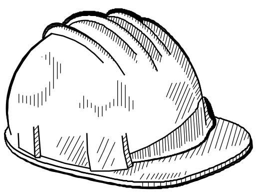
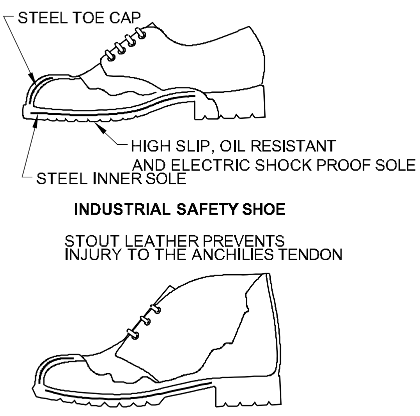
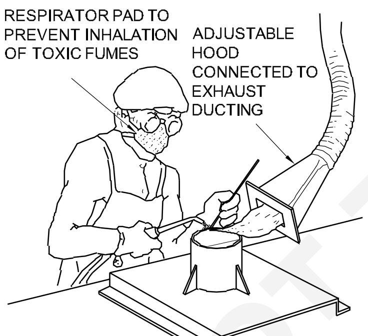
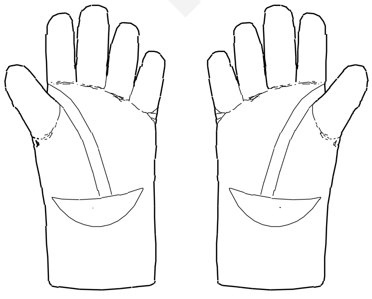
They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

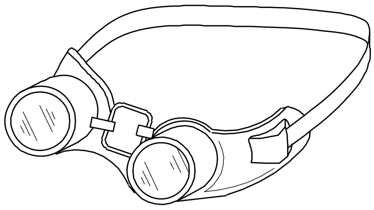
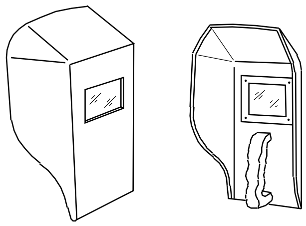
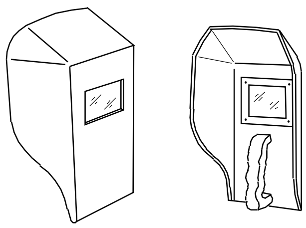
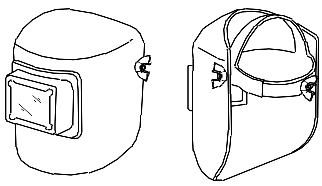
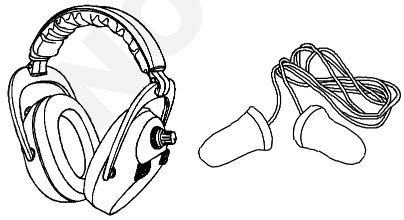
The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective program with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

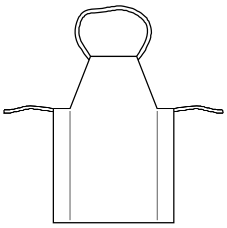
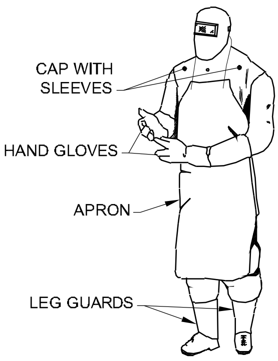
Table 1

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

Personal protective equipment and their uses and hazards are listed in Table 2

Types of protection	Hazards	PPE to be used
Head protection (Fig 1) HELMET 	1. Falling objects 2. Striking against objects 3. Spatter	Helmets
Foot protection (Fig 2)  INDUSTRIAL SAFETY SHOE INDUSTRIAL SAFETY BOOT	1. Hot spatter 2. Falling objects 3. Working wet area	Leather leg guards Safety shoes Gum boots
Nose (Fig 3)  	1. Dust particles 2. Fumes/gases/ vapours	Nose mask
Hand Protecion (Fig 4)  GLOVES	1. Heat burn due to direct contact 2. Blows spark moderate heat 3. Electric shock	Hand gloves

Types of protection	Hazards	PPE to be used
Eye protection (Fig 5 & Fig6)   HAND SCREEN	1. Flying dust particles 2. UV rays, IR rays heat and High amount of visible	Goggles Face shield radiation Hand shield Head shield
Face protection (Fig 6 &Fig 7)  HAND SCREEN  WELDING HELMET	1. Spark generated during Welding, grinding 2. Welding spatter striking 3. Face protection from UV rays	Face shield Head shield with or without ear muff Helmets with welders Screen for welders
Ear protection (Fig 7) EAR MUFFS EAR PLUG 	1. High noise level	Ear plug Ear muff

Types of protection	Hazards	PPE to be used
Body protection (Fig 8, & Fig 9)  APRON LEATHER APRONS  	1. Hot particles	Leather aprons

Quality of PPE's

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

Selection of PPE's requires certain conditions

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

Proper use of PPEs

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

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

First-aid

Scan the QR Code to view the video for this exercise

Objectives: At the end of this lesson you shall be able to
- **state what is first aid**
- **list the important guide lines for the first aid**
- **explain the ABC of the first aid**
- **brief how to give first-aid for a victim who need first aid.**

Basic first aid: Basic first aid refers to the initial process of assessing and addressing the needs of someone who has been injured or is in physiological distress due to choking, a heart attack, allergic reactions, drugs or other medical emergencies. Basic first aid allows one to quickly determine a person's physical condition and the correct course of treatment.

Golden hours: India have best of technology made available in hospitals to treat devastating medical problem viz. head injury, multiple trauma, heart attack, strokes etc, but patients often do poorly because they don't gain access to that technology in time. The risk of dying from these conditions, is greatest in the first 30 minutes, often instantly. This period is referred to as Golden period. By the time the patient reach hospitals, they would have passed that critical period. First aid care come handy to save lives. It helps to get to the nearest emergency room as quickly as possible through safe handling and transportation. The shorter that time, the more likely the best treatment applied.

Important guideline for first aiders

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

Remember A-B-Cs

The ABCs of first aid refer to the three critical things the first aiders need to look for.

- Airway - Does the person have an unobstructed airway?
- Breathing - Is the person breathing?
- Circulation - Does the person show a pulse at major pulse points (wrist, carotid artery, groin)

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

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

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

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

- Keep head and neck aligned.
- Carefully roll them onto their back while holding his head.
- Open the airway by lifting the chin. (Fig 1)

Fig 1

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Look, listen and feel for signs of breathing

Look for the victim's chest to raise and fall, listen for sounds of breathing.

If the victim is not breathing, see the section below

- If the victim is breathing, but unconscious, roll them onto their side, keeping the head and neck aligned with the body. This will help drain the mouth and prevent the tongue or vomit from blocking the airway.

Check the victim's circulation: Look at the victim's colour and check their pulse (the carotid artery is a good option; it is located on either side of the neck, below the jaw bone). If the victim does not have a pulse, start CPR.- If you are trained.

Treat bleeding, shock and other problems as needed

After establishing that the victim is breathing and has a pulse, next priority should be to control any bleeding. Particularly in the case of trauma, preventing shock is the priority.

- **Stop bleeding:** Control of bleeding is one of the most important things to save a trauma victim. Use direct pressure on a wound before trying any other method of managing bleeding.
- **Treat shock:** Shock, a loss of blood flow from the body, frequently follows physical and occasionally psychological trauma. A person in shock will frequently have ice cold skin, be agitated or have an altered mental

status, and have pale colour to the skin around the face and lips. Untreated, shock can be fatal. Anyone who has suffered a severe injury or life-threatening situation is at risk for shock.

- **Choking victim:** Choking can cause death or permanent brain damage within minutes.
- **Treat a burn:** Treat first and second degree burns by immersing or flushing with cool water. Don't use creams, butter or other ointments, and do not pop blisters. Third degree burns should be covered with a damp cloth. Remove clothing and jeweler from the burn, but do not try to remove charred clothing that is stuck to burns.
- **Treat a concussion:** If the victim has suffered a blow to the head, look for signs of concussion. Common symptoms are: loss of consciousness following the injury, disorientation or memory impairment, vertigo, nausea, and lethargy.
- **Treat a spinal injury victim:** If a spinal injury is suspected, it is especially critical, not move the victim's head, neck or back unless they are in immediate danger.

Stay with the victim until help arrives: Try to be a calming presence for the victim until assistance can arrive.

Unconsciousness (COMA): Unconscious also referred as Coma, is a serious life threatening condition, when a person lie totally senseless and do not respond to calls, external stimulus. But the basic heart, breathing, blood circulation may be still intact, or they may also be failing. If unattended it may lead to death.

The condition arises due to interruption of normal brain activity. The causes are too many.

- Shock (Cardiogenic, Neurogenic)
- Head injury (Concussion, Compression)
- Asphyxia (obstruction to air passage)
- Extreme of body temperature (Heat, Cold)
- Cardiac arrest (Heart attack)
- Stroke (Cerebra-vascular accident)
- Blood loss (Hemorrhage)
- Dehydration (Diarrhea & vomiting)
- Diabetes (Low or high sugar)
- Blood pressure (Very low or very high)
- Over dose of alcohol, drugs
- Poisoning (Gas, Pesticides, Bites)
- Epileptic fits (Fits)
- Hysteria (Emotional, Psychological)

The following symptoms may occur after a person has been unconscious:

- Confusion
- Drowsiness
- Headache
- Inability to speak or move parts of his or her body (see stroke symptoms)
- Light headedness
- Loss of bowel or bladder control (incontinence)
- Rapid heartbeat (palpitation)
- Stupor

First aid

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

DO NOT

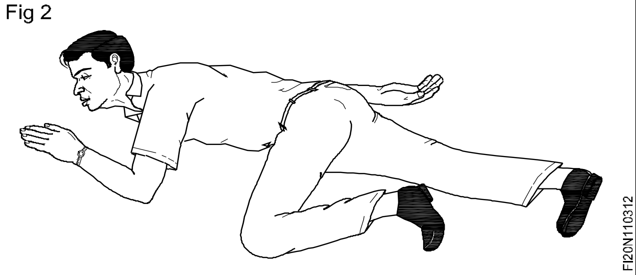
- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

Loss of consciousness may threaten life if the person is on his back and the tongue has dropped to the back of the throat, blocking the airway. Make certain that the person is breathing before looking for the cause of unconsciousness. If the injuries permit, place the casualty in the recovery position with the neck extended. Never give anything by mouth to an unconscious casualty.

How to diagnose an unconscious injured person

- **Consider alcohol:** look for signs of drinking, like empty bottles or the smell of alcohol.
- **Consider epilepsy:** are there signs of a violent seizure, such as saliva around the mouth or a generally disheveled scene?
- **Think insulin:** might the person be suffering from insulin shock (see 'How to diagnose and treat insulin shock")?

Fig 2



- **Think about drugs:** was there an overdose? Or might the person have under dosed - that is not taken enough of a prescribed medication?
- **Consider trauma:** is the person physically injured?
- **Look for signs of infection:** redness and/ or red streaks around a wound.
- **Look around for signs of Poison:** an empty bottle of pills or a snakebite wound.
- **Consider the possibility of psychological trauma:** might the person have a psychological disorder of some sort?
- Consider stroke, particularly for elderly people.
- Treat according to what you diagnose.

Shock: A severe loss of body fluid will lead to a drop in blood pressure. Eventually the blood's circulation will deteriorate and the remaining blood flow will be directed to the vital organs such as the brain. Blood will therefore be directed away from the outer area of the body, so the victim will appear pale and the skin will feel ice cold.

Operation of electrical mains

Objectives : At the end of this lesson you shall be able to
- **explain the term 'emergency'**
- **explain the need to switch off the circuit during emergency**
- **explain the method of locating the area sub-main and switches in the shop floor**
- **explain the position of handle with respect to ON & OFF in case of iron clad switches, MCB and ordinary house hold stitches.**

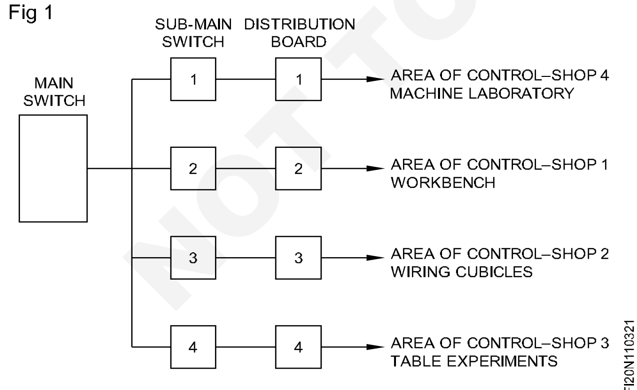
Scan the QR Code to view the video for this exercise

An emergency is an unexpected occurrence and requires immediate action. In a place like a workshop such a situation can arise when a person gets a shock due to electrical current or a person gets injured by the rotating part of a machine.

In such situations, switching off the supply will be the first and best solution to avoid further damage to the victim. For this, every person involved in the workshop should know which switch controls the area where the victim of shock remains.

Normally the total wiring in a workshop is controlled by a main switch and the different areas within the workshop may have two or more sub-main switches as shown in Fig.1.

Fig 1



To ascertain the area of the sub-main control, switch off one of the sub-main switches and try to switch 'on' the lights, fans and power points in that suspected area. If they do not work, then the area covered by the fan, light and power points are controlled by the sub-main switch. One after another, switch off the sub-main switches and locate their area of control. Mark the area of control of the switch in the plan of the wireman's section.

In a well organised workshop, the main switch, the sub main switches and distribution ways will have clear marking to show their area of control. (Fig 1) If this is not found, do this now. However, If you are not sure about the area of control the sub-main of the switches it is always better to switch 'off' the main switch itself.

Fig 2

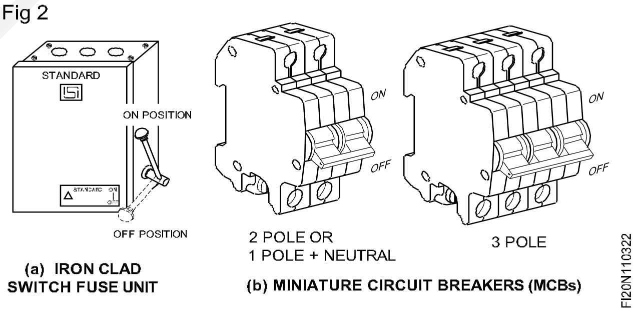
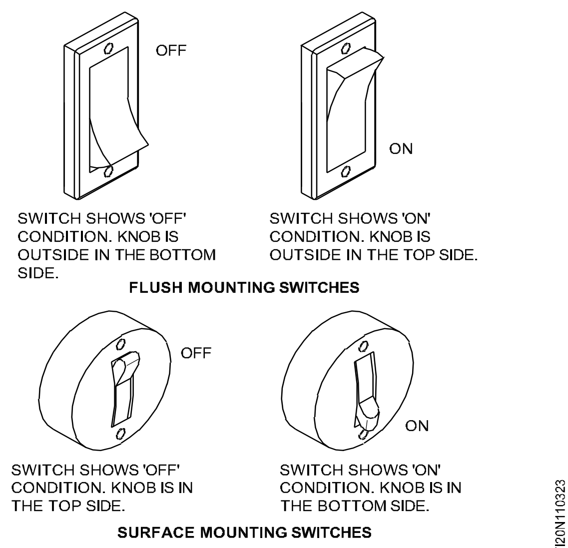


Fig 3



The handle of iron clad switches and the knob of MCB should be pushed down to switch 'off ' the circuits as shown in Fig 2. whereas in the ordinary switches, the switch off the circuit should be done by pushing the switch to upward position. (Fig 3)

The emergency situations could happen even at home Hence, identify the area of control of the switch and mark them in the main/sub-main/ distribution bound of your house switch board as a safety measure. Educate the intimates of the house how to switch off the circuit in case of any emergency.

Electrical safety

Objectives : At the end of this lesson you shall be able to
- **explain the necessary of adopting the safety rules**
- **list the safety rules and follow them.**

Safety rules

Necessity of safety rules: Safety consciousness is one of the essential attitudes required for any job. A skilled electrician always should strive to form safe working habits. Safe working habits always save men, money and material. Unsafe working habits always end up in loss of production and profits, personal injury and even death. The safety hints given below should be followed by Electrician to avoid accidents and electrical shocks as his job involves a lot of occupational hazards.

The listed safety rules should be learnt, remembered and practised by every electrician. Here a electrician should remember the famous proverb, "Electricity is a good servant but a bad master".

Safety rules

- Only qualified persons should do electrical work
- Keep the workshop floor clean, and tools in good condition.
- Do not work on live circuits, if unavoidable, use rubber gloves rubber mats, etc.
- Use wooden or PVC insulated handle screwdrivers when working on electrical circuits.
- Do not touch bare conductors.
- When soldering, place the hot soldering irons in their stand. Never lay switched 'ON' or heated soldering iron on a bench or table as it may cause a fire to break out.
- Use only correct capacity fuses in the circuit. If the capacity is less it will blow out when the load is connected. If the capacity is large, it gives no protection and allows excess current to flow and endangers men and machines, resulting in loss of money.
- Replace or remove fuses only after switching off the circuit switches.
- Use extension cords with lamp guards to protect lamps against breakage and to avoid combustible material coming in contact with hot bulbs.
- Use accessories like sockets, plugs and switches and appliances only when they are in good condition and be sure they have the mark of BIS (ISI). (Necessity using BIS (ISI) marked accessories is explained under standardisation.
- Never extend electrical circuits by using temporary wiring.
- Stand on a wooden stool, or an insulated ladder while repairing live electrical circuits/appliances or replacing fused bulbs. In all the cases, it is always good to open the main switch and make the circuit dead.
- Stand on rubber mats while working/ operating switch panels, control gears etc.
- Position the ladder, on firm ground.
- While using a ladder, ask the helper to hold the ladder against any possible slipping.
- Always use safety belts while working on poles or high rise points.
- Never place your hands on any moving part of rotating machine and never work around moving shafts or pulleys of motor or generator with loose shirt sleeves or dangling neck ties.
- Only after identifying the procedure of operation, operate any machine or apparatus.
- Run cables or cords through wooden partitions or floor after inserting insulating porcelain tubes.
- Connections in the electrical apparatus should be tight. Loosely connected cables will heat up and end in fire hazards.
- Use always earth connection for all electrical appliances along with 3-pin sockets and plugs.
- While working on dead circuits remove the fuse grips; keep them under safe custody and also display 'Men on line' board on the switchboard.
- Do not meddle with inter locks of machines/switch gears
- Do not connect earthing to the water pipe lines.
- Do not use water on electrical equipment.
- Discharge static voltage in HV lines/equipment and capacitors before working on them.

Disposal of waste material

Scan the QR Code to view the video for this exercise

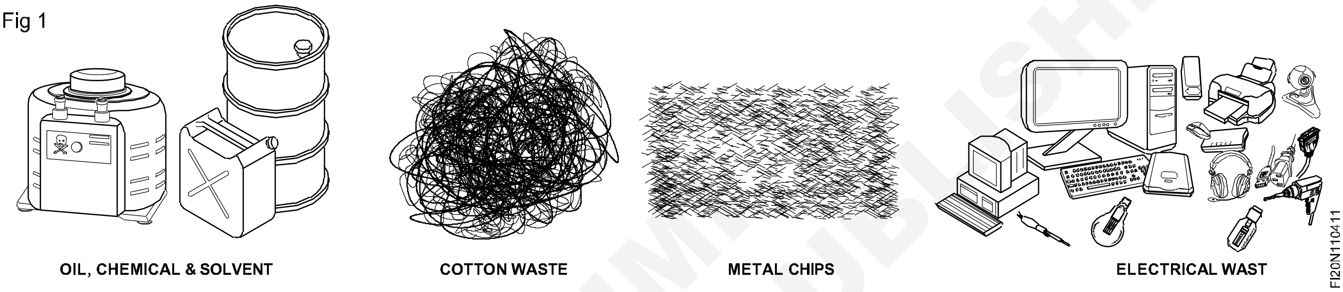
Objectives: At the end of this lesson you shall be able to
- **state what is waste material**
- **list the waste materials in a work shop**
- **explain the methods of disposal of waste material.**
- **state advantage of disposal of waste material.**
- **state colour code for bins for waste segregation.**

Waste material: industrial waste is the waste produced by industrial activity such as that of factories, mills and mines.

List of waste material (Fig 1)

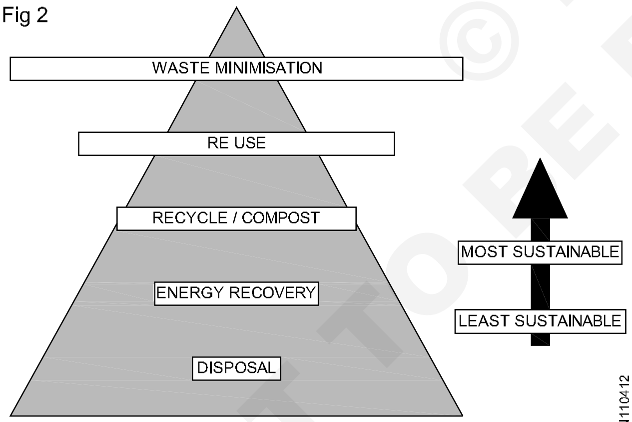
- Cotton waste
- Metal chips of different material.
- Oily waste such as lubricating oil, coolant etc.
- Other waste such electrical, glass etc.

Fig 1



Methods of waste disposal (Fig 2)

Fig 2



METHOD OF WASTE DISPOSAL

Recycling: Recycling is one of the most well known method of managing waste. It is not expensive and can be easily done by you. If you carry out recycling. you will save a lot of energy, resources and thereby reduce pollution.

Composting: This is a natural process that is completely free of any hazardous by-products. This process involves breaking down the materials into organic compounds that can be used as manure.

Landfills: Waste management through the use of landfills involves the use of a large area. This place is dug open and filled with the waste.

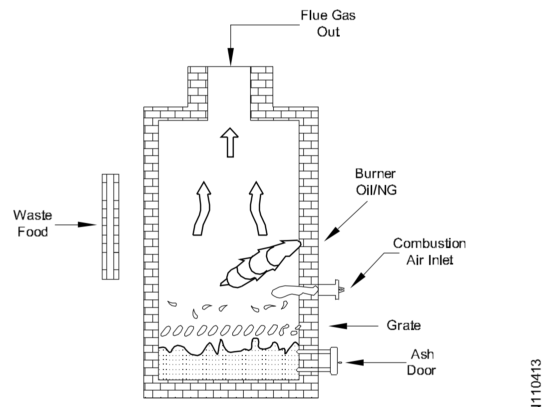
Burning the waste material: If you cannot recycle or if there are no proper places for setting up landfills, you can burn the waste matter generated in your household. Controlled burning of waste at high temperatures to produce steam and ash is a preferred waste disposal technique.

Advantage of waste disposal:

- Ensures workshop neat & tidy
- Reduces adverse impact on health
- Improves economic efficiency
- Reduce adverse impact on environment

Incineration (Fig 3)

Fig 3



INCINERATION PROCESS

It is the process of controlled combustion of garbage to reduce it to incombustible matter, ash, waste gas and heat. It is treated and released into the environment (Fig 3). This reduced 90% volume of waste, some time the heat generated used to produce electric power.

Waste compaction: The waste materials such as cans and plastic bottles compact into blocks and send for recycling. This process space need, thus making transportation and positioning easy.

Colour code for bins for waste segregation given in Table 1

Table 1

Sl.No.	Waste Material	Color code
1	Paper	Blue
2	Plastic	Yellow
3	Metal	Red
4	Glass	Green
5	Food	Black
6	Others	Sky blue

Occupational safety and health

Objectives: At the end of this lesson you shall be able to
- **describe occupational safety and its importance at work place to prevent unsafe act and conditions in work-related activities**
- **brief the Environmental guidelines, legislations & regulations in India, framed to protect workplace health and safety.**
- **list the Occupational safety and health Tips.**

Occupational safety, and health

Occupational safety, and health means actions or working conditions which are safe from any cause resulting in danger to life, physique, mentality or health arising out of or related to working environment. OSH includes the laws, standards and programs that are aimed at making the workplace better for workers, along with co-workers, family members, customers, and other stakeholders.

The goal of Occupational safety and health

The goal of Occupational safety and health program is to foster a safe and healthy occupational environment. OSH also protects all the general public who may be affected by the occupational environment.

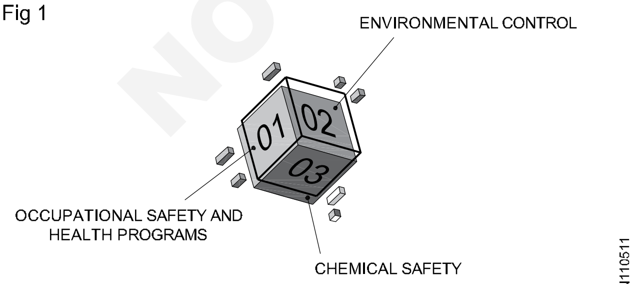
Environmental safety

Environmental safety is defined by the guidance, policies, and practices enforced in order to ensure that the surrounding environment is free from hazards that will warrant the safety and well-being of workers and employees, residents near industrial operations, as well as the prevention of accidental environmental damage

The surrounding areas include industrial facilities, work areas, and laboratories. Environmental safety is a crucial issue for any industrial activity as negligence and non-compliance heighten the risk resulting in injuries, illnesses, and accidental environmental releases.

Environmental safety is usually divided into three subcategories: (fig1) Occupational safety and Health Programs, Environmental Control, and Chemical Safety. (Fig 1)

Fig 1



ENVIRONMENTAL SAFETY SEGMENTS

In order to protect the workers against work related sickness, disease and injury. The International labour organization(ILO) came up with an official order on OSH.

Similarly government of India is enacted the following acts

- The legislation for labour welfare, known as the Factories Act 1948, was enacted with the prime objective of protecting workmen employed in factories against industrial and occupational hazards. There are number of Acts enacted by the government of India and amended from time to time; among them the following are the most important ones in this regard:
- Factories Act, 1948,
- Mines Act, 1952,
- Dock workers (Safety, Health and welfare) Act, 1986,
- Building and other Construction workers (Regulation of Employment and conditions of service) Act, 1996,
- Plantation Labour Act, 1951,
- Contract Labour (Regulation and Abolition) Act, 1970
- The Child labour (Prohibition and Regulation) Act, 1986, etc.

Constitutional provisions form the basis of workplace safety and health laws in India by imposing a duty on the State governments to implement policies that promote the safety and health of workers at workplaces. In addition, safety and health statutes for regulating occupational safety and health (OSH) of persons at work exist in different sectors, namely manufacturing, mining, ports, and construction sector.

The health and safety at work Act,1974 states employers are responsible for protecting the safety of their employees at work by preventing potential dangers in the workplace. It places general duties on employers to ensure the health, safety and welfare of all persons while at work.

Legislation is a directive proposed by a legislative body while a regulation is a specific requirement within legislation. Legislation is broader and more general while regulation is specific and details how legislation is enforced.

The difference between legislation and regulation is that legislation is the act of process of making certain laws while regulation is maintaining the law or set of rules that govern the people. It is a government-driven or ministerial order having the force of law.

The ILO's primary goal is to promote opportunities for women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity. In 2003 the ILO adopted a global strategy to improve preventive standards on occupational safety and health to provide essential tools for governments, employers, and workers to establish safe practices and health culture for providing maximum safety at work.

The four important aims of health and safety legislation is to

i secure the safety, health and welfare of employees and other people at work;

ii protect the public from the safety and health risks of business activities;

iii amend statutes relating to safety aspects of substances, equipment and environment;

iv eliminate workplace risks at the source.

Occupational safety and health Tips:

- Be aware of your surroundings.
- Maintain a correct posture.
- Take break regularly.
- Use Equipment properly.
- Locate Emergency Exits.
- Report Unsafe conditions.
- Practice Effective Housekeeping.
- Make use of mechanical aids.
- Wear the correct Safety equipment.
- Reduce workplace stress.

Scan the QR Code to view the video for this exercise

Safety signs

Objective : At the end of this lesson you shall be to
- **state the safety attitude and list the four basic categories of safety signs.**

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

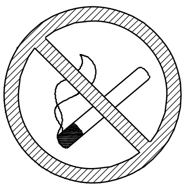
Safety signs fall into four separate categories. These can be recognised by their shape and colour. Sometimes they may be just a symbol; other signs may include letters or figures and provide extra information such as the clearance height of an obstacle or the safe working load of a crane.

The four basic categories of signs are as follows:

- prohibition signs (Fig 1 & Fig 5)
- mandatory signs (Fig 2 & Fig 6)
- warning signs (Fig 3 & Fig 7)
- information signs (Fig 4)

Fig 1

PROHIBITION SIGNS



SHAPE CIRCULAR

COLOUR RED BORDER AND CROSS BAR. BLACK SYMBOL ON WHITE BACKGROUND

MEANING WARNS OF HAZARD OR DANGER.

EXAMPLE CAUTION,RISK OF ELECTRIC SHOCK

FI20N110611

Fig 2

MANDATORY SIGNS

SHAPE CIRCULAR

COLOUR RED BORDER AND CROSS BAR. BLACK SYMBOL ON WHITE BACKGROUND

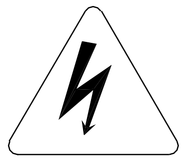
MEANING WARNS OF HAZARD OR DANGER.

EXAMPLE CAUTION,RISK OF ELECTRIC SHOCK

FI20N110612

Fig 3

WARNING SIGNS



DANGER
415V

SHAPE CIRCULAR

COLOUR RED BORDER AND CROSS BAR. BLACK SYMBOL ON WHITE BACKGROUND

MEANING WARNS OF HAZARD OR DANGER.

EXAMPLE CAUTION,RISK OF ELECTRIC SHOCK

FI20N110613

Fig 4

INFORMATION SIGNS

SHAPE CIRCULAR

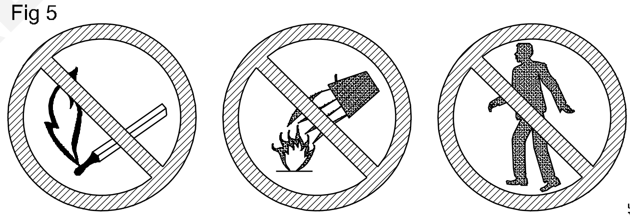
COLOUR RED BORDER AND CROSS BAR. BLACK SYMBOL ON WHITE BACKGROUND

MEANING WARNS OF HAZARD OR DANGER.

EXAMPLE CAUTION,RISK OF ELECTRIC SHOCK

FI20N110614

Fig 5



SMOKING AND NAKED FLAMES PROHIBITED | DO NOT EXTINGUISH WITH WATER | PEDESTRIANS PROHIBITED

FI20N110615

Mandatory signs

Fig 6

Warning signs

Fig 7

Question about your safety

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

Are you familiar with the safety laws that govern you 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 provided with all the necessary safety equipment?

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

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

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

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

Response to emergencies

Scan the QR Code to view the video for this exercise

Objectives: At the end of this lesson you shall be able to
- **respond incase of power failure, system failure and fire**
- **report an emergency.**

Power failure, System failure & Fire

1 If there is a power failure, start the emergency generator. This provides power to close the shutter, which is the first priority. The generator will also keep the UPSs and the cryogenic compressors running,

- Get a flash light.
- Look out for power transfer switch and switch over to normal power to emergency power by pressing the latch.
- Check the fuel valves open or not - Open the valves.
- Check to see that the main breaker switch ON the generator is in OFF position.
- Move the starter switch of the generator to run position. The engine will start at once.
- Allow few minutes to warm up the engine.
- Check all the gauges, pressure, temperature, voltage and frequency.
- Check the "AC line" and "Ready" green light on the front panel.

2 System failure

- If the bug or virus, invades the system. The system failure happens.
- Several varieties of bugs are there

1 Assasin bug

2 Lightening bug

3 Brain bug

For more details refer instruction manual for "System failure".

3 Fire

When fire alarm sounds in your buildings

- Evacuate to outside immediately.
- Never go back
- Make way for fire fighters and their trucks to come
- Never use an elevator
- Do not panic

Report an emergency

Reporting an emergency is one of those things that seems simple enough, until actually when put to use in emergency situations. A sense of shock prevail at the accident sites. Large crowd gather around only with inquisitive nature, but not to extend helping hands to the victims. This is common in road side injuries. No passer by would like to get involved to assist the victims. Hence first aid managements is often very difficult to attend to the injured persons. The first aiders need to adapt multitask strategy to control the crowd around, communicate to the rescue team, call ambulance etc, all to be done simultaneously. The mobile phones helps to a greater deal for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure that the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extermely disruptive.

- A fire - If you're reporting a fire, describe how the fire started and where exactly it is located. If someone has already been injured, missing, report that as well.
- A life - threatening medical emergency, explain how the incident occurred and what symptoms the person currently displays.

Call emergency service

The emergency number varies - 100 for Police & Fire, 108 for Ambulance.

Report your location

The first thing the emergency dispatcher will ask where you are located, so the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information.

Scan the QR Code to view the video for this exercise

Importance of housekeeping

Objectives: At the end of this lesson you shall be able to
- **list the steps involves in house keeping**
- **state good shop floor practices followed in industry**

Housekeeping

The following activities to be performed for better up keep of working environment:

- **Cleaning of shop floor:** Keep clean and free from accumulation of dirt and scrap daily
- **Cleaning of Machines :** Reduce accidents to keep machines cleaned well
- **Prevention of Leakage and spillage:** Use splash guards in machines and collecting tray
- **Disposal of Scrap-** Empty scrap, wastage, sward from respective containers regularly
- **Tools Storage-** Use special racks, holders for respective tools
- **Storage Spaces:** Identify storage areas for respective items. Do not leave any material in gangway
- **Piling Methods-** Do not overload platform, floor and keep material at safe height.
- **Material handling:** Use forklifts, conveyors and hoist according to the volume and weight of the package.

Good shop floor practices followed in industry

Good Shop floor practices are motivating action plans for improvement of the manufacturing process.

- All workers are communicated with daily target on manufacturing, activities.
- Informative charts are used to post production, quality and safety results compared to achievements.
- Workers are trained on written product quality standards.
- Manufactured parts are inspected to ensure adherence to quality standards.
- Production processes are planned by engineering to minimize product variation.
- 5s methods are used to organize the shop floor and production lines.
- Workers are trained on plant safety practices in accordance with Occupational Safety Health (OSH) standards.
- Workers are trained on "root cause" analysis for determining the causes of not following.
- A written preventive maintenance plan for upkeep of plant, machinery & equipment
- Management meets with plant employees regularly to get input on process improvements.
- Process Improvement Teams are employed to implement "best practices"

Introduction to 5S concept and its application

Objectives: - At the end of this lesson you shall be able to
- **stat what is 5S**
- **state the general benefits of implementing 5S**
- **explain the terms in 5S and its concept of implementation.**

Introduction

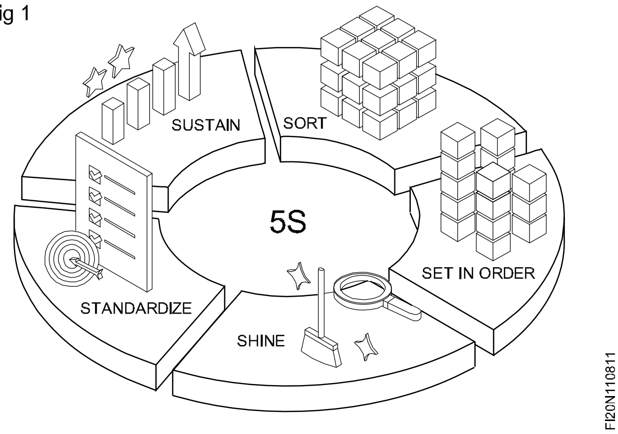
5S is a philosophy and a way of organizing and managing the workspace and work flow with the intent to improve efficiency by eliminating waste, improving flow and reducing process unreasonableness. There are five steps in the system, each starting with the letter S:

1 Sort   2 Set in order   3 Shine
4 Standardize   5 Sustain

The Steps of 5S (Fig 1)

5S was created in Japan, and the original "S" terms were in Japanese, so English translations for each of the five steps may vary. The basic ideas and the connections between them are easy to understand, though.

Fig 1

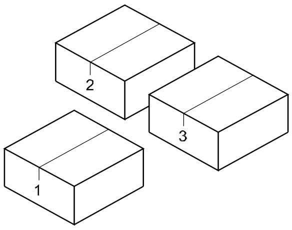


Step Name	Japanese term	Explanation
1	Sort Seri (tidiness)	Remove unnecessary items from each area
2	Set In Order	Seiton (orderliness) Organize and identify storage for efficient use
3	Shine Seiko (cleanliness)	Clean and inspect each area regularly
4	Standardize	Seiketsu (standardization) Incorporate 5S into standard operating procedures
5	Sustain Shinseki (discipline)	Assign responsibility, track progress, and continue the cycle

Step 1 Sort

The first step in the 5S process is Sort, or "seiri," which translates to "tidiness." The goal of the Sort step is to eliminate clutter and clear up space by removing things that don't belong in the area. (Fig 2)

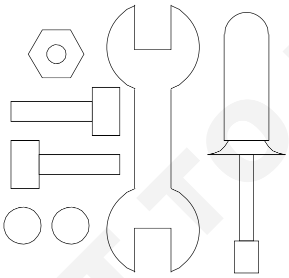
Fig 2



Step 2: Set In Order

The second step, Set in Order, was originally called "seiton," which translates to "orderliness." A variety of names have been used in English: "Systematic Organization," "Straightening Out," and "Simplify," for example. No matter what it's called, the goal of this step is to organize the work area. Each item should be easy to find, use, and return: a place for everything, and everything in its place. (Fig 3)

Fig 3



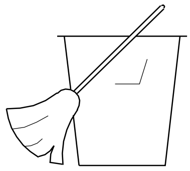
Implementation steps of Set in order

- Draw up a map, and then implement it
- Physically arrange the workplace first, and then map it out
- Map as you go, testing ideas and writing down what works well

Step 3: Shine

The third step of 5S is Shine, or "seiso," which means "cleanliness." While the first and second steps cleared up space and arranged the area for efficiency, this step attacks the dirt and grime that inevitably builds up underneath the clutter, and works to keep it from coming back.(Fig 4)

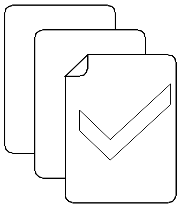
Fig 4



Step 4: Standardize

The fourth step is Standardize, or "seiketsu," which simply means standardization. By writing down what is being done, where, and by whom, you can incorporate the new practices into normal work procedure. This paves the way for long-term change.(Fig 5)

Fig 5



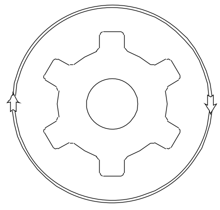
Tools for Standardizing

- 5S checklists
- Job cycle charts
- Procedure labels and signs

Step 5: Sustain

The fifth step of a 5S program is Sustain, or "shitsuke," which literally means "discipline." The idea here is continuing commitment. It's important to follow through on the decisions that you've made and continually return to the earlier steps of 5S, in an ongoing cycle. (Fig 6)

Fig 6



Sustaining a 5S program can mean different things in different work places, but there are some elements that are common in successful programs.

- Management support
- Department tours
- Updated training
- Progress audits
- Performance evaluations

Basic understanding on hot work, confined space work and material handing equipment

Objectives: At the end of this lesson you shall be able to
- **state what is hot working**
- **brief confined space work**
- **use of material handling equipment.**

Hot work

Hot work is defined as forging, gas cutting, welding, soldering and brazing operations for construction, maintenance/repair activities.

Hot work fire and explosive hazards. Workers performing hot work such as welding, gas cutting, brazing, soldering are exposed to the risk of fires from ignition or flammable or combustible materials in the space, and from leaks of flammable gas into the space, from hot work equipment.

A confined space also has limited or restricted means for entry or exist and is not designed for continuous occupancy. It includes but are not limited to tanks, vessels, silos, storage bins, hoppers, vaults, pits, manholes, tunnels, equipment housings, duct work, pipelines, etc.

Materials handling equipment

Materials handling equipment is a mechanical equipment used for the movement, storage, control and protection / protecting of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal.

Different types of material handling equipment

- Tools
- Vehicles
- Storage units
- Appliance and accessories

Racks

Pallet racks, drive-through or drive-in racks, push back racks, and sliding racks.

Truck/Trolley

Conveyor system

- Fork lift
- Cranes
- Pallet truck

Lifting and handling loads

Objectives : At the end of this lesson you shall be able to
- **state the types of injury caused by the improper method of lifting and carrying loads and how to prevent them**
- **state the 6 points in the process of manual lifting methods.**

Scan the QR Code to view the video for this exercise

Many of the accidents reported involve injuries caused by lifting and carrying loads. Wrong lifting techniques can result in injury.

A load need not necessarily be very heavy to cause injury The wrong way of lifing may cause injury to the muscles and joints even though the load is not heavy.

Further injuries during lifting and carrying may be caused by tripping over and object and falling or striking an object with a load.

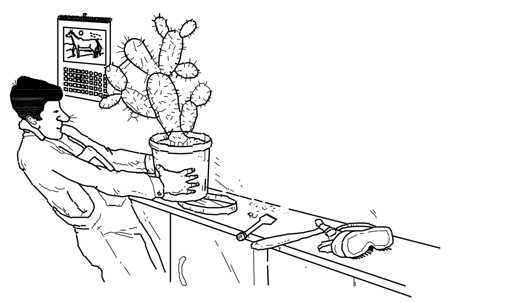
Type of injury and how to prevent them?

Cuts and abrasions: Cuts and abrasions are caused by rough surfaces and jagged edges:

By splinters and sharp or pointed projections. (Fig 1)

Leather hand gloves will usually be sufficient for protection, but the load should be checked to make sure of this, since large or heavy loads may involve body contact as well.

Fig 1

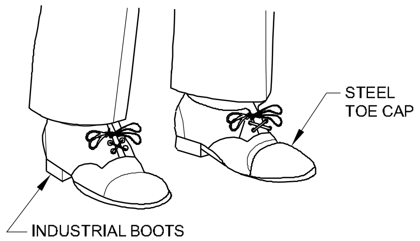


Crushing of feet or hands

Feet or hands should be so positioned that they will not be trapped by the load. Timber wedges can used when raising and lowering heavy loads to ensure fingers and hands are not caught and crushed.

Safety shoes with steel toe caps will protect feet (Fig 2)

Fig 2



Strain to muscles and joints

Strain to muscles and joints may be result of:

- Lifting a load which is too heavy, or of lifting incorrectly.

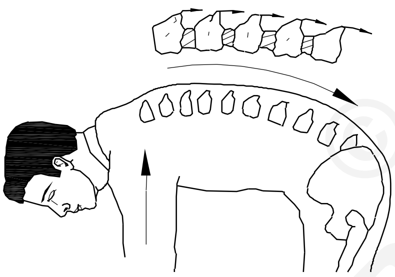
Sudden and awkward movements such as twisting or jerking during a lift can put severe strain on muscles.

Stop lifting'-lifting from a standing position with the back rounded increases the chance of back injury.

The human spine is not an efficient weight lifting machine and can be easily damaged if incorrect techniques are used.

The stress on a rounded back can be about six times greater than if the spine is kept straight. Fig 3 shows and example of stoop lifting.

Fig 3



Preparing to lift

Before lifting or handling any load ask yourself the following questions.

What has to be moved?

Where from and where to?

Will assistance be required?

Is the route through which the load has to be moved is clear of obstacles?

Is the place where the load has to be kept after moving is clear of obstacles?

Load which seems light enough to carry at first will become progressively heavier, the farther you have to carry it.

The person who carries the load should always be able to see over or around it.

The weight that a person can lift will vary according to:

- Age
- Physique, and
- Condition

It will also depend on whether one is used to lifting and handling heavy loads.

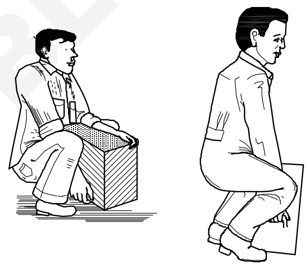
What makes an object difficult to lift and carry?

- Weight is not the only factor which makes it difficult to lift and carry.
- The size and shape can make an object awkward to handle.
- Loads high require the arms to be extended in front of the body, place more strain on the back and stomach.
- The absence of hand holds or natural handling points can make it difficult to raise and carry the object.

Correct manual lifting techniques

- Approach the load squarely, facing the direction of travel
- The lift should start with the lifter in a balanced squatting position, with the legs slightly apart and the load to be lifted held close to the body.
- Ensure that a safe firm hand grip is obtained. Before the weight is taken, the back should be straightened and held as near the vertical position as possible. (Fig4)

Fig 4

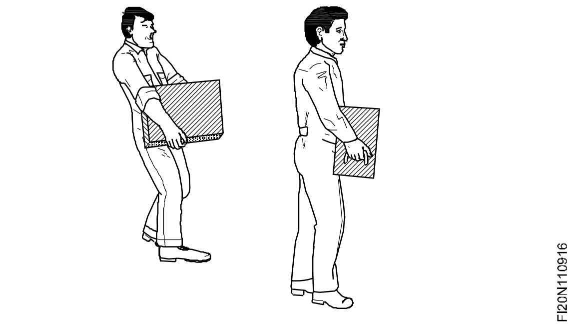


- To raise the load, first straighten the legs. This ensures that the lifting strain is being correctly transmitted and is being taken by the powerful thigh muscles and bones.
- Look directly ahead, not down at the load while straightening up, and keep the back straight, this will ensure a smooth, natural movement without jerking or straining (Fig 5)

Fig 5

- To complete the lift, raise the upper part of the body to the vertical position. When a load is near to an individual's maximum lifting capacity it will be necessary to lean back on the hips slightly (to counter balance the load) before straightening up.(Fig 6)

Fig 6



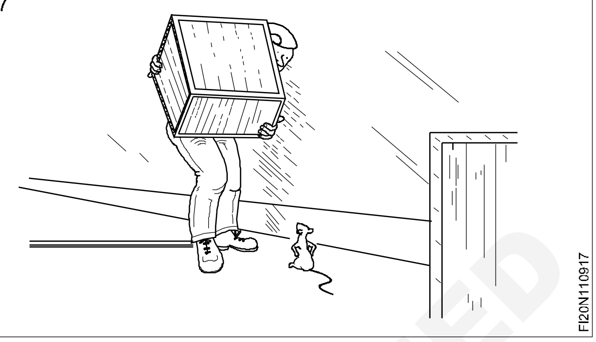
Keeping the load well near to the body, carry it to the place where it is to be set down. When turning, avoid twisting from the waist- turn the whole body in one movement.

Lowering the load

Make sure the area is clear of any obstructions. (Fig 7)

Bend the knees to a semi- squatting position, keep the back and head erect by looking straight ahead, not down at the load. It may be helpful to rest the elbows on the thighs during the final stage of lowering.

Fig 7



Moving heavy equipment

Objectives: At the end of this lesson you shall be able to
- **name the methods followed in industry to move heavy equipment**
- **describe the procedure to be followed for moving heavy equipment on layers and rollers**
- **list the safety consideration while raising a load and moving a load.**

Heavy equipment's are moved in industry using any of the following methods.

Crane and slings

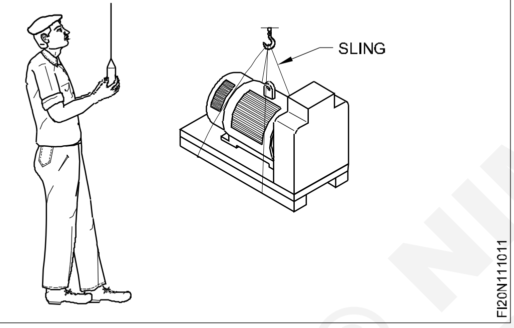
Winches

Machine moving platforms

Layers and rollers

Using crane and slings: This method is used whenever loads are to be lifted and moved. (Fig 1)

Fig 1



> **Examine the steel rope sling for any cut, abrasion, wear fraying or corrosion.**

Damaged slings must not be used.

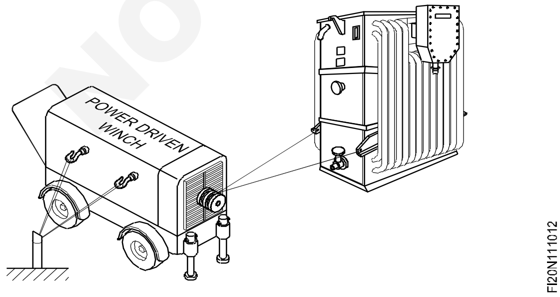
Distribute the weight as evenly as possible between the slings when using more than one sling. (Fig 1)

Keep the slings as near to vertical as possible.

Winches

Winches are used to pull heavy loads along the ground. They may be power-driven (Fig 2) or hand operated. (Fig3)

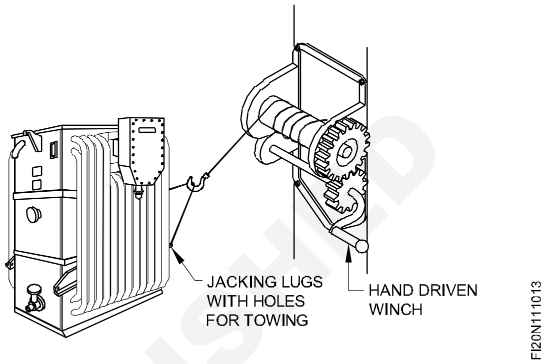
Fig 2



Ensure that the safe working load (SWL) of the winch is adequate for the task.

Secure the winch to a structure which is strong enough to withstand the pull.

Fig 3



On open ground, drive long stakes into the ground and secure the winch to them.

Choose a suitable sling and pass it around the base of the load. Secure it to the hook of the winch.

> **Some heavy items have special lugs welded to them for jacking and towing purposes.**

Safety consideration

> **Before using any winch, check that the brake and ratchet mechanism are in working order. Practise how to use the brakes.**

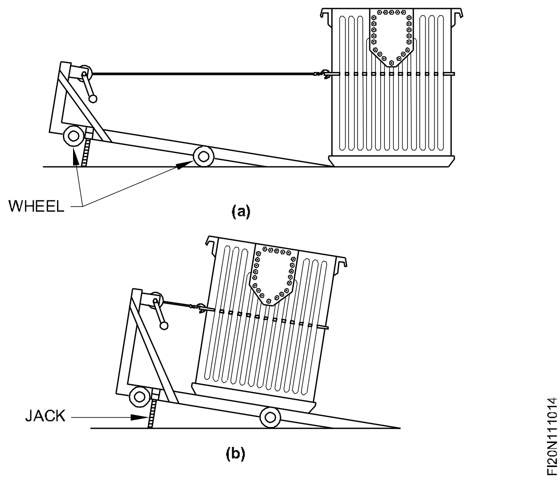
Keep hands and fingers well away from the gear wheels.

Keep the bearings and gears oiled or greased.

Machine moving platforms

This is a special device made to move heavy equipment in industry. Fig 4 shows the method of loading a heavy transformer.

Fig 4



Pass a suitable sling round the load at a convenient height.

Attach the sling to the hook of the winch and draw the load on the platform until its centre of gravity lies between the front and rear wheels.

Lower the jacks so that the platform rests on its wheels.

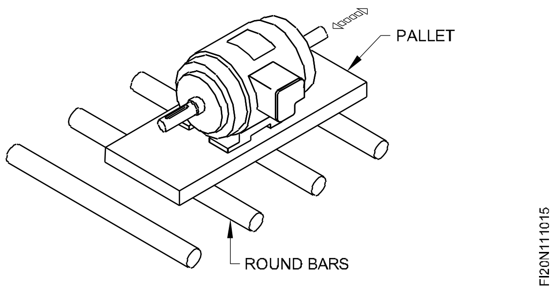
For unloading follow the procedure in the reverse order.

Using layers and rollers

Sometimes a load cannot be moved along the ground because of the irregular shape of its base or because it is not rigid enough.

Place such a load on a flat-bottomed pallet or 'layer' resting on the round bars. (Fig 5)

Fig 5



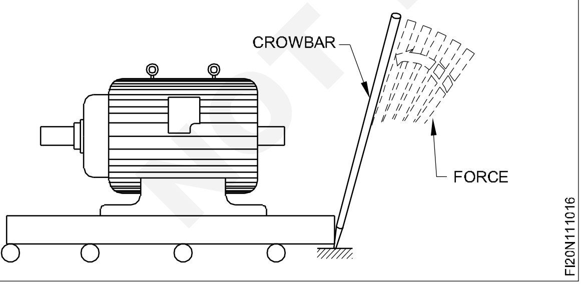
Ensure the bars (rollers) are long enough to project at each side of the load, for ease of handling.

They should be large enough to roll easily over any uneven surface along the route but should be small enough to be handled easily.

Two or three bars of equal diameter are sufficient for most loads but if four or more are used, the load may be moved faster as there is no delay when moving the rear bar to the front. (Fig 5)

Move the load by using a crowbar as shown in Fig 6. Keep the crowbar at the end of the pallet with an angle and a firm grip on the ground. Apply the force at the top of the bar as shown.

Fig 6



Caution

When a load is on rollers, only shallow slopes can be negotiated.

Hold the load in check all the time if it is on the slope.

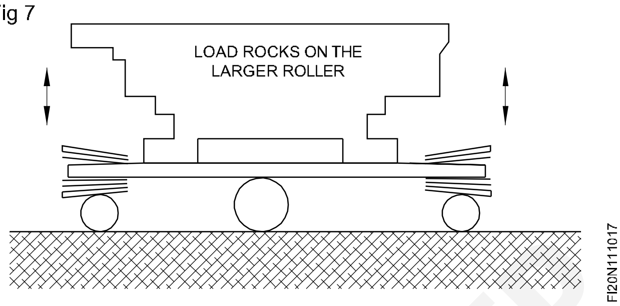
Use a winch with an effective brake for this operation.

To negotiate a corner on rollers

For a moderate load, insert one roller a little larger in diameter than the others as the corner is approached.

When this roller is under the centre of gravity of the load, the load can be rocked to and fro on the roller and swiveled around sideways. (Fig 7)

Fig 7

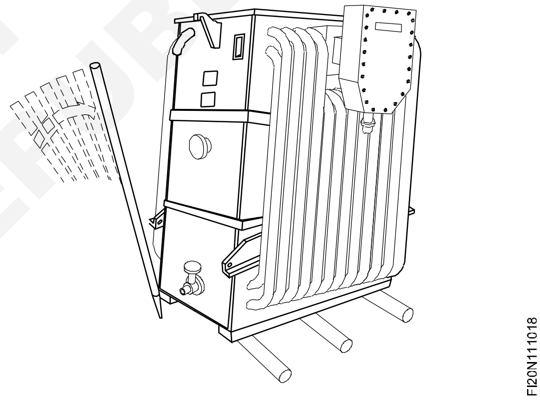


For heavier loads

Stop the load on the roller at the beginning of the corner.

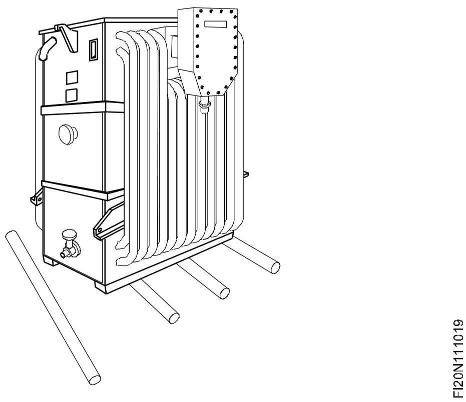
Twist the load round on the rollers by pushing the sides with crowbars until the load is just over the ends of the rollers. (Fig 8)

Fig 8



Place some rollers at an angle to the front of the load. (Fig 9)

Fig 9



Push the load forward on to these rollers.

Twist the load further round and place the freed rollers in front of and at an angle to the load.

Continue until the load is pointing in the desired direction.

Safety consideration

Moving heavy loads with crowbars or jacks

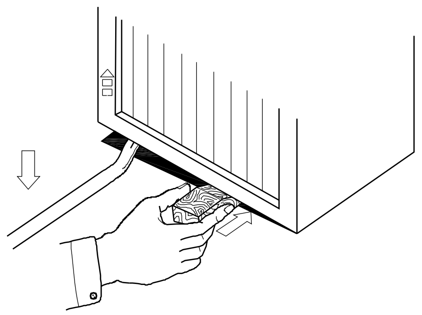
Make sure your hands are clear of the load before lowering it on to the packing or rollers.

Do not use your hands underneath the packing when positioning it. Use a push block.

Place the packing on the floor and push it under the load. (Fig 10)

Hold it by its side faces keeping the fingers well away from the lower edge of the load and from the floor. (Fig 10)

Fig 10



Raising a load

Check that the slings are correctly secured to the load and to the hook. Ensure they are not twisted or caught on a projecting part of the load.

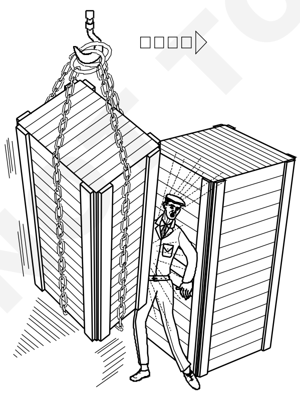
Before starting to lift a load, if you cannot see an assistant on the far side of the load, verify that he is ready to lift the load and ensure that his hands are clear of the slings.

Warn nearby workers that the lifting is about to begin.

Lift slowly.

Take care to avoid being crushed against other objects as the load rises. (Fig 11) It may swing or rotate as it leaves the ground.

Fig 11



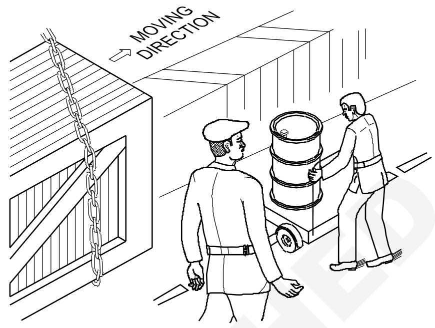
Minimise such movement by locating the hooks as accurately as possible above the centre of gravity of the load.

Keep the floor clear of unnecessary objects.

Moving a load

Check that there are no obstacles in the way of the crane and load. (Fig 12)

Fig 12



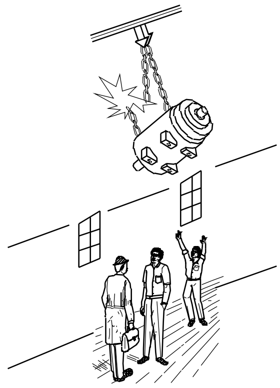
Stand clear off the load and move it steadily.

Be prepared to stop the load quickly if somebody moves into its path.

Allow for the natural swing of the load when changing speed or direction.

Ensure that the load will not pass over the head of other people. (Fig 13)

Fig 13



The tackle or sling may fall or slip.

Warn other workers to stand clearly away from the route of the load.

Remember that accidents do not happen, they are caused.

Linear measurement

Objectives: At the end of this lesson you shall be able to
- **name the base unit of linear measurement as per the International System of units of measurement (SI)**
- **state the multiples of a metre and their values**
- **state the purpose of steel rule**
- **name the types of steel rule**
- **state the precautions to be followed while using a steel rule.**

Scan the QR Code to view the video for this exercise

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 METRE.

Length - SI UNITS and MULTIPLES

Base unit

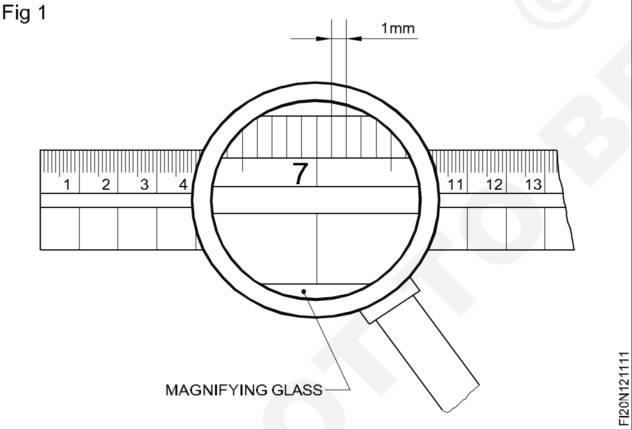
The base unit of length as per the Systems International is metre. The table given below lists some multiples of a meter.

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

Measurement in engineering practice

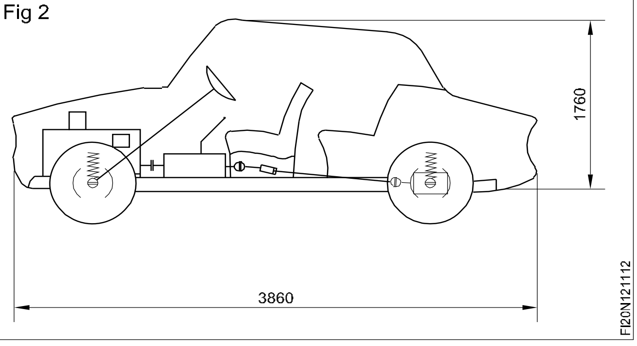
Usually, in engineering practice, the preferred unit of length measurement is millimetre. (Fig 1)

Fig 1



Both large and small dimensions are stated in millimetres. (Fig 2)

Fig 2

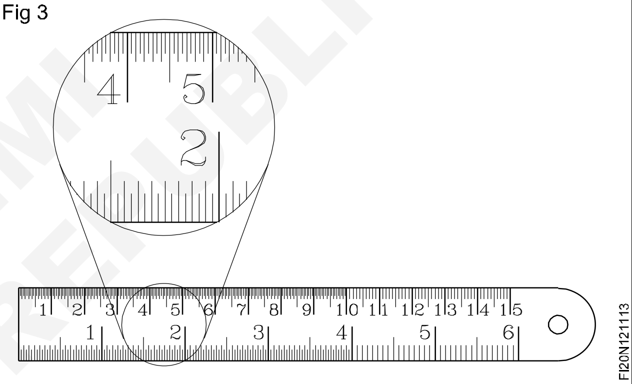


The British system of length measurement

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.

Engineer's steel rule (Fig 3) are used to measure the dimensions of work pieces.

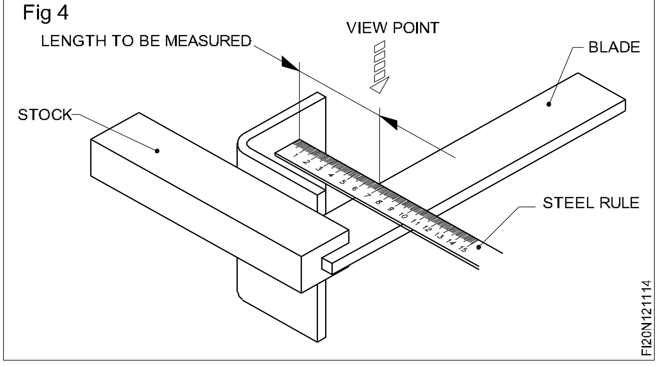
Fig 3



Steel rules are made of spring steel or stainless steel. These rules are available in length 150mm, 300mm and 600mm. The reading accuracy of steel rule is 0.5 mm and 1/64 inch.

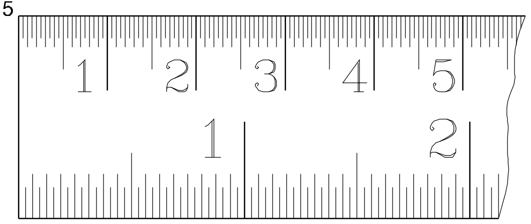
For accurate reading it is necessary to read directly to avoid errors arising out of parallax. (Fig 4)

Fig 4



Steel rule in English measure, they can also be available with metric and English graduation in a complete range of sizes 150, 300, 500 and 1000 mm. (Fig 5)

Fig 5



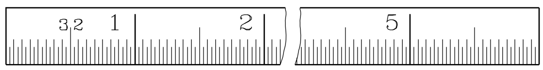
Other types of rule

- narrow steel rules
- short steel rules
- full flexible steel rule with tapered end.

Narrow steel rule

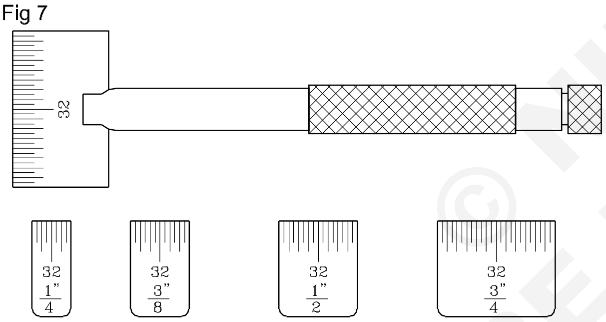
Narrow steel rule is used to measure the depth of key-ways and depth of smaller dia, blind holes of jobs, where the ordinary steel rule can not reach. Its width is approximately 5 mm and thickness 2 mm. (Fig 6)

Fig 6



Short steel rule (Fig 7)

Fig 7



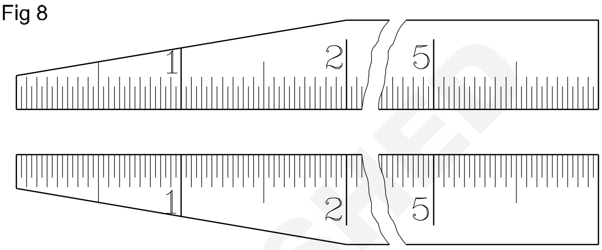
This set of five small rules together with a holder is extremely useful for measurements in confined or hard to reach locations which prevent the use of ordinary steel rules. It is used suitably for measuring grooves, short shoulder, recesses, key ways etc. in machining operation on shapers, millers and tool and die work.

The rules are easily inserted in the slotted end of the holder and are rigidly clamped in place by a slight turn of the knurled nut at the end of the handle. Five rule lengths are provided 1/4", 3/8", 1/2", 3/4" and 1" and each rule is graduated in 32[nds] on one side and 64ths on the reverse side.

Steel rule with tapered end

This rule is a favorite with all mechanics since its tapered

Fig 8



end permits measuring of inside size of small holes, narrow slots, grooves, recesses etc. This rule has a taper from 1/2 inch width at the 2 inch graduation to 1/8 inch width at the end. (Fig 8)

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

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

Angular measurement

Angular measurement of angles of an object is usually expressed in degrees, minutes and seconds. One degree is divided into 60 minutes and one minute is to 60 seconds.

Measurements of fundamental, derived units

Measurement of length				
Metric			**British**	
Micron	1µ	= 0.001 mm	Thousand[th] of an inch	= 0.001"
Millimetre	1 mm	= 1000µ	Inch	= 1"
Centimetre 1 cm		= 10 mm	Foot 1 ft	= 12"
Decimeter 1 dm		= 10 cm	Yard 1yd	= 3 ft
Metre 1 m		= 10 dm	1 furlong 1 fur	= 220 yds
Decametre 1 dam		= 10 metre	1 mile	= 8 fur

Scribers

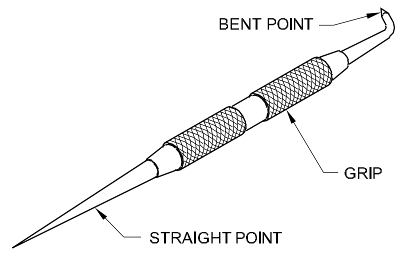
Scan the QR Code to view the video for this exercise

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

Scribers: In lay out work it is necessary to scribe lines to indicate the dimensions of the workpiece to be filed or machined. The scriber is a tool used for this purpose. It is made of high carbon steel and hardened. For drawing clear and sharp lines, the point should be ground and honed frequently for maintaining its sharpness.

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

Fig 1

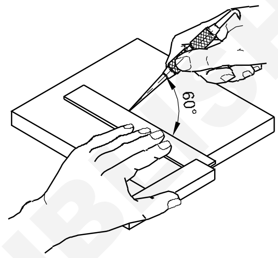


While scribing lines, the scriber is used like a pencil so that the lines drawn are close to the straight edge. (Fig 2)

Scriber points are very sharp; therefore, do not put the plain scriber in your pocket.

Place a cork on the point when not in use to prevent accidents.

Fig 2

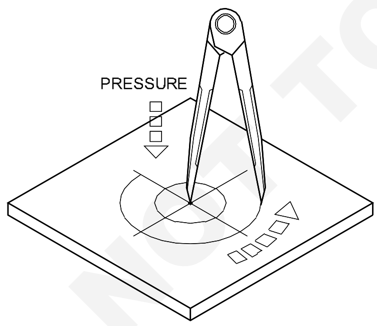


Dividers

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 hints on divider points.**

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

Fig 1



Dividers are available with firm joints and spring joints. (Figs 1 & 4). The measurements are set on the dividers with a steel rule. (Fig 2)

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

Fig 2

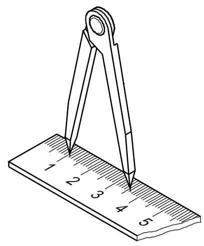
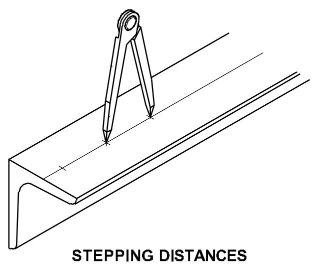
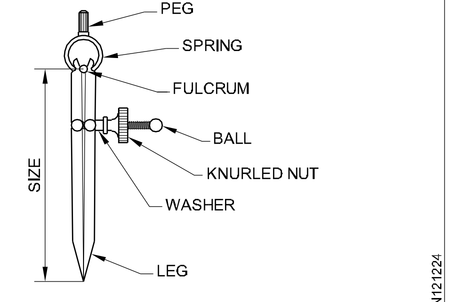


Fig 3



The distance from the point to the centre of the fulcrum roller (pivot) is the size of the divider. (Fig 4)

Fig 4

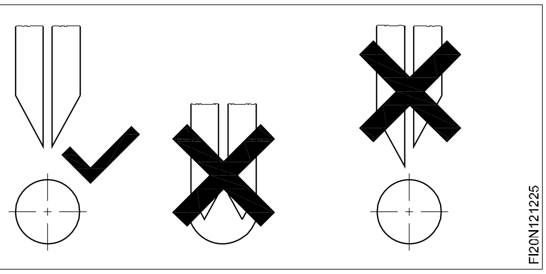


SPRING JOINT DIVIDER

For the correct location and seating of the divider point prick punch marks of 30° are used.

The two legs of the divider should always be of equal length. (Fig 5) Dividers are specified by the type of their joints and length.

Fig 5



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

Scan the QR Code to view the video for this exercise

Calipers

Objectives: At the end of this lesson you shall be able to
- **name the commonly used calipers**
- **state the advantages of spring joint calipers.**

Calipers are indirect measuring instruments used for transferring measurements from a steel rule to a job, and vice versa.

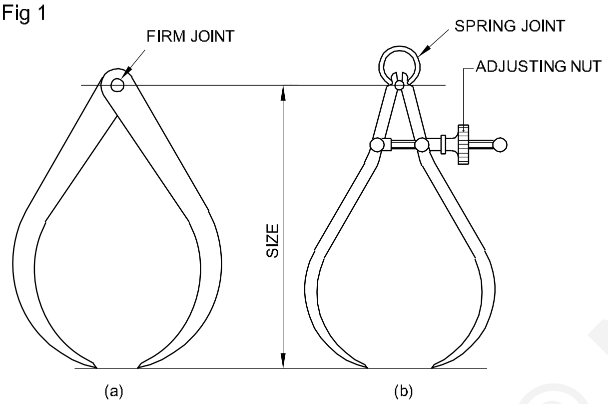
Calipers are classified according to their joints and their legs.

Joint

– Firm joint calipers (Fig 1a)

– Spring joint calipers (Fig 1b)

Fig 1



Legs

– Inside caliper for internal measurement. (Fig 2)

– Outside caliper for external measurement. (Fig 3)

Fig 2

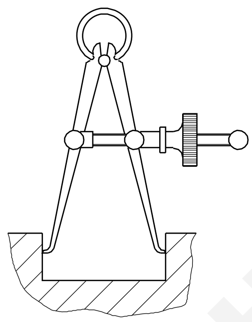
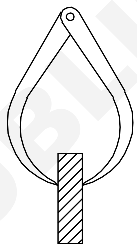


Fig 3



Calipers are used 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 calipers with sensitive feel.

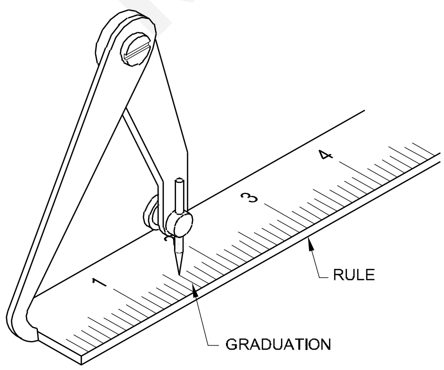
Spring joint calipers have the advantage of quick setting with the help of an adjusting nut. For setting a firm joint caliper, tap the leg lightly on a wooden surface.

Jenny calipers

Objectives: At the end of this lesson you shall be able to
- **state the uses of a jenny caliper**
- **state the two types of legs of a jenny caliper.**

Jenny calipers have one leg with an adjustable divider point, while the other is a bent leg. (Fig 1) These are available in sizes of 150 mm, 200 mm, 250 mm and 300 mm.

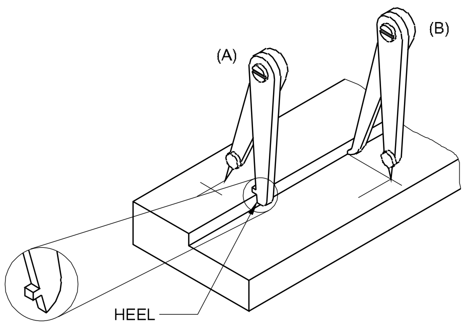
Fig 1



Jenny calipers are used

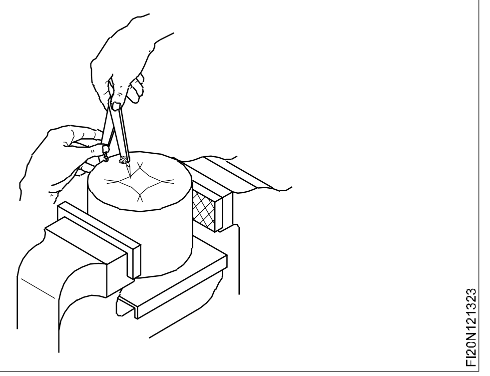
– for marking lines parallel to the inside and outside edges (Fig 2)

Fig 2



- for finding the centre of round bars. (Fig 3)

Fig 3



These calipers are available with the usual bent leg or with heel.

Calipers with bent leg (Fig 2B) are used for drawing lines parallel along an inside edge, and the heel type (Fig 2A) is used for drawing parallel lines along the outer edges.

The other names for this caliper are:

- hermaphrodite calipers
- leg and point calipers
- odd leg caliper

Scan the QR Code to view the video for this exercise

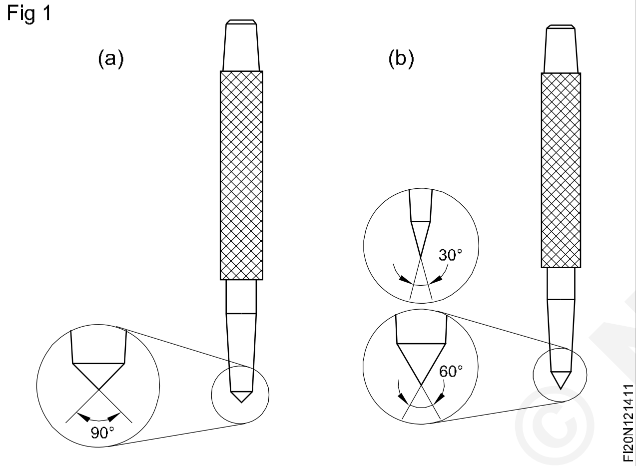
Types of marking punches

Objectives: At the end of this lesson you shall be able to
- **name the different punches in marking**
- **state the features of each punch and its uses.**

Punches are used in order to make certain dimensional features of the layout permanent. There are two types of punches. They are centre punch and prick punch made of high carbon steel, hardened and ground.

Centre Punch: The angle of the point is 90° in a centre punch. The punch mark made by this is wide and not very deep. This punch is used for locating centre of the holes. The wide punch mark gives a good seating for starting the drill. (Fig 1a)

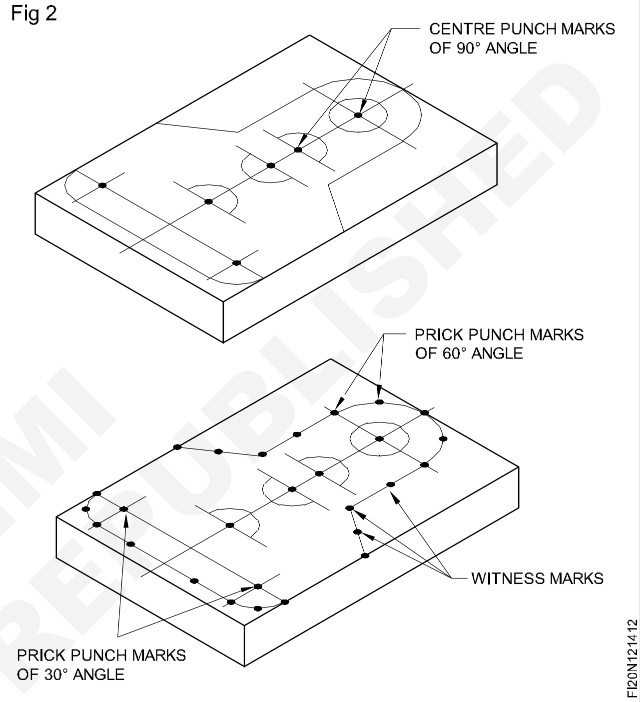
Fig 1



Prick Punch/Dot punch: The angle of the prick punch is 30° or 60°. (Fig 1b) The 30° point punch is used for making light punch marks needed to position dividers. The divider point will get a proper seating in the punch mark. The 60° punch is used for marking witness marks and called as dot punch. (Fig 2)

The witness marks should not be too close to one another.

Fig 2



Hammers

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

An engineer's hammer is a hand tool used for striking purposes while punching, bending, straightening, chipping, forging or riveting.

Major parts of a hammer: The major parts of a hammer are the head and the handle.

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

The parts of a hammer-head are the face (1), pein (2), cheek (3) and the eyehole (4).

Face: The face is the striking portion. A slight convexity is given to it to avoid digging of the edge. It is used for striking while chipping, bending, punching, etc.

Pein: 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 such as:

– ball pein (Fig.2a)

– cross-pein (Fig.2b)

– straight pein. (Fig 2c)

Fig 1

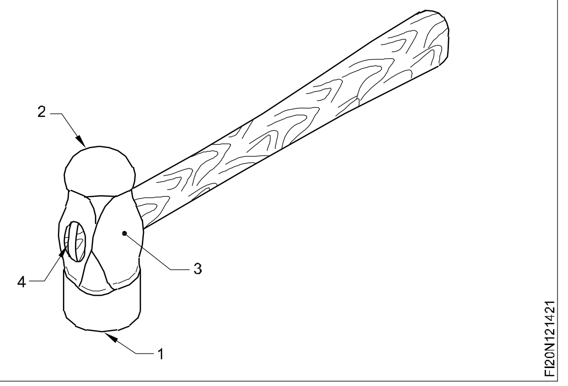
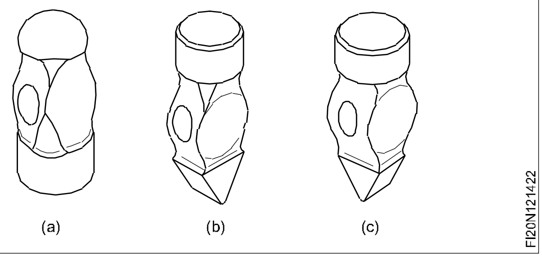


Fig 2



The face and the pein are case hardened.

Cheek: 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.

Eyehole: The eyehole is meant for fixing the handle. It is shaped to fit the handle rigidly. The wedges fix the handle in the eyehole. (Figs 3 and 4)

Fig 3

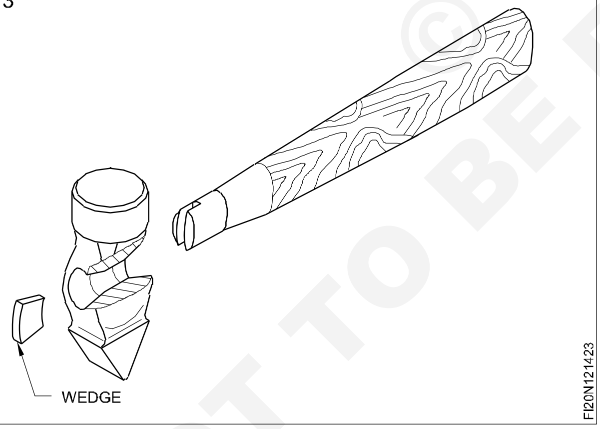
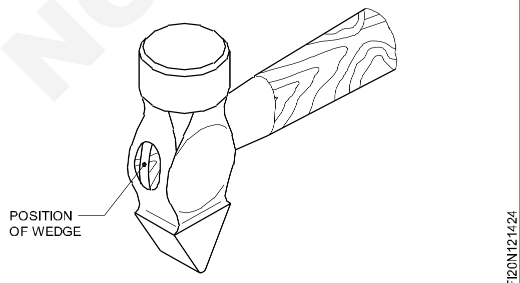


Fig 4



Application of hammer pein: The ball pein is used for riveting. (Fig 5)

The cross-pein is used for spreading the metal in one direction. (Fig 6)

Fig 5

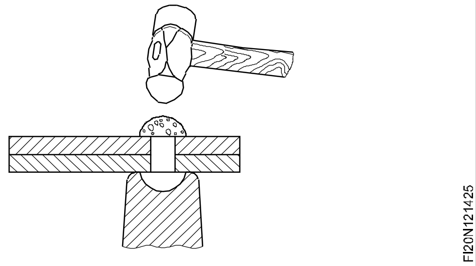
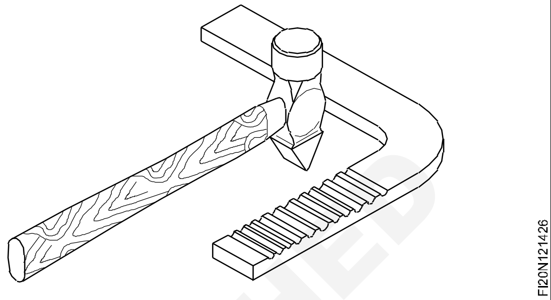
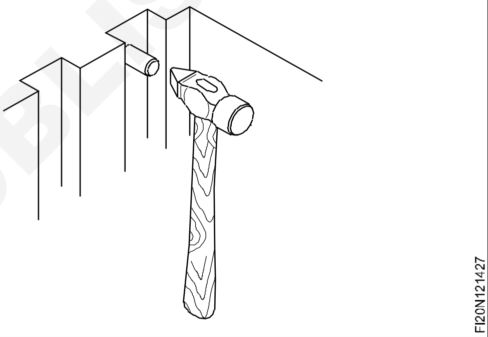


Fig 6



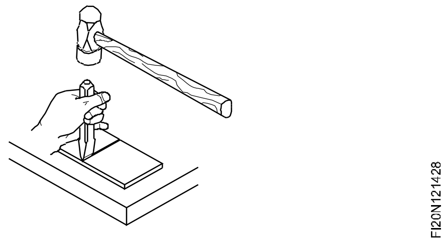
The straight pein is used at the corners. (Fig 7)

Fig 7



The ball pein hammer is used for driving a chisel in parting metal. (Fig 8)

Fig 8



Specification: An engineer's hammers are specified by their weight and the shape of the pein. Their weight varies from 125 gms to 750 gms.

The weight of an engineer's hammer, used for marking purposes, is 250 gms.

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 hammer head and handle whether any crack is there
- ensure that the face of the hammer is free from oil or grease.

'V' Blocks

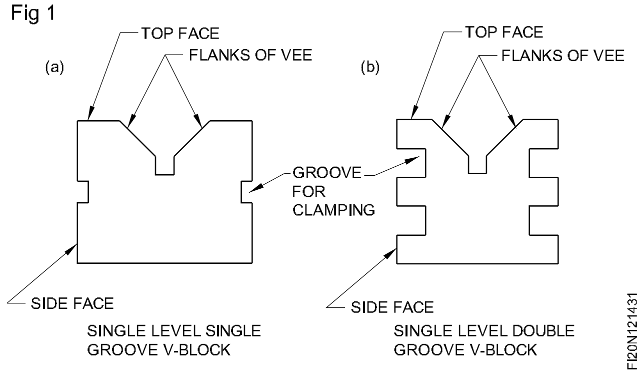
Objectives: At the end of this lesson you shall be able to
- **state the constructional features of 'v' blocks**
- **name the types of 'v' blocks and state their uses**
- **specify 'v' blocks as per B.I.S standard.**

Scan the QR Code to view the video for this exercise

Constructional features

'V' Blocks are devices used for marking and setting up work on machines. The features of the common type of 'V' Blocks are as given in Figs 1 and 2.

Fig 1



The included angle of the VEE is 90° in all cases. 'V' Blocks are finished to a high accuracy in respect of dimension, flatness and squareness.

Types

Different types of 'V' blocks are available. As per BIS, there are four types, as listed below.

Single level single groove 'V' Block (Fig 1)

This type has only one 'V' groove, and has single groove (slots) on either side. These grooves are for accommodating the holding clamps.

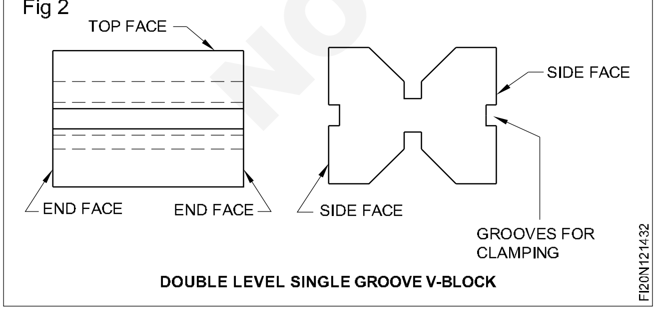
Single level double groove 'V' Block (Fig 2)

This type will have one 'V' groove, and two grooves (slots) on either side for clamping in two positions.

Double level single groove 'V' Block (Fig 3)

In this case, the 'V' Block will have two 'V' grooves on the top and bottom, and a single groove for clamping on either side.

Fig 2



Matched pair 'V' Block (Figs 4 and 5)

These blocks are available in pairs which have the same size and the same grade of accuracy. They are identified by the number or letter given by the manufacturer. These

Fig 3

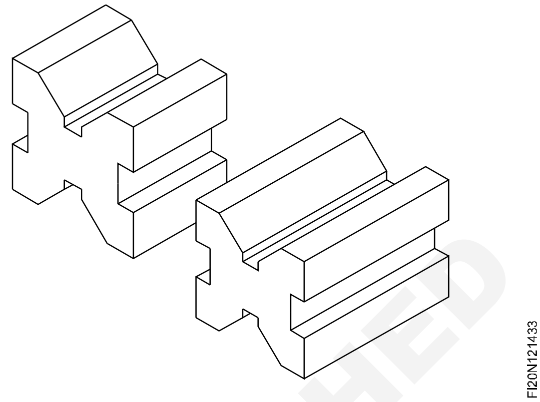
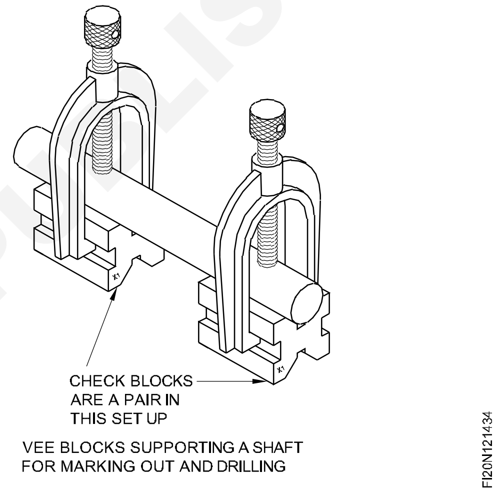


Fig 4



sets of blocks are used for supporting long shafts parallel on machine tables or marking off tables.

Grades and materials

'V' Blocks are available in Grade A and Grade B.

Grade A 'V' Blocks

These are more accurate, and are available only up to 100 mm length. They are made of high quality steel.

Grade B 'V' Blocks

These blocks are not as accurate as the ones in Grade A. These blocks are used for general machine shop work. These blocks are available up to 300 mm length. These 'V' Blocks are made of closely grained cast iron.

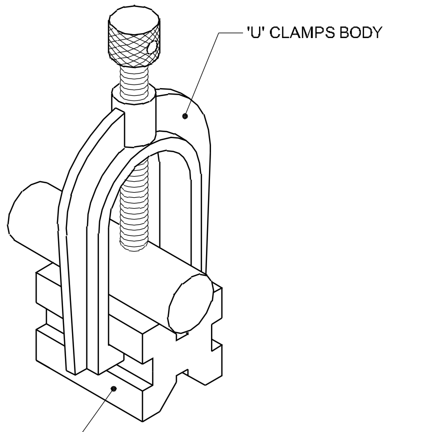
Clamping devices for `V'-Blocks

'U' clamps are provided for holding cylindrical jobs firmly on 'V' Blocks. (Fig 6)

Designation

'V' Blocks are designated by the nominal size (length) and the minimum and maximum diameter of the workpiece capable of being clamped, and the grade and the number of the corresponding B.I.S. standard.

Fig 5



In the case of matched pairs, it should be indicated by the letter M.

For 'V' Blocks with clamps it should be indicated as, 'WITH CLAMPS'.

Example

A 50 mm long (nominal size) 'V' Block capable of clamping workpieces between 5 to 40 mm in diameter and of Grade A will be designated as

'V' Block 50/5 - 40 A - I.S.2949.

In the case of a matched pair, it will be designated as

'V' Block M 50/5 - 40 A I.S.2949.

For 'V' Block supplied with clamps, the designation will be

'V' Block with clamp 50/5 - 40 A I.S. 2949.

Care and maintenance

- Clean before and after use.
- Choose the correct size of 'V' block according to the job requirement.
- Apply oil after the use.

Marking off and marking off table

Objectives : At the end of this lesson you shall be able to
- **state why marking off is necessary**
- **state the function of witness marks**
- **state the features of marking tables**
- **write the uses of marking tables**
- **state the maintenance aspects concerning marking tables.**

Marking off

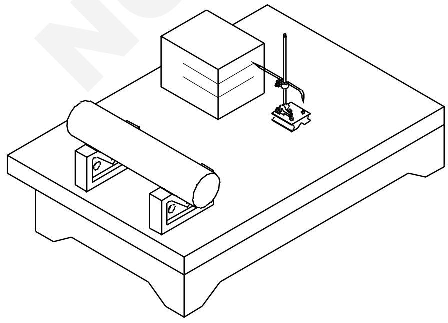
Marking off or layout is carried out to indicate the locations of operation to be done, and provide guidance during rough machining or filing.

Witness marks

The line marked on metal surfaces is likely to be erased due to handling. To avoid this, permanent marks are made by placing punch marks at convenient mark intervals along the marked line. Punch marks act as a witness against inaccuracies in machining and hence, they are known as witness marks.

Marking off table (Figs 1 and 2)

Fig 1



A marking table (marking-off table) is used as a reference surface for marking on workpieces.

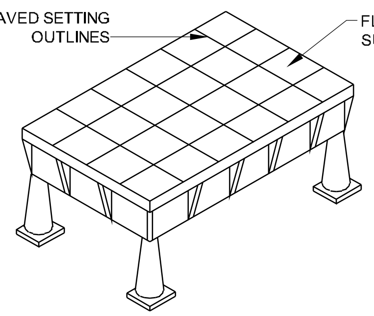
Marking tables are of rigid construction with accurately finished top surfaces. The edges are also finished at right angles to the top surface.

Marking tables are made of cast iron or granite, and are available in various sizes. These tables are also used for setting measuring instruments, and for checking sizes, parallelism and angles.

Care and maintenance

> **A marking table is very precise equipment, and should be protected from damage and rust.**
>
> **After use, the marking table should be cleaned with a soft cloth.**
>
> **The Surface of the marking table, made of cast iron, should be protected by applying a thin layer of oil.**

Fig 2



Bench vice

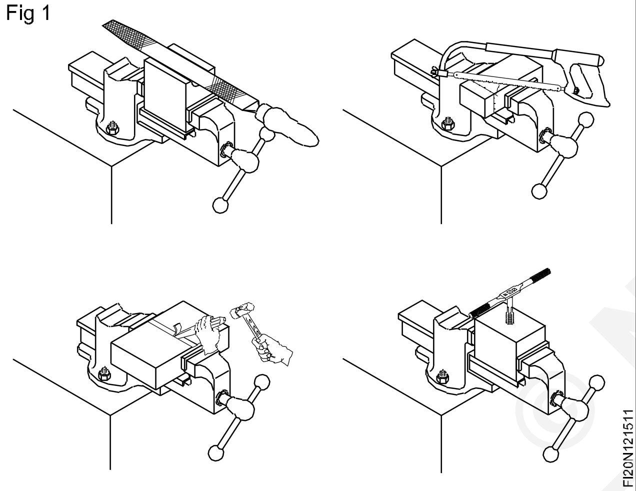
Objectives: At the end of this lesson you shall be able to
- **state the uses of bench vice**
- **specify the size of the bench vice**
- **name the parts of the bench vice**
- **state the uses of vice clamps.**
- **mention the care and maintenance of vices**

Scan the QR Code to view the video for this exercise

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

A bench vice is made of cast iron or cast steel and it is used to hold work for filing, sawing, threading and other hand operations. (Fig 1)

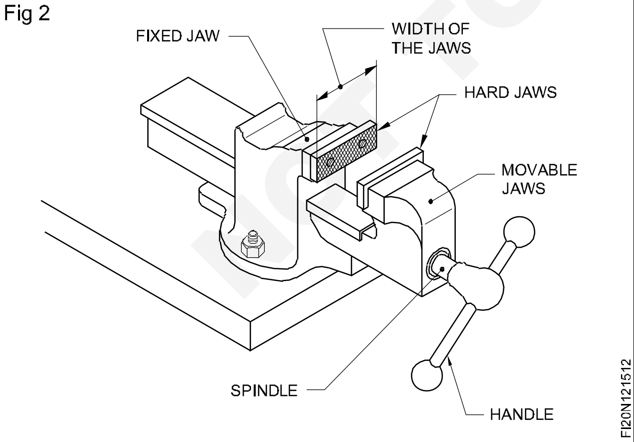
Fig 1



The size of the vice is stated by the width of the jaws.eg. 150mm parallel jaw bench vice

Parts of a bench vice (Fig 2)

Fig 2



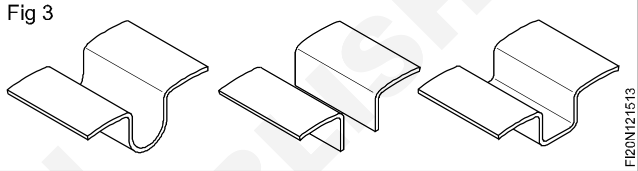
The following are the parts of a vice.

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

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

Vice clamps or soft jaws (Fig 3)

Fig 3



To 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 be damaged.

Care and maintenance of vices

- Always keep all threaded and moving parts clean by wiping the vice with a cloth after each use.
- Make sure to oil and lubricate the joints and sliding parts.
- To oil the sliding section, open the jaws completely and apply a layer of grease to the screen.
- Remove the rust if appears on the vice using rust remover chemical.
- When the vice is not in use bring the jaws lightly gap together and place the handle in a vertical position.
- Avoid striking the handle of the vice by a hammer for tightening fully, otherwise the handle will become bend or damaged.

Hacksaw frames and blades

Objectives: At the end of this lesson you shall be able to
- **name the different types of hacksaw frames**
- **specify hacksaw blades**
- **name the different type of hacksaw blades**
- **describe the method of sawing**

Scan the QR Code to view the video for this exercise

Hacksaw frame: A hacksaw frame is used along with a blade to cut metals of different sections, and is specified by the type and maximum length of the blade that can be fixed.

Example

Adjustable hacksaw frame - tubular - 250 - 300mm or 8" - 12"

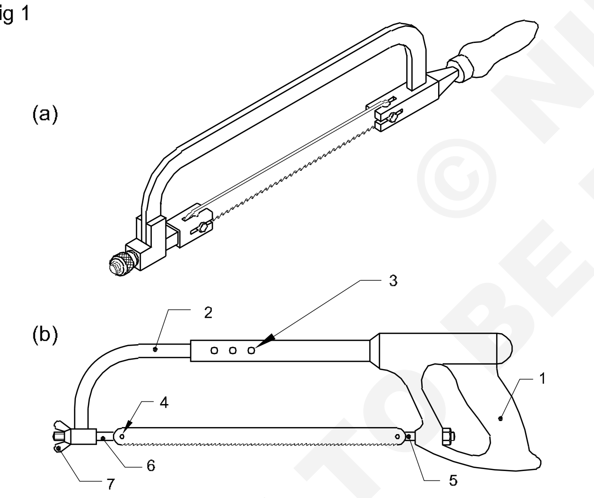
Types of hacksaw frames

Solid frame (Fig 1a)**:** Only a blade of a particular standard length can be fitted to this frame. e.g 300 mm or 250 mm.

Adjustable frame (flat type)**:** Different standard lengths of blades can be fitted to this frame i.e. 250 mm and 300 mm.

Adjustable frame (tubular type) (Fig 1b)**:** This is the most commonly used type. It gives a better grip and control, while sawing.

Fig 1



Parts of a hacksaw frame

1 Handle

2 Frame

3 Tubular frame with holes for length adjustment

4 Retaining pins

5 Fixed blade-holder

6 Adjustable blade-holder

7 Wing-nut

A hacksaw blade is made of either low alloy steel (LA) or high speed steel (HSS), and is available in standard lengths of 250 mm and 300mm. (Fig 2)

Parts of a hacksaw blade (Fig 2)

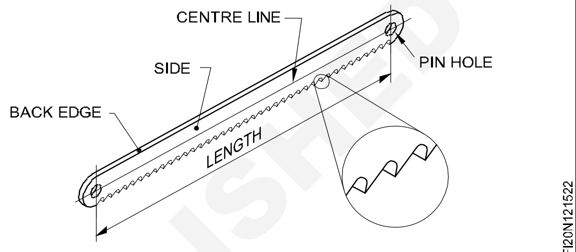
1 Back edge

2 Side

3 Centre line

4 Pin holes

Fig 2



Type of hacksaw blades

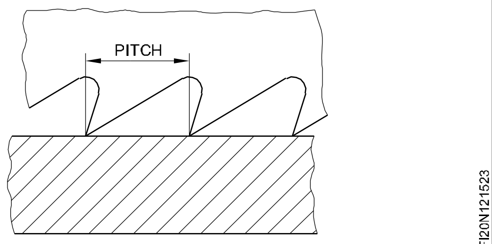
All-hard blade: The full length of the blade between the pins is hardened and it is used for harder metals such as tool steel, die steel and HCS.

Flexible blade: Only the teeth are hardened. Because of their flexibility these blades are useful for cutting along curved lines. Flexible blades should be thinner than all-hard blades.

Pitch of the blade (Fig 3)**:** The distance between adjacent teeth is known as the 'pitch' of the blade.

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

Fig 3



Specification: Hacksaw blades are specified by the length, pitch and type of material. (The width and thickness of blade is standardised)

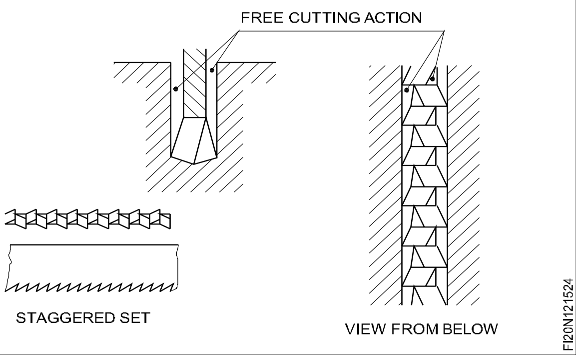
Example

300 x 1.8 mm pitch LA all-hard blade.

To prevent the hacksaw 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 hacksaw blade. This is achieved by the setting of the hacksaw teeth. There are two types of hacksaw teeth settings.

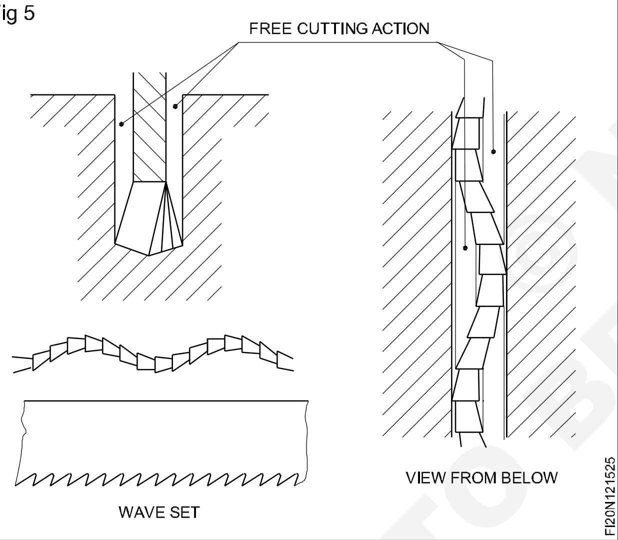
Staggered set (Fig 4)**:** Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting, and provides for good chip clearance.

Fig 4



Wave set (Fig 5)**:** In this, the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

Fig 5



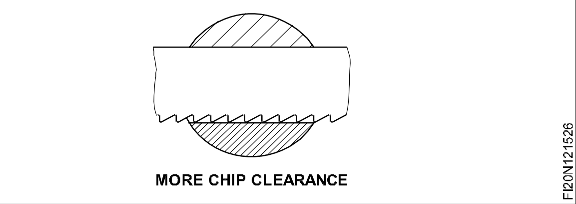
Pitch	Type of set
0.8 mm	Wave-set
1.0 mm	Wave-set or staggered
Over 1.0 mm	Staggered

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

Selection of blade: The selection of the blade depends on the shape and hardness of the material to be cut.

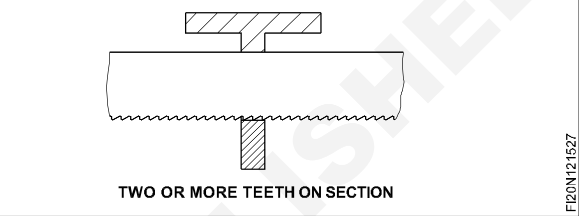
Pitch selection (Fig 6)**:** For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch blade.

Fig 6



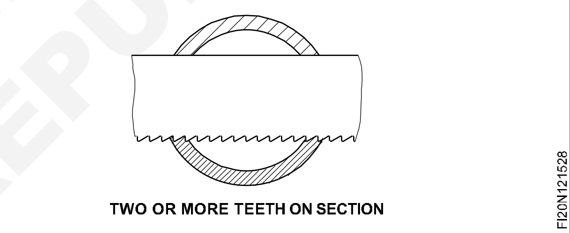
For tool steel, high carbon, high speed steel etc. use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 7)

Fig 7



For conduit and other thin tubing, sheet metal work etc. use a 0.8 mm pitch. (Fig 8)

Fig 8



Method of sawing

Select the correct blade for the material to be cut.

HSS - Blades are used for tough resistant materials

High Carbon Steel - General cutting

Select the correct number of teeth / inch the general rule is that atleast 3 teeth should extend across the surface of the material to be cut.

The hand holds the hacksaw handle, and the index finger is support the handle and also points in the direction of cutting.

The other hand holds the frame, near the wing nut. Cutting/ sewing should be carried out close to the jaws of the vice. This ensures that the metal does not flex or bend under the force of the hacksaw and the sawing motion.

Scan the QR Code to view the video for this exercise

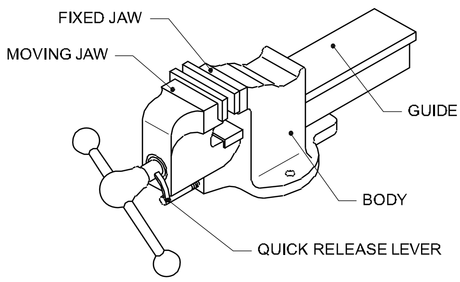
Types of vices

Objectives: At the end of this lesson you shall be able to
- **state the different types of vices**
- **state the uses of quick releasing vice, pipe vice, hand vice, pin vice and leg vice.**

There are different types of vices used for holding work-pieces. 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.

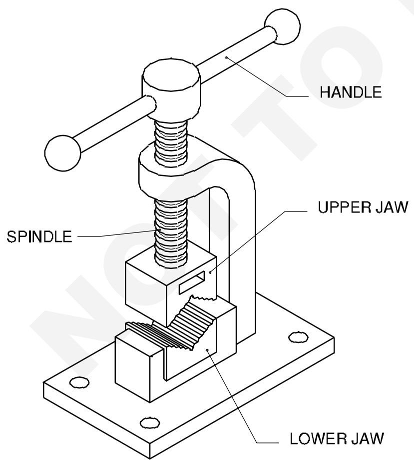
Fig 1



Pipe vice (Fig 2)**:** A pipe vice is used for holding round sections of metal, tubes and pipes. In the vice, the screw is vertical and movable. The jaw works vertically.

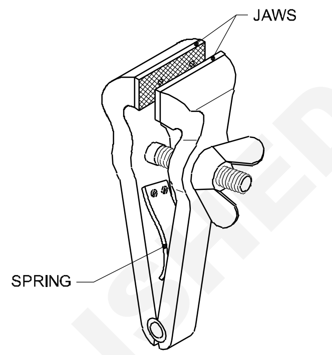
The pipe vice grips the work at four points on its surface. The parts of a pipe vice are shown in Fig 2.

Fig 2



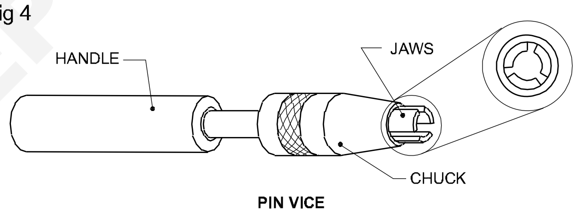
Hand vice (Fig 3)**:** Hand vices are used for gripping screws, rivets, keys, small drills and other similar objects which are too small to be conveniently held in the bench vice. A hand vice is made in various shapes and sizes. The length varies from 125 to 150 mm and the jaw width from 40 to 44 mm. The jaws can be opened and closed using the wing nut on the screw that is fastened to one leg, and passes through the other.

Fig 3



Pin vice (Fig 4)**:** The pin vice is used for holding small diameter jobs. It consists of a handle and a small collet chuck at one end. The chuck carries a set of jaws which are operated by turning the handle.

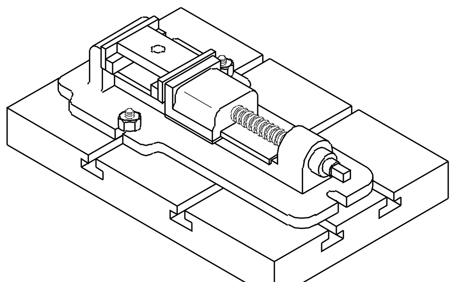
Fig 4



Toolmaker's vice (Fig 5)**:** The toolmaker's vice is used for holding small work which requires filing or drilling and for marking of small jobs on the surface plate. This vice is made of mild steel.

Toolmaker's vice is accurately machined.

Fig 5



Leg vice

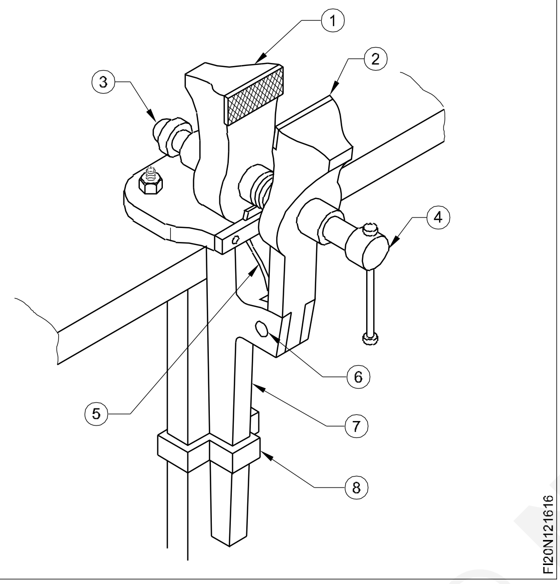
A leg vice is a holding device generally used in a forge shop for bending and forging work. It is made fo mild steel to avoid breakage while hammering.

Main pats of a leg vice (Fig 6**)**

The following are the main parts of a leg vice.

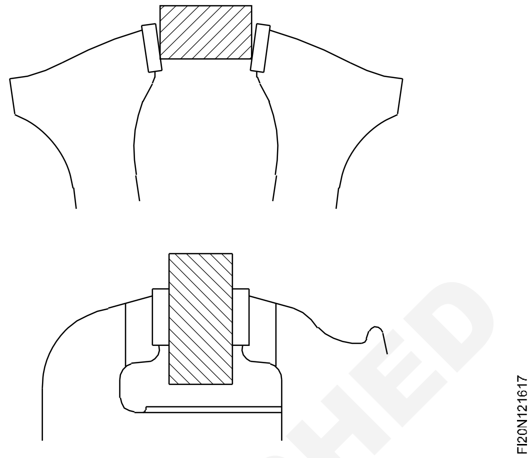
1 Solid jaw
2 Movable jaw
3 Threaded jaw
4 Spindle
5 Spring
6 Pivot
7 Leg
8 Clamp

Fig 6



Since the hinged jaw moves in a radial path, the job held in this vice in not gripped properly because of the line contact. (Fig 7) Hence a work which can be carried out on a bench vice is not held on a leg vice. Jobs which require hammering only are held on a leg vice.

Fig 7



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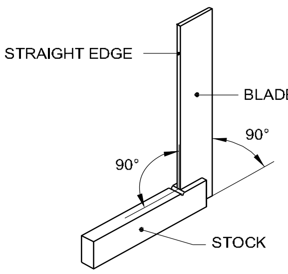
Try square

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 an instrument which is used to check squareness (angles of 90°) of a surface.

Fig 1



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

Try squares are made of hardened steel.

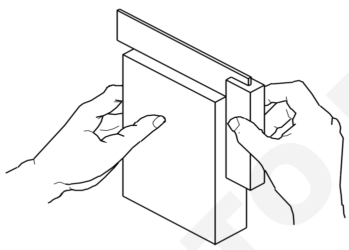
Try squares are specified according to the length of the blade i.e. 100 mm, 150 mm, 200 mm.

Uses:

The try-square is used to:

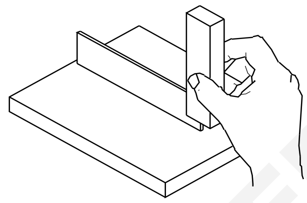
– check the squareness (Fig 2)

Fig 2



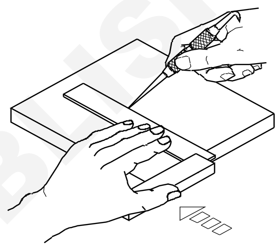
– check the flatness (Fig 3)

Fig 3



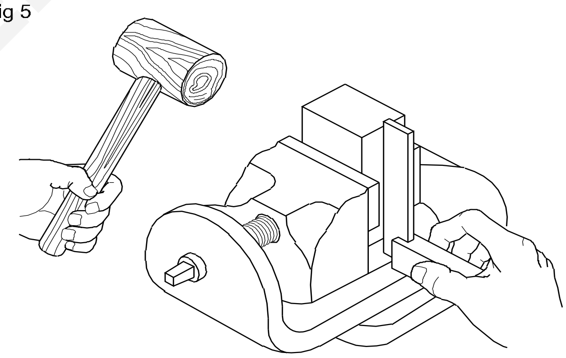
– mark lines at 90° to the edges of workpieces (Fig 4)

Fig 4



– set workpieces at right angles. (Fig 5)

Fig 5



Elements of a file

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

Methods of material cutting: The three methods of metal cutting are abrasion (Fig.1), fusion (Fig 2) and incision (Fig 3)

Filling is a method for removing excess material from a workpiece by using a file which acts as a cutting tool. Figure 4 shows how to hold a file. Files are available in many shapes and sizes.

Fig 1

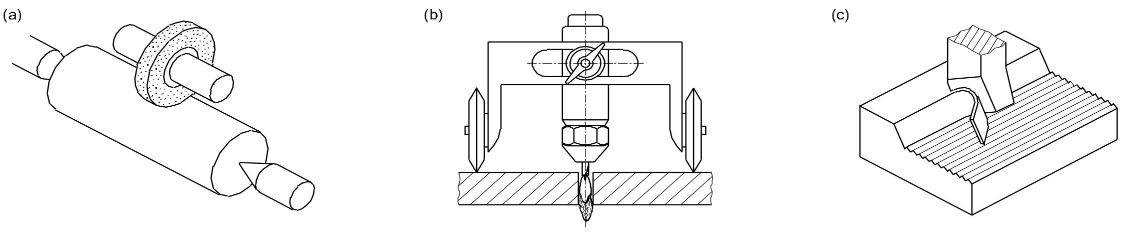
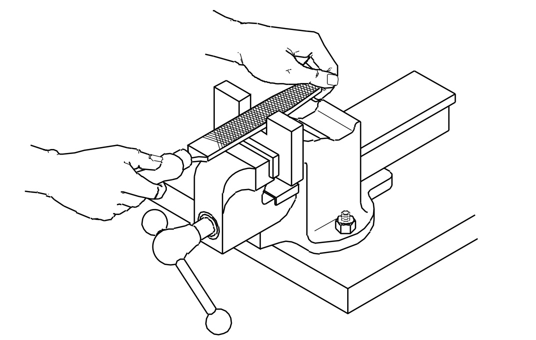


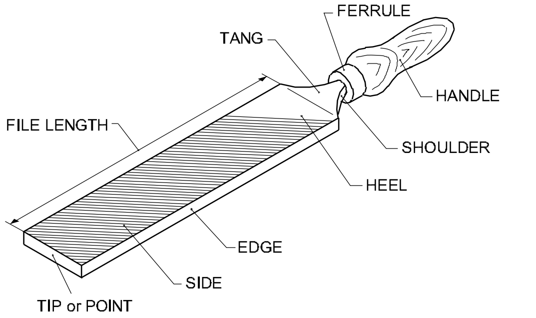
Fig 2



Parts of a file (Fig 3)

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

Fig 3



Tip or Point
the end opposite to tang

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

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

Heel
The portion of the broad part without teeth

Shoulder
the curved part of the file separating tang from the body

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

Handle
The part fitted to the tang for holding the file

Ferrule
A protective metal ring to prevent cracking of the handle.

Materials

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

Cut of files

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

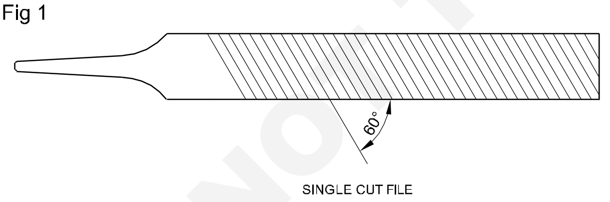
The teeth of all file are formed by cuts made on its face. Files have cuts of different types. Files with different cuts have different uses.

Types of cuts

Basically there are four types.
Single cut, Double cut, Rasp cut and Curved cut.

Single cut file (Fig 1)

Fig 1



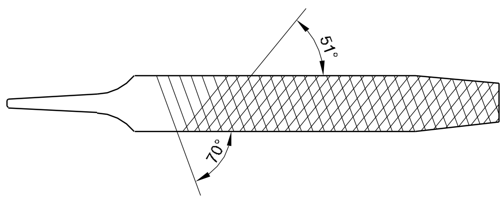
A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60^0 to the centre line. It can cut chips as wide as the cut of the file. Files with this cut are useful for filing soft metals like brass, aluminium, bronze and copper.

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

Double cut file (Fig 2)

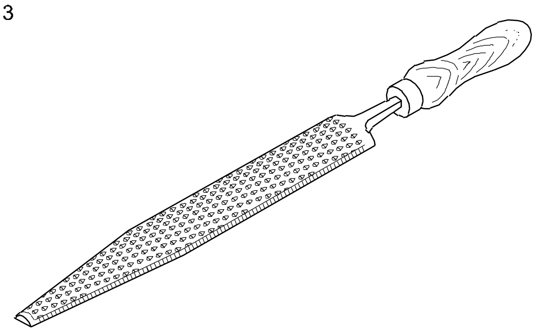
A double cut file has two rows of teeth cut diagonal to each other. The first row of teeth is known as OVERCUT and they are cut at an angle of 70^0. The other cut, made diagonal to this, is known as UPCUT, and is at an angle of 51^0. This removes stock faster than the single cut file.

Fig 2



Rasp cut file (Fig 3)

Fig 3

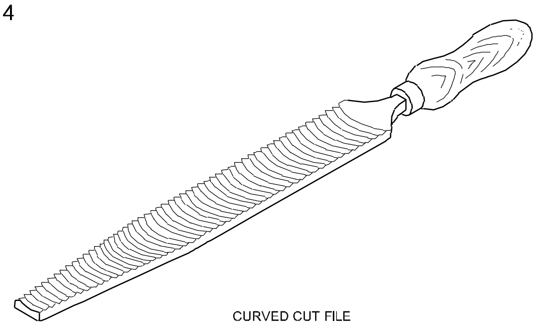


The rasp cut has individual, sharp, pointed teeth in a line, and is useful for filing wood, leather and other soft materials.

These files are available only in half round shape.

Curved cut file (Fig 4)

Fig 4



CURVED CUT FILE

FI20N121734

These files have deeper cutting action and are useful for filing soft materials like - aluminium, tin, copper, and plastic.

The curved cut files are available only in a flat shape.

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

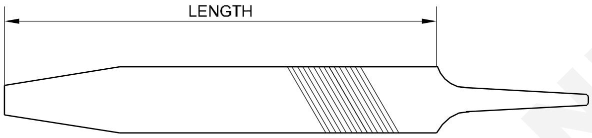
File specifications and grades

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

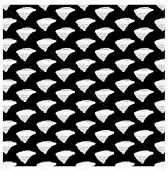
Files are manufactured in different types and grades to meet the various needs.

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

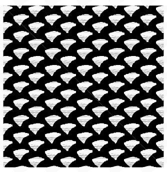
Length is the distance from the tip of a file to the heel.



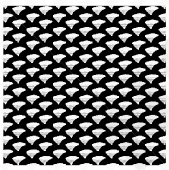
File grades are determined by the spacing of the teeth.



A **rough file** is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.

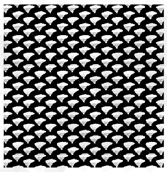


A **bastard file** is used in cases where there is a heavy reduction of material

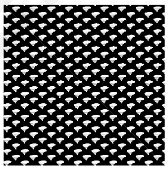


A **second cut file** is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.

It may also be observed that the number of cutting edges in rows of a file changes according to the Length of a file.



A **smooth file** is used to remove small quantity of material and to give a good finish.



A **dead smooth** file is used to bring the material to accurate size with a high degree of finish.

The most used grades of files are bastard, second cut, smooth and dead smooth. These are the the grades recommended by the bureau of indian standards (BIS)

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

The number of cutting edge in rows in each of the above grades over a Length of 10mm as shown in Table (1).

TABLE (1)

Grade of files (Number of cuts over the length of 10mm)					
Length of file	**Rough**	**Bastard**	**Second cut**	**Smooth**	**Dead smooth**
150mm	8	13	17	24	33
200mm	7	11	16	22	31
250mm	6	10	15	20	30
300mm	5	9	14	19	28

Types of files

Objectives: At the end of this lesson you shall be able to
- **identify the different shape of files(types)**
- **state the uses of flat files, Hand files square, round, half round, triangular and knife-edge files**
- **state the correct shape of files for filing different profiles.**

Scan the QR Code to view the video for this exercise

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

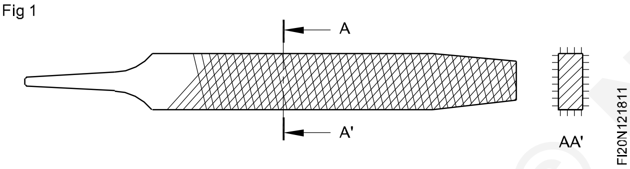
The shape of files is stated by its cross section.

Common files of different shapes: Flat file, Hand file, Square file, Round file, Half round file, Triangular file and Knife-edge file.

Flat file (Fig 1)

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

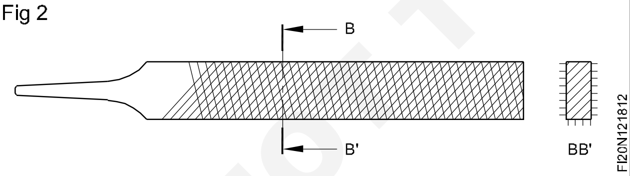
Fig 1



Hand file (Fig 2)

These files are similar to the flat files in their cross section. The edges along the width are parallel throughout 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 filing surfaces which are at right angles to surfaces already finished.

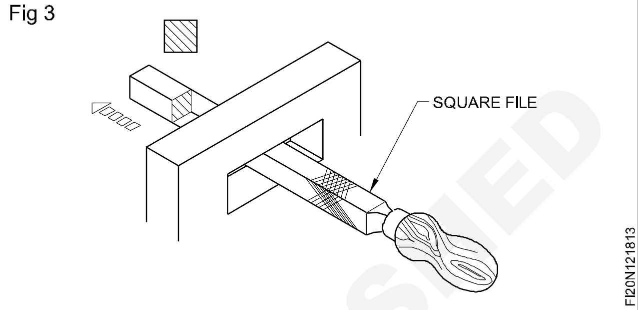
Fig 2



Flat files are general purpose files. They are available in all grades. Hand files are particularly useful for filling at right angles to a finished surface.

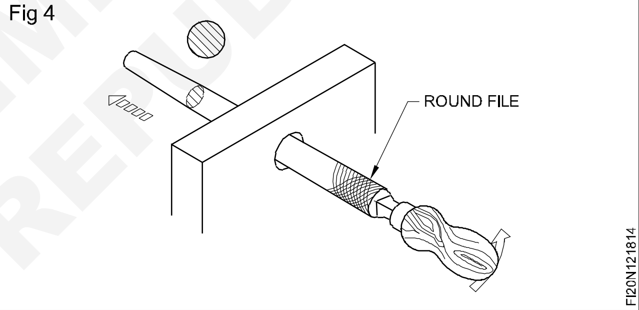
Square File: The square file is square in its cross section. It is used for filing square holes, internal square corners, rectangular openings, keyways and splines. (Fig 3)

Fig 3



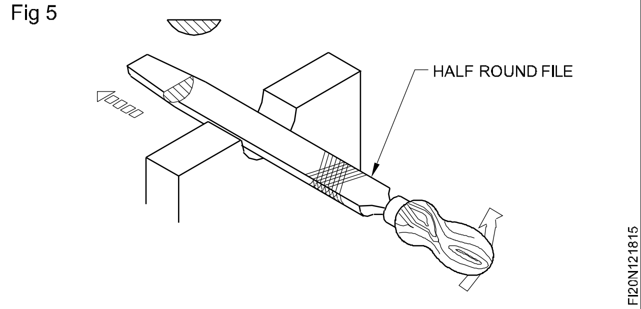
Round file: A round file is circular in its cross section. It is used for enlarging the circular holes and filing profiles with fillets. (Fig.4)

Fig 4



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.5)

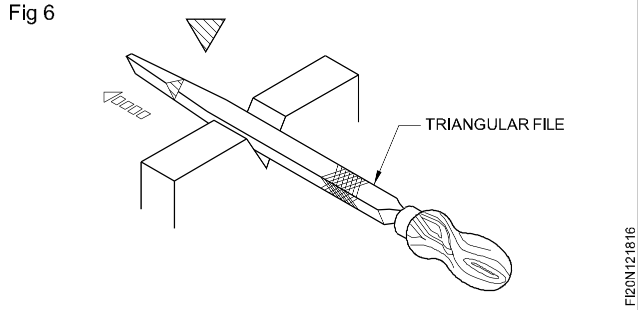
Fig 5



Knife edge file: A knife edge file has the cross section of a sharp triangles. It is used for filing narrow grooves and angles above 10^o (Fig.7)

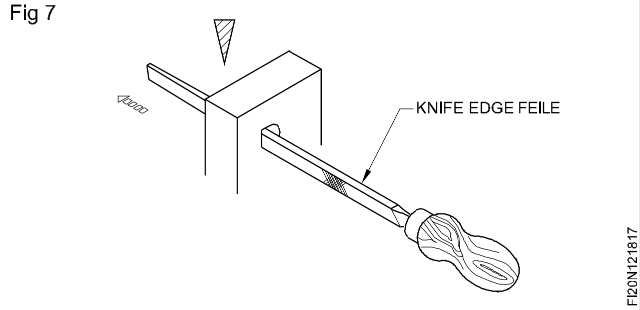
The above files have one third of their lengths tapered. They are available both single and double cuts.

Fig 6



Triangular file: A triangular file is of a triangular cross section. It is used for filing corners and angles which are more than 60°. (Fig.6)

Fig 7



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

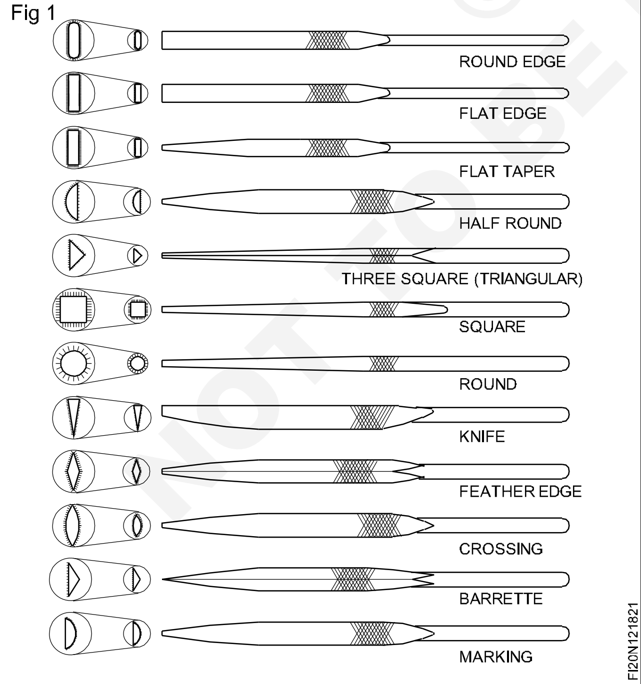
Needle files

Objectives: At the end of this lesson you shall be able to
- **name the different shapes of needle files**
- **designate needle files as per BIS.**

Needle files are usually available in sets with assorted shapes. These types of files are used for delicate, light kinds of work. These files are available in bastard and smooth grade.

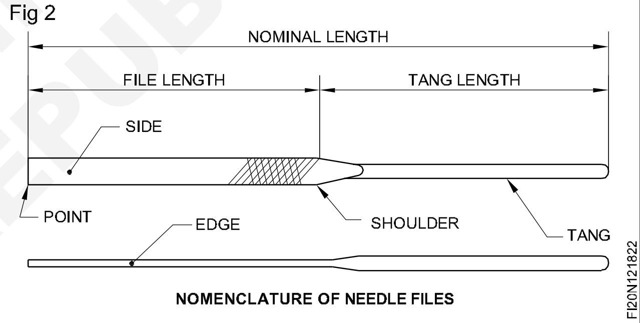
Shapes: The common shapes of needle files are shown in figure 1. The shapes are round edge, flat edge, flat taper, half round, triangular, square, round, knife, feather edge, crossing, barred and marking. (Fig 1)

Fig 1



Nomenclature of needle files. (Fig.2)

Fig 2



NOMENCLATURE OF NEEDLE FILES

Length: These files are available in a nominal length of 120mm to 180mm.

Grades: The grades of cut may be identified by the cut number as follows

- bastard - Cut 0.

- smooth - Cut 2.

Designation of needle files: The needle files are designated by their names

- grade of cut

- nominal length

- BIS number

Example

A flat edge needle file with grade of cut bastard, having a nominal length of 160mm shall be designated as flat edge needle file bastard, 160 IS 3152

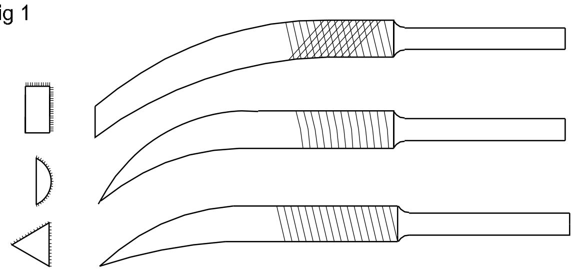
Special files

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

In addition to the common type of files, files are also available in a variety of shapes for 'special' applications. These are as follows.

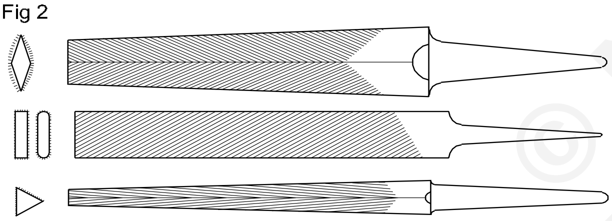
Riffle files (Fig 1)**:** These files are used for die-sinking, engraving and in silversmith's work. They are made in different shapes and sizes and are made with standard cuts of teeth.

Fig 1



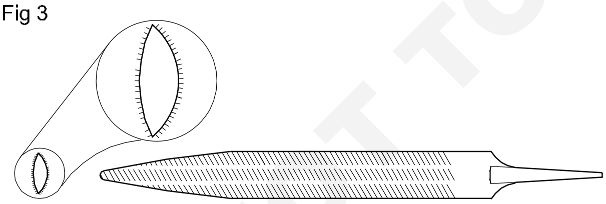
Mill saw files (Fig 2)**:** Mill saw files are usually flat and have square or rounded edges. These are used for sharpening teeth of wood-working saws, and are available in single cut.

Fig 2



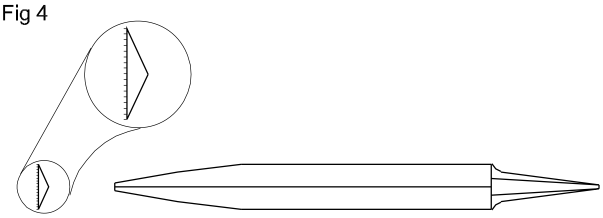
Crossing file (Fig 3)**:** This file is used in the place of a half round file. Each side of the file has different curves. It is also known as 'fish back' file.

Fig 3



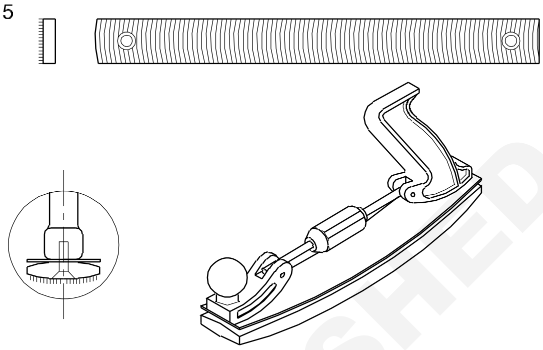
Barrette file (Fig 4)**:** This file has a flat, triangular face with teeth on the wide face only. It is used for finishing sharp corners.

Fig 4



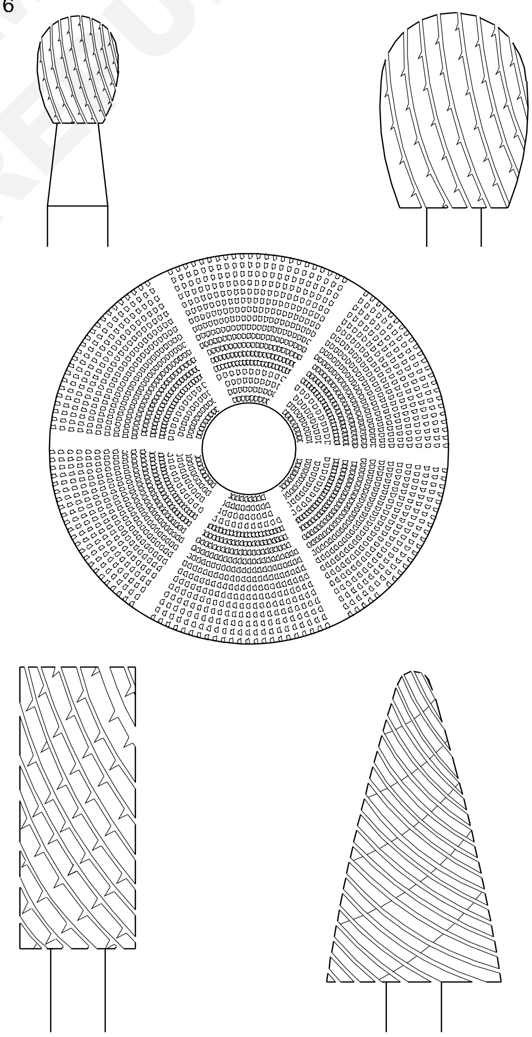
Tinker's file (Fig 5)**:** This file has a rectangular shape with teeth only at the bottom face. A handle is provided on the top. This file is used for finishing automobile bodies after tinkering.

Fig 5



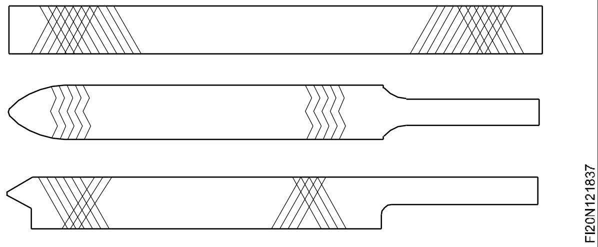
Rotary files (Fig 6)**:** These files are available with a round shank. They are driven by a special machine with a portable motor and flexible shaft. These are used in diesinking and mould-making work.

Fig 6



Machine files for hand filing machine (Fig 7)**:** Machine files are of double cut, having holes or projections to fix to the holder of the filing machine. The length and shape will vary according to the machine capacity. These files are suitable for filing the inner and outer surfaces, and are ideal for die sinking and other tool-room work.

Fig 7



Pinning of files

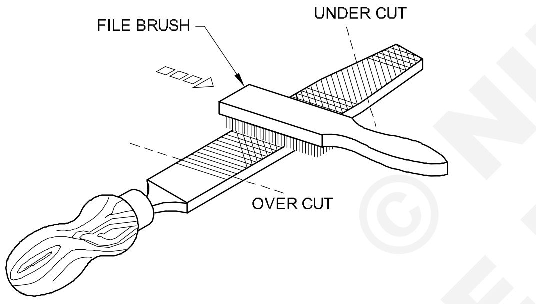
Objective: At the end of this lesson you shall be able to
- **clean the files.**

During filing, sometimes the metal chips (filings) will clog between the teeth of files. This is known as 'pinning' of files.

Files which are pinned will produce scratches on the surface being filed, and also will not bite well.

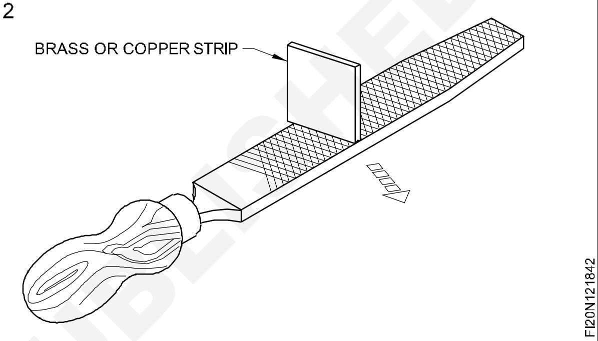
Pinning of the files is removed by using a file brush also called a file card, (Fig 1) with either forward or backward stroke.

Fig 1



Filings which do not come out easily by the file card should be taken out with a brass or copper strip. (Fig 2)

Fig 2



For new files, use only soft metal strips (brass or copper) for cleaning. The sharp cutting edges of the files will wear out quickly if a steel file card is used. When filing a workpiece to a smooth finish more 'pinning' will take place because the pitch and depth of the teeth are less.

Application of chalk on the face of the file will help reduce the penetration of the teeth and 'pinning'.

Clean the file frequently in order to remove the filings embedded in the chalk powder.

Care and maintenance

Objective: At the end of this lesson you shall be able to
- **write the care and maintenance of file.**

- Do not use files having the blunt cutting edge
- Remember that files cut on the push stroke. Never apply the pressure on the pull stroke, or you could crush the file teeth, blunt them or cause them to break off.
- Prevent from pinning.
- Giving your files teeth a light brush with oil during long storage.
- Normally do not apply any oil while filing.
- Files should be stored separately so that their faces cannot rub against each other or against other tools.

Convexity of files

Objective: At the end of this lesson you shall be able to
- **list the reasons for convexity on files.**

Most files have the faces slightly bellied lengthwise. This is known as convexity of a file. This should not be confused with the taper of a file. A flat file has faces which are convex and it also tapers slightly in width and thickness.

Purpose: If the file is parallel in thickness, all the teeth on the surface of the work will cut. This would require more downward pressure to make the file 'bite' and also more forward pressure to make the file to cut.

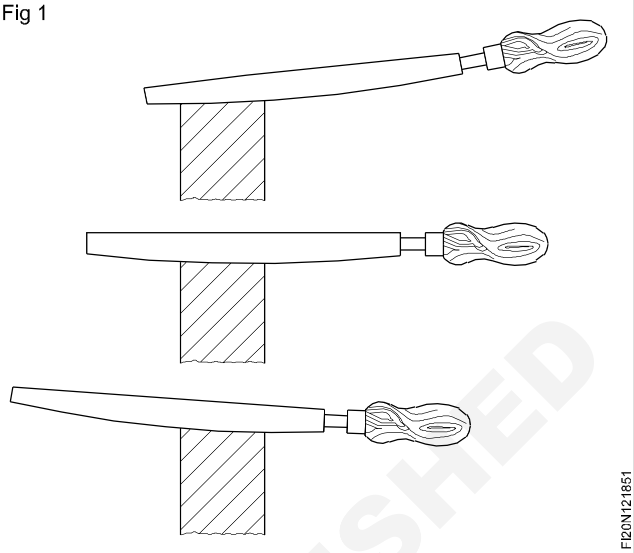
It is more difficult to control a file of uniform thickness.

To produce a flat surface with a file of parallel thickness, every stroke should be straight. But it is not possible due to the see-saw action of the hand.

If the file is made with parallel faces, while giving heat treatment, one face may warp and become concave, and the file will be useless for flat filing.

Excessive chip removal at the front or rear workpiece edge is prevented and filing of the flat surface is made easier because of the convexity on the cutting faces. (Fig 1)

Fig 1



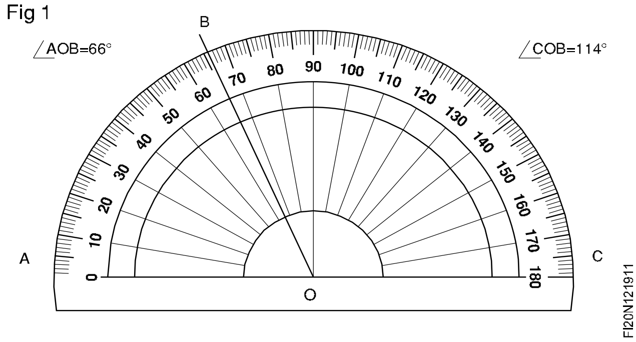
Scan the QR Code to view the video for this exercise

Measurement of angles

Objectives: At the end of this lesson you shall be able to
- **state the units and fractional units of angles**
- **express degrees, minutes and seconds using symbols.**

The unit of an angle: For angular measurements a complete circle is divided into 360 equal parts. Each division is called a degree. (A half circle will have 180°) (Fig 1)

Fig 1



Subdivisions of an angle: For more precise angular measurements, one degree is further divided into 60 equal parts. This division is one MINUTE (‘). The minute is used to represent a fractional part of a degree and is written as 30° 15’.

One minute is further divided into smaller units known as seconds (“). There are 60 seconds in a minute.

An angular measurement written in degrees, minutes and seconds would read as 30° 15' 20".

Examples for angular divisions

1	complete circle	360°
1/2	circle	180°
1/4	of a circle (right angle)	90°

Sub divisions 1 degree or 1° = 60 mts or 60'
1 min or 1' = 60 secs or 60"

Angular measuring instruments (Semi-precision)

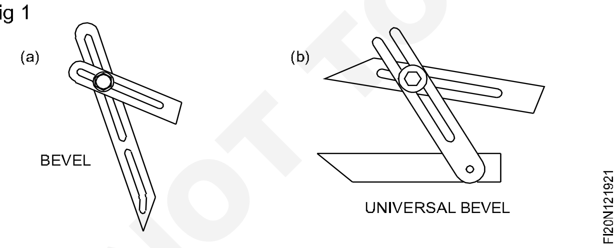
Objectives: At the end of this lesson you shall be able to
- **state the names of semi-precision angular measuring instruments**
- **differentiate between bevel and universal bevel gauges**
- **state the features of bevel protractors.**

The most common instruments used to check angles are the:

bevel or bevel gauge (Fig 1)

universal bevel gauge (Fig 2)

Fig 1



bevel protractor. (Fig 3)

Bevel gauges : The bevel gauges cannot measure angles directly. They are, therefore, indirect angular measuring instruments. The angles can be set and measured with bevel protractors.

Universal bevel gauges : The universal bevel gauge has an additional blade. This helps in measuring angles which cannot be checked with an ordinary bevel gauge. (Fig 4)

Bevel protractor (Fig 3): The bevel protractor is a direct angular measuring instrument, and has graduation marked from 0° to 180°. Angles can be measured within an accuracy of 1° using this instrument. (Fig 3)

Fig 2

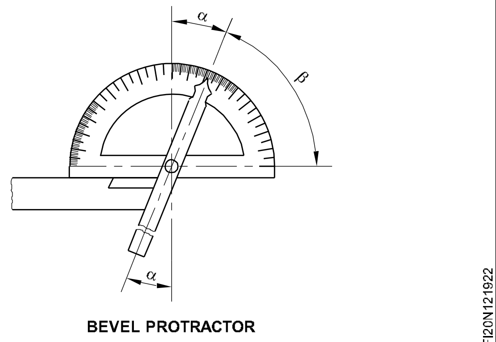
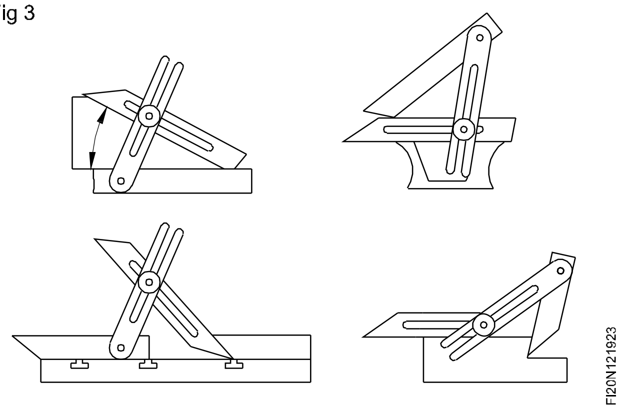


Fig 3



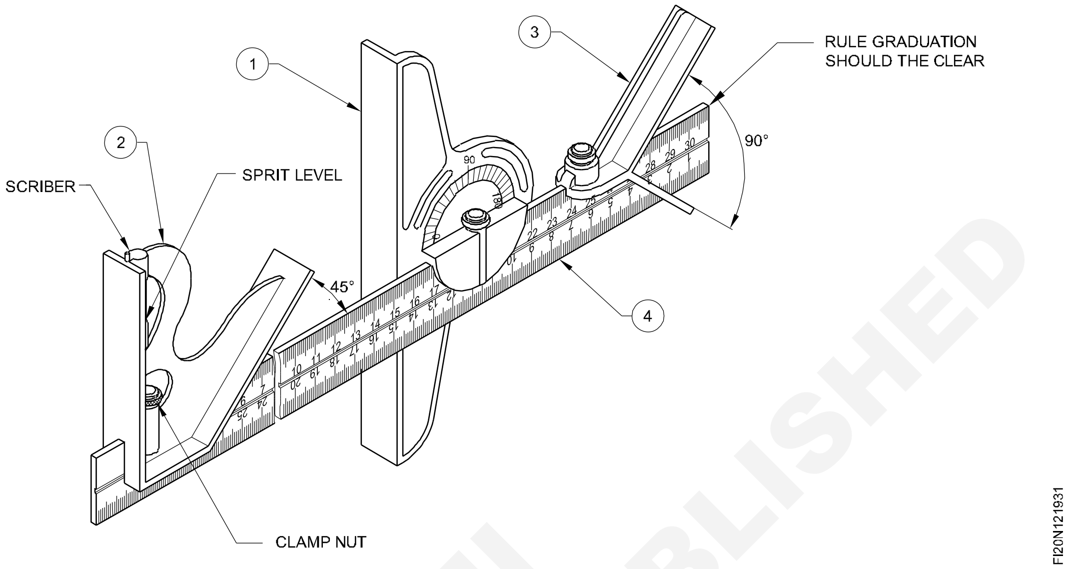
Combination set

Objectives: At the end of this lesson you shall be able to
- **name the parts of a combination set**
- **state the uses of each attachment in a combination set**

Combination sets can be used for different types of work, like layout work, measurement and checking of angles.

The combination set (Fig 1) has a

Fig 1



Protractor head	(1)
Square Head	(2)
Centre head, and a	(3)
Rule	(4)

Protractor Head

The protractor head can be rotated and set to any required angle.

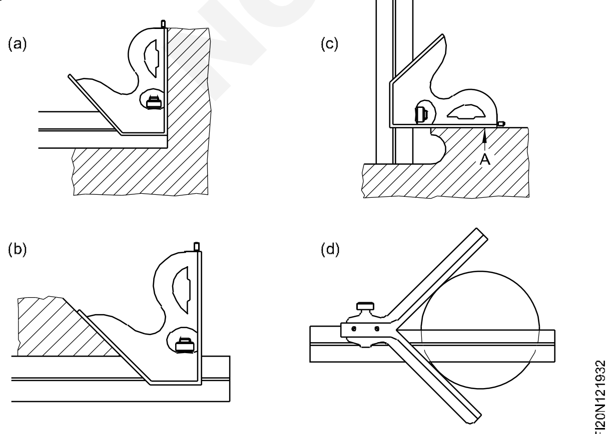
The protractor head is used for marking and measuring angles within an accuracy of 1^0. The spirit level attached to this is useful for setting jobs in a horizontal plane. (Fig.6)

Square Head

The square head has one measuring face at 90^0 and another at 45^0 to the rule.

It is used to mark and check 90^0 and 45^0 angles. It can also be used to set workpieces on the machines and measure the depth of slots. (Fig 2,3 and 4)

Fig 2

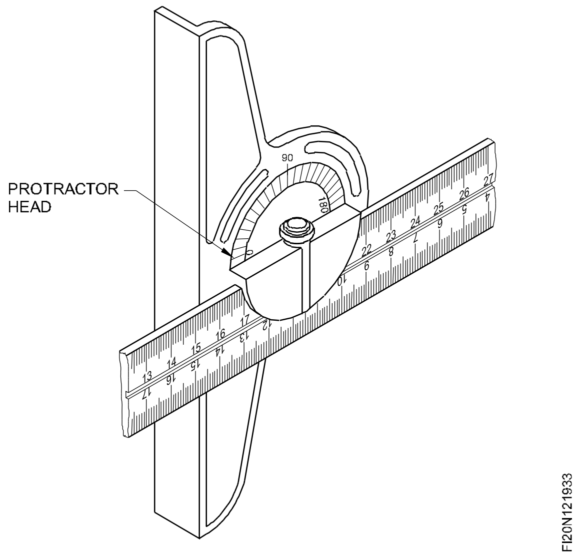


Centre Head

This along with the rule is used for locating the centre of cylindrical jobs. (Fig 5)

For ensuring accurate results, the combination set should be cleaned well after use and should not be mixed with cutting tools, either while using or storing.

Fig 3



Measuring standards (English & metric)

Objective: At the end of this lesson you shall be able to
- **describe the measuring standards of english and metric units.**

Necessity

All physical quantities are to be measured in terms of standard quantities.

Unit

A unit is defined as a standard or fixed quantity of one kind used to measure other quantities of the same kind.

Classification

Fundamental units and derived units are the two classifications.

Fundamental units

Units of basic quantities of length, mass and time.

Derived units

Units which are derived from basic units and bear a constant relationship with the fundamental units.

Ex : Area, Volume, Pressure, Force, etc.

System of units

F.P.S. system is the British system in which the basic units of length, mass and time are foot, pound and second respectively.

C.G.S. system is the metric system in which the basic units of length, mass and time are centimetre, gram and second respectively.

M.K.S system is another metric system in which the basic units of length, mass and time are metre, kilogram and second respectively.

S.I. units is referred to as Systems International units which is again of metric and the basic units, their names and symbols are Listed in table - 1

Table 1

Basic Quantity	Metric Unit		British unit	
	Name	Symbol	Name	Symbol
Length	Metre	m	Foot	F
Mass	Kilogram	kg	Pound	P
Time	Second	S	Second	S
Current	Ampere	A	Ampere	A
Temperature	Kelvin	K	Farenheit	F°
Light intensity	Candela	Cd	Candela	Cd

Fundamental units and derived units are the two classification of units.

Length, mass and time are the fundamental units in all the systems (ie) F.P.S, C.G.S, M.K.S and S.I systems.

Surface gauges

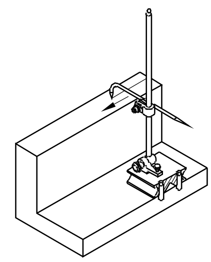
Objectives: At the end of this lesson you shall be able to
- **state the uses of surface gauges**
- **name the types of surface gauges**
- **state the advantages of universal surface gauges.**
- **state care and maintenance of surface gauges**

Scan the QR Code to view the video for this exercise

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

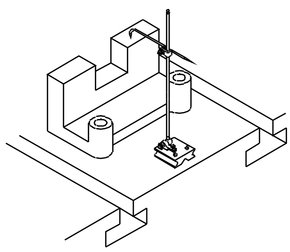
scribing lines parallel to a datum surface (Fig.1)

Fig 1



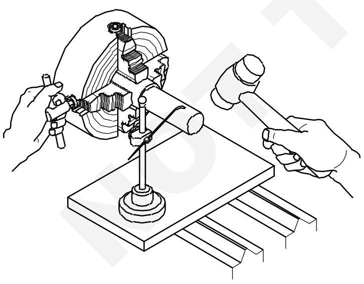
Setting jobs on machines parallel to a datum surface (Fig.2)

Fig 2



Checking the height and parallelism of jobs, setting jobs concentric to the machine spindle. (Fig 3)

Fig 3



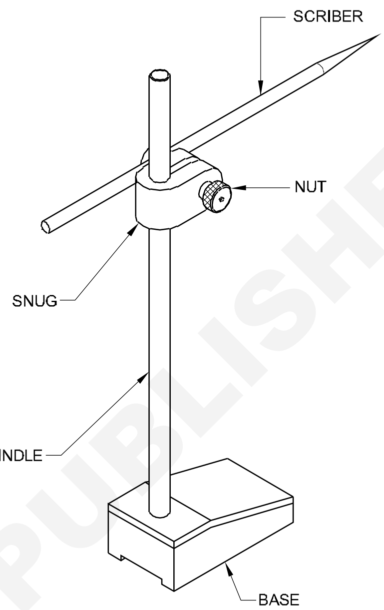
Types of surface gauges

Surface gauges/scribing blocks are of two types, fixed and universal.

Suface gauge - fixed type (Fig 4)

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

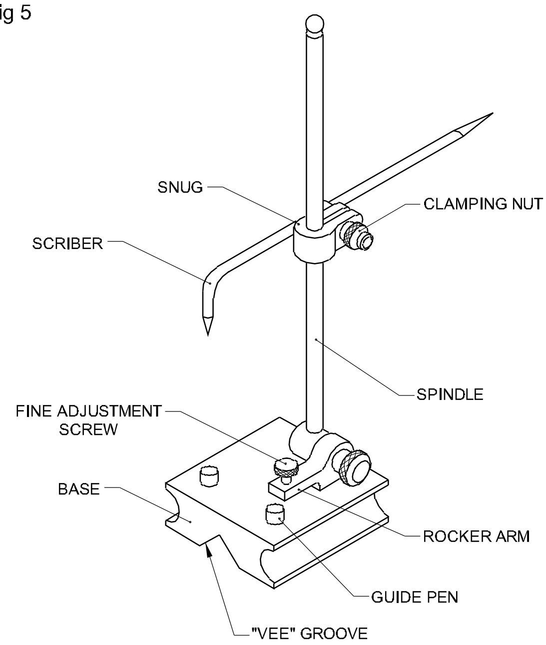
Fig 4



Universal surface gauge (Fig 5)

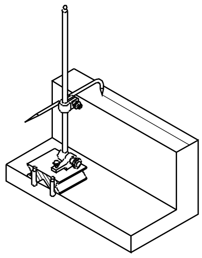
This has the following additional features: The spindle can be set to any position. Fine adjustment can be made quickly. Can also be used on cylindrical surfaces.

Fig 5



Parallel lines can be scribed from any datum edge with the help of guide pins. (Fig 6)

Fig 6



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Parts and functions of a Universal Surface Gauge

Base

The base is made of steel or cast iron with a 'V groove at the bottom. The 'V' groove helps to seat on circular work. The guide-pins, fitted in the base, are helpful for scribing lines from any datum edge.

Rocker arm

The rocker arm is attached to the base along with a spring and a fine adjustment screw. This is used for fine adjustments.

Spindle

The spindle is attached to the rocker arm.

Scriber

The scriber can be clamped in any position on the spindle with the help of a snug and a clamping nut.

Care and maintenance

- Clean before and after the use
- Apply thin layer of oil to the bottom of the surface base before using for marking.
- Sharpen the Scriber if necessary.
- Do not exert more pressure while marking

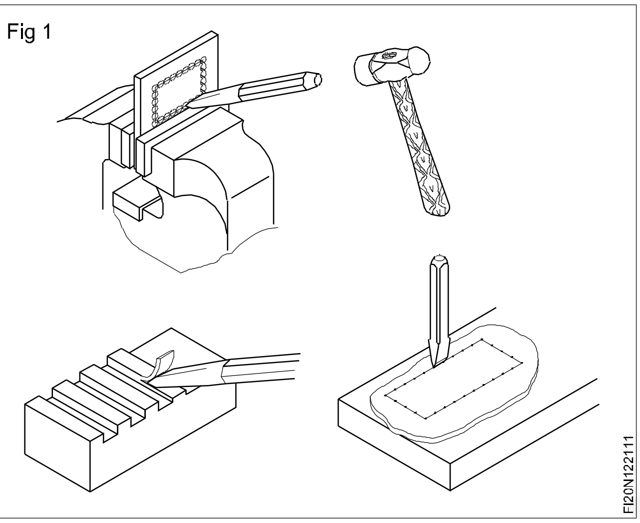
Cold Chisel

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**
- **specify the chisel**

Scan the QR Code to view the video for this exercise

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

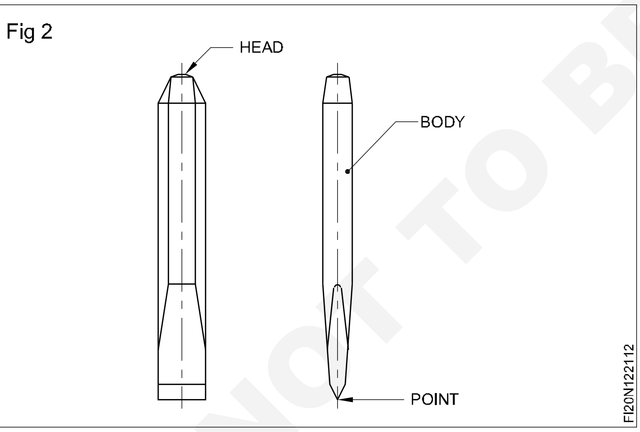
Fig 1



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

Parts of a Chisel (Fig 2)**:** A chisel has the following parts.

Fig 2



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.

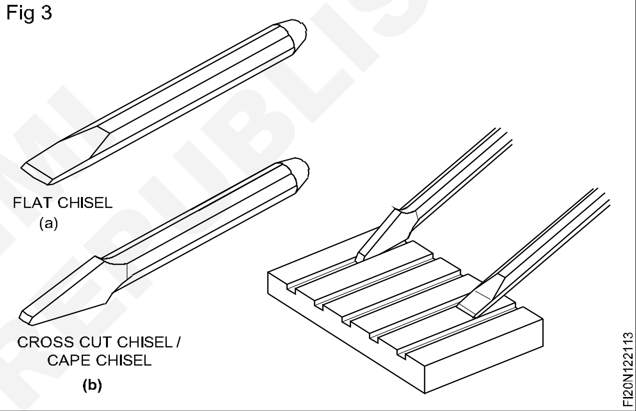
Common types of chisels: There are five common types of chisels.

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

Flat chisels (Fig.3a)**:** They are used to remove metal from large flat surfaces and chip-off excess metal of welded joints and castings.

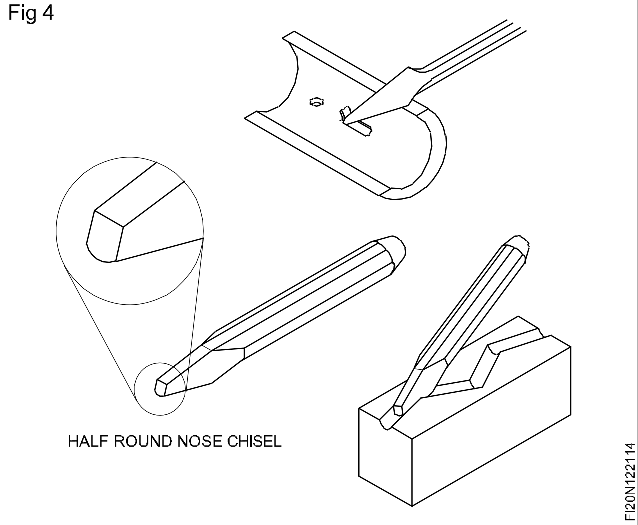
Cross-cut or cape chisels (Fig.3b)**:** These are used for cutting key ways, grooves and slots.

Fig 3



Half-round nose chisels (Fig 4)**:** They are used for cutting curved grooves (oil grooves).

Fig 4



Diamond point chisels (Fig 5)**:** These are used for squaring materials at the corners, joints.

Fig 5

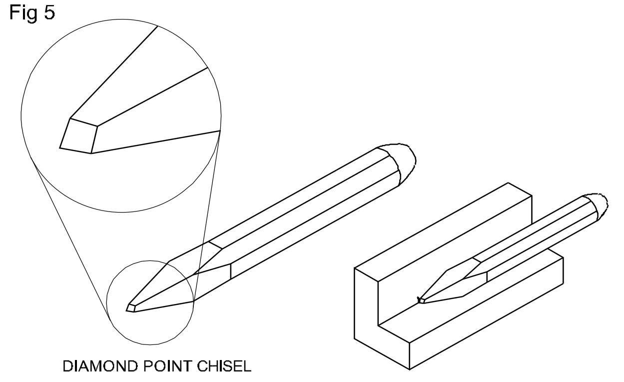
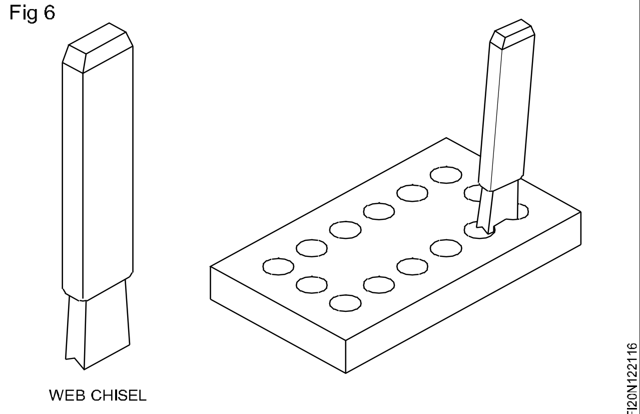


Fig 6



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

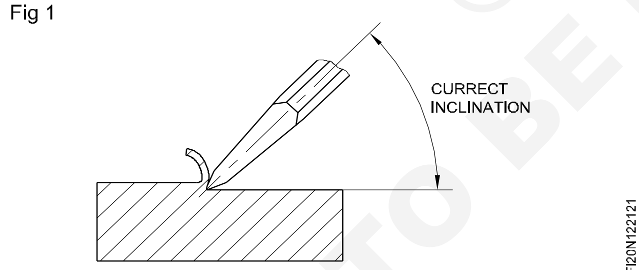
Angles of chisels

Objectives: At the end of this lesson you shall be able to
- **select the point angles of chisels for different materials**
- **state the effect of rake and clearance angles**
- **brief the care and maintenance of chisels.**

Point angles and materials: The correct point/cutting angle of the chisel depends on the material to be chipped. Sharp angles are given for soft materials, and wide angles for hard materials.

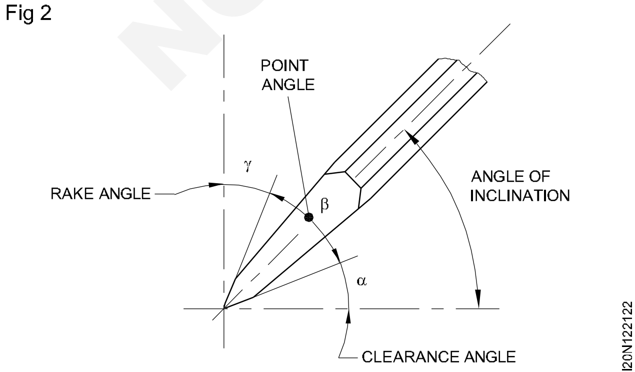
The correct point and angle of inclination generate the correct rake and clearance angles. (Fig 1)

Fig 1



Rake angle: Rake angle is the angle between the top face of the cutting point, and normal (90°) to the work surface at the cutting edge. (Fig 2)

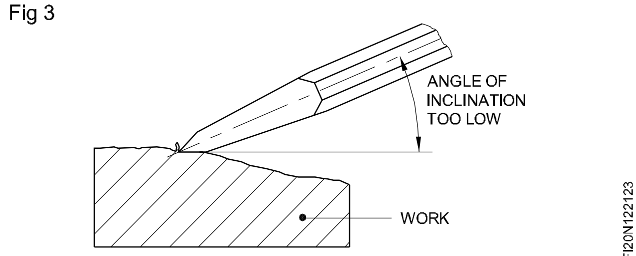
Fig 2



Clearance angle: Clearance angle is the angle between the bottom face of the point and the tangent to the work surface originating at the cutting edge. (Fig 2)

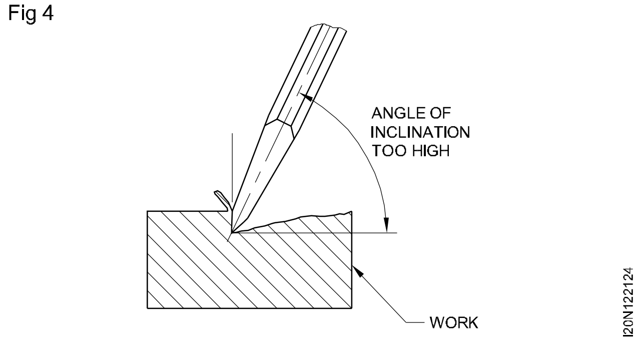
If the clearance angle is too low or zero, the rake angle increases. The cutting edge cannot penetrate into the work. The chisel will slip. (Fig 3)

Fig 3



If the clearance angle is too great, the rake angle reduces. The cutting edge digs in and the cut will become deeper and deeper. (Fig 4) The correct point angle and angle of inclination for different materials for chipping is given in Table 1.

Fig 4



Crowning: A slight curvature is ground called "Crowning" to the cutting edge of the chisel, to prevent digging of corners, which leads to breakage of chisel point. "Crowning" allows the chisel to move freely along a straight line while chipping.

Table 1

Material to be cut	**Point angle**	**Angle inclination**
High Carbon Steel	65°	39.5°
Cast iron	60°	37°
Mild steel	55°	34.5°
Brass	50°	32°
Copper	45°	29.5°
Aluminium	30°	22°

Care & maintenance

- Sharpen the chisel before use.
- Apply oil to avoid rust.
- Don't use the mushroom head chisel.
- Use safety goggles while chipping.
- While chipping.
- No greasy subject on the head of the chisel.

Ordinary depth gauge

Scan the QR Code to view the video for this exercise

Objectives: At the end of this lesson you shall be able to
- **state the uses of ordinary depth gauge**
- **name the parts of depth gauge.**

Ordinary depth gauge

Ordinary depth gauge is semi precision instrument used for measuring of depth of recesses, slots and steps.

Parts of ordinary depth gauge

1 Graduated beam

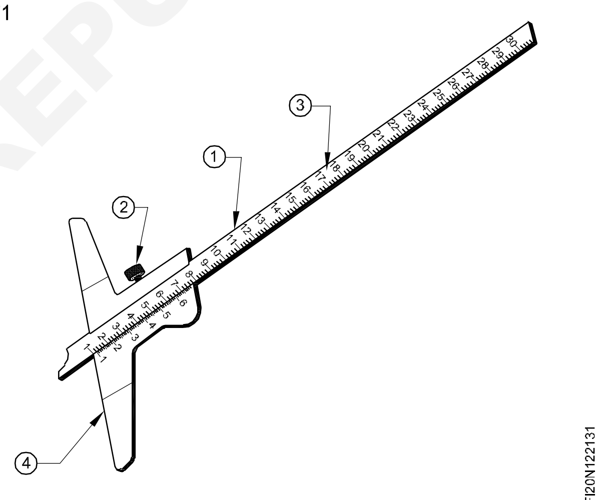
2 Clamping screw

3 Scale

4 Base

Available in the ranges of 0-200 mm. Ordinary depth gauge is used to measure an accuracy of 0.5 mm.

Fig 1



Marking media

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

Scan the QR Code to view the video for this exercise

Purpose of marking media

In marking off/Layout, the surface of the job/workpiece is coated with a medium to show the marked lines clear and visible. To get clear and thin lines, the best layout medium is to be selected.

Different marking media

The different marking media are Whitewash, Marking blue, Prussian Blue, Copper Sulphate and Cellulose Lacquer.

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 andcastings with oxidised surface. (Fig 1)

Whitewash is not recommended for workpieces of high accuracy.

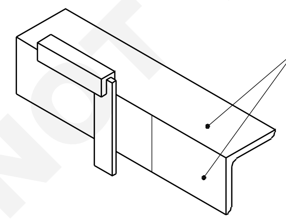
Marking blue

A Chemical dye, blue based colour mixed with methylated spirit used for marking on workpieces which are reasonably machined surface.

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 1

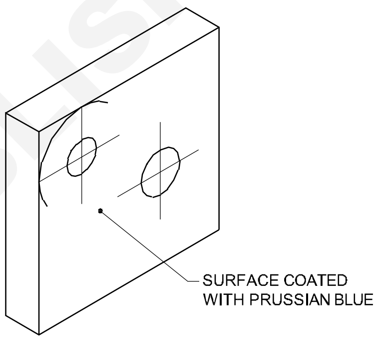


Copper sulphated

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

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

Fig 2



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

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

In present days, marking media used are readily available in aerosol container, which can be applied by spraying on to any surface, which needs marking.

Readymade solutions of marking dye/ink which are quick drying and thin layer to mark precise dimensions and clear visible lines. Also permanent marker pens are available in different. colours, which are quick drying and used for smaller workpieces of metal, wood and plastics.

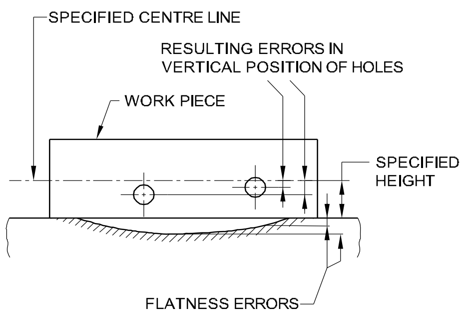
Surface plates

Objectives: At the end of this lesson you shall be able to
- **state the necessity of surface plate**
- **state the material of surface plate**
- **state the specification of surface plate.**

Surface plates - their necessity

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

Fig 1



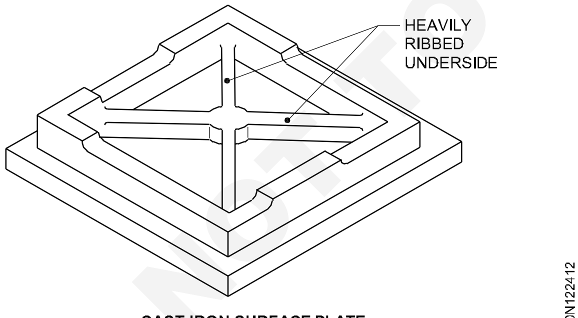
EFFECT OF MARKING-OUT FROM NON-FLAT SURFACE. NOTE THAT THE ERRORS IN THE HOLE POSITIONS ARE EQUAL TO THE FLATNESS ERRORS

Materials and construction

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

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

Fig 2

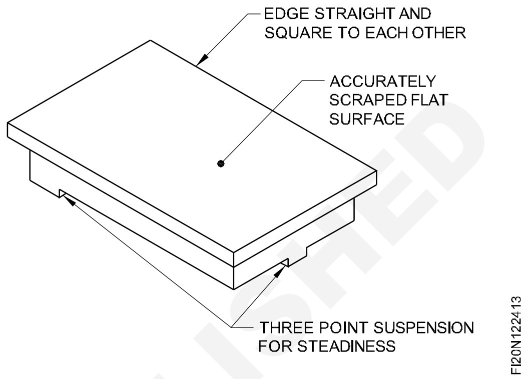


CAST IRON SURFACE PLATE

For the purpose of steadiness and convenience in levelling, a three point suspension is given. (Fig 3)

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

Fig 3



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.

Care & maintenance

- Clean before and after use.
- Do not keep job on the surface plate.
- Don't keep any cutting tool on the table.

Angle plates

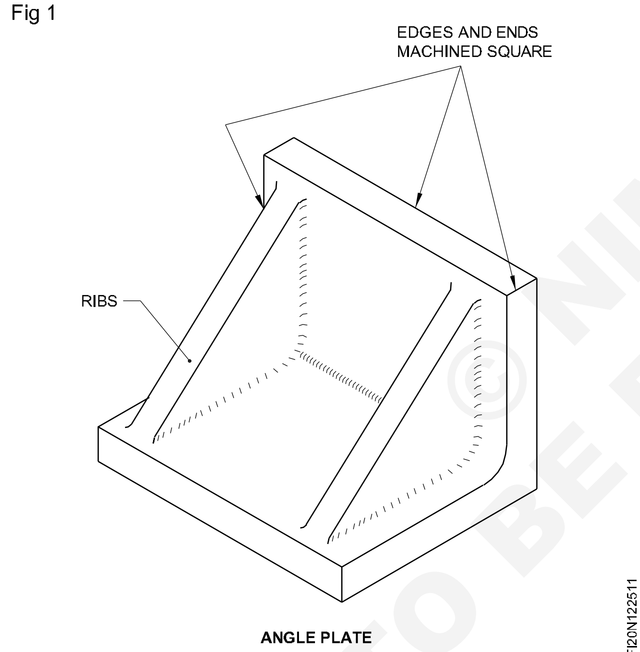
Objectives: At the end of the lesson you shall be able to
- **state the constructional features of different types of angle plates**
- **name the types of angle plates**
- **state the uses of different types of angle plates**
- **state the grades of angle plates.**
- **specify angle plates. Constructional features**

Angle plates have two plane surfaces, machined perfectly flat and at right angles. Generally these are made of closely grained cast iron or steel. The edges and ends are also machined square. They have ribs on the machined part for good rigidity and to prevent distortion.

Types of angle plates

Plain solid angle plate (Fig 1)

Fig 1



Among the three types of angle plates normally used, the plain solid angle plate is the most common. It has the two plane surfaces perfectly machined at 90° to each other. Such angle plates are suitable for supporting work-pieces during layout work. They are comparatively smaller in size.

Slotted type angle plate (Fig 2)

The two plane surfaces of this type of angle plate have slots milled. It is comparatively bigger in size than the plain solid angle plate.

The slots are machined on the top plane surfaces for accommodating clamping bolts. This type of angle plate can be tilted 90° along with the work for marking or machining. (Figs 3 and 4)

Fig 2

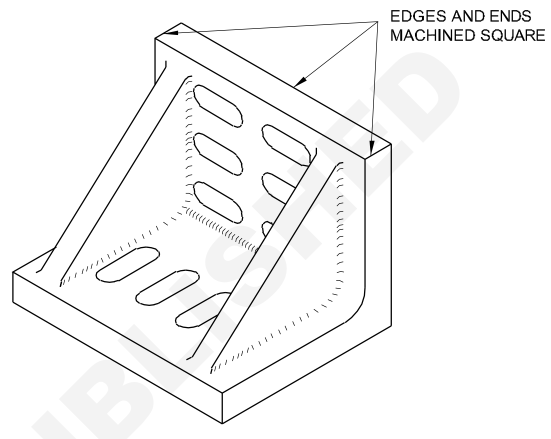
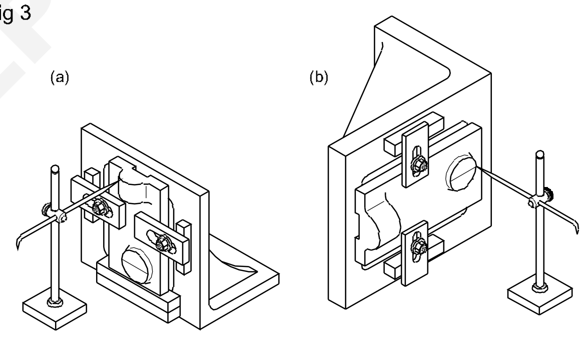
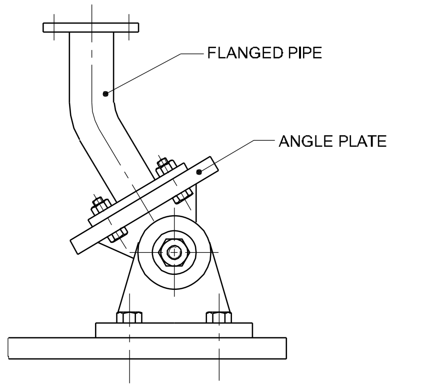


Fig 3



Swivel type angle plate (Fig 5)

Fig 4

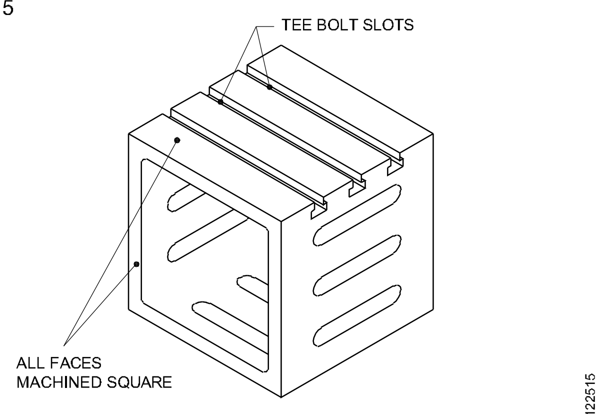


This is adjustable so that the two surfaces can be kept at an angle. The two machined surfaces are on two separate pieces which are assembled. Graduations are marked on one to indicate the angle of tilt with respect to the other. When both zeros coincide, the two plane surfaces are at 90° to each other. A bolt and nut are provided for locking in position.

Box angle plate (Fig 6)

They have applications similar to those of other angle plates. After setting, the work can be turned over with the box enabling further marking out or machining. This is a significant advantage. This has all the faces machined square to each other.

Fig 5



BOX ANGLE PLATE

Grades

Angle plates are available in two grades - Grade 1 and Grade 2. The Grade 1 angle plates are more accurate and are used for very accurate tool room type of work. The Grade 2 angle plates are used for general machine shop work. In addition to the above two grades of angle plates, precision angle plates are also available for inspection work.

Sizes

Angle plates are available in different sizes. The sizes are indicated by numbers. Table 1 gives the number of the sizes and the corresponding size proportions of the angle plates.

Specification of angle plates

a) Size 6 Grade 1

Box plate will be designated as - box angle plate 6 Gr 1 IS 623.

b) Size 2 - Grade 2 angle plate will be designated as

Angle plate 2 Gr 2 I.S 623.

TABLE 1

Size No.	L	B	H
1	125	75	100
2	175	100	125
3	250	150	175
4	350	200	250
5	450	300	350
6	600	400	450
7	700	420	700
8	600	600	1000
9	1500	900	1500
10	2800	900	2200
Grade 2 only			

Care & Maintenance

– Clean before and after use.

– Apply oil after the use.

Parallel blocks

Objectives: At the end of this lesson you shall be able to
- **name the types of parallels**
- **state the constructional features of parallel blocks**
- **specify parallel blocks as per BIS recommended**
- **state the uses of parallel blocks.**

Parallel blocks of different types are used for setting workpieces for machining. The commonly used are of two types.

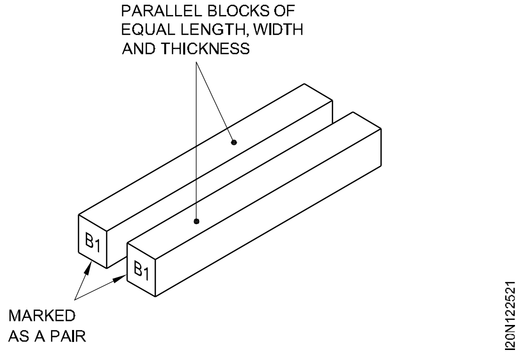
– Solid Parallels

– Adjustable Parallels

Solid parallels (Solid parallel blocks) (Fig 1)

This is the type of parallel which is very much used in machine shop work. They are made of steel pieces of rectangular cross section, and are available in different lengths and cross sectional sizes.

Fig 1



They are hardened and ground, and, sometimes, finished by lapping.

Parallels are machined to close limits, and are perfectly flat, square, and parallel throughout the length. These are made in pairs of identical dimensions.

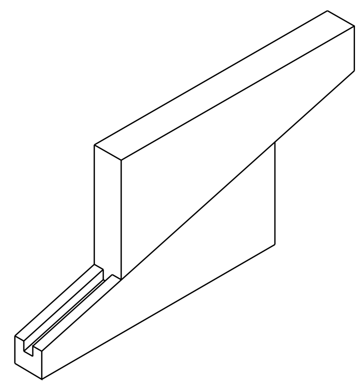
Grades

Parallels are made in two grades - Grade A and Grade B. Grade A is meant for fine toolroom type of work, and Grade B for general machine shop work.

Adjustable parallels (Fig 2)

These consist of two tapered blocks sliding one over the other in a tongue and groove assembly. These types of parallels can be adjusted and set to different heights.

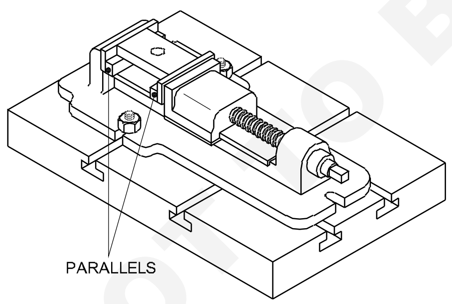
Fig 2



Uses

Solid and adjustable parallels are used for parallel setting of workpieces while machining. They are also useful for raising the workpieces held in vices or machine tables to provide better observation of the machining process. (Fig 3)

Fig 3



Parallels are made in pairs and should be used in matching pairs to ensure accuracy in set-up.

Care and maintenance

- Clean before and after the use.
- Apply oil after use
- Do not use as a hammer.

Sizes of parallels

These are given in TABLE 1 and TABLE 2.

Designation of parallels

Parallels are designated by the type, grade (for solid parallels only) size, and the number of the standard. Fig 4

Examples

Solid parallel A5 x 10 x 100 IS: 4241

Adjustable parallel 10 x 13 IS:4241

Fig 4

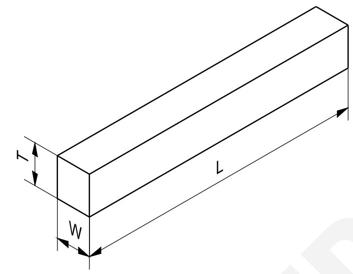


Table 1

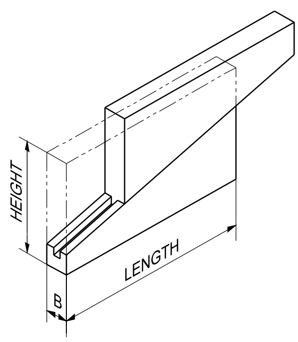
Sizes of solid parallels

Grade	Size T.W.L.
A & B	5 x 10 x 100
A & B	10 x 20 x 150
A & B	15 x 25 x 150
A & B	20 x 35 x 200
A & B	25 x 45 x 250
A & B	30 x 60 x 250
A & B	35 x 70 x 300
B	40 x 80 x 350
B	50 x 100 x 400

Table 2

Range and size of Adjustable Parallels

Fig 5



Height Range	Length
10 - 13	40
13 - 16	50
16 - 20	60
20 - 25	65
25 - 30	70
30 - 40	85
40 - 50	100

Physical and mechanical properties of metals

Objectives: At the end of this lesson you shall be able to
- **name the different physical and mechanical properties of materials**
- **state the characteristics of the mechanical properties of metals.**

Properties of metals: Metals have different properties. Depending on the type of application, different metals are selected.

Physical properties of metals

- Colour
- Weight/Specific gravity
- Structure
- Conductivity
- Magnetic property
- Fusibility

Colour

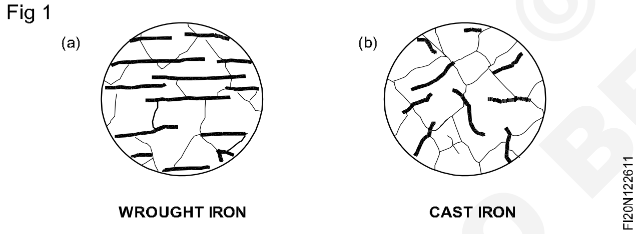
Different metals have different colours. For example, copper is of a distinctive red colour. Mild steel is of a blue/black sheen.

Weight

Metals differ based on their weight. A metal, like aluminium, weighs lighter (specific gravity 2.8) than many others, and a metal, like lead, is heavy (specific gravity 9).

Structure (Figs 1 and 2)

Fig 1



Generally metals can also be differentiated by their internal microstructure. Metals like wrought iron and aluminium will have a fibrous structure, and metals like cast iron and bronze will have a granular structure.

Conductivity: Thermal conductivity and electrical conductivity are the measure of the ability of a material to conduct heat and electricity. Conductivity will vary from metal to metal. Copper and aluminium are good conductors of heat and electricity.

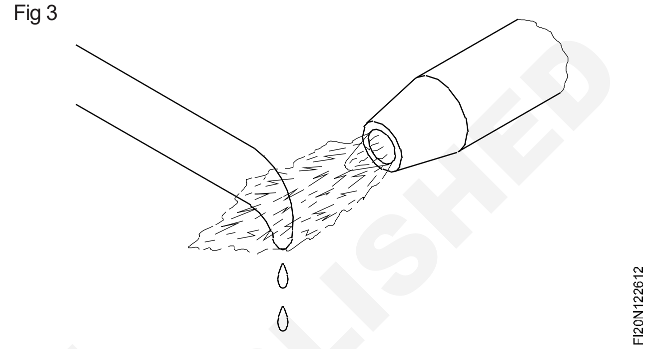
Magnetic property: A metal is said to possess magnetic property, if it is attracted by a magnet.

Almost all ferrous metals, excepting some types of stainless steel, can be attracted by a magnet and all non-ferrous metals and their alloys will not be attracted by a magnet.

Fusibility (Fig 3)

It is the property possessed by a metal by virtue of which it melts when heat is applied. Many materials are subject to the transformation in shape (i.e.) from solid to liquid at different temperatures. Tin has a low melting temperature (232ºC)and tungsten melts at a high temperature (3370ºC).

Fig 3



Specific gravity

It is the ratio between the weight of the metal and the weight of equal volume of water.

Mechanical properties

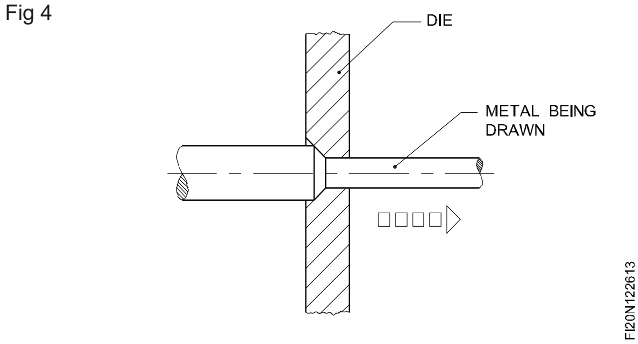
The mechanical properties of a metal are

- ductility
- malleability
- hardness
- brittleness
- toughness
- tenacity
- elasticity

Ductility (Fig 4)

A metal is said to be ductile when it may be drawn out in tension without rupture. Wire-drawing depends upon ductility for its successful operation. A ductile metal must be both strong and plastic. Copper and aluminium are good examples of ductile metals.

Fig 4



Malleability (Figs 5 and 6)

Fig 5

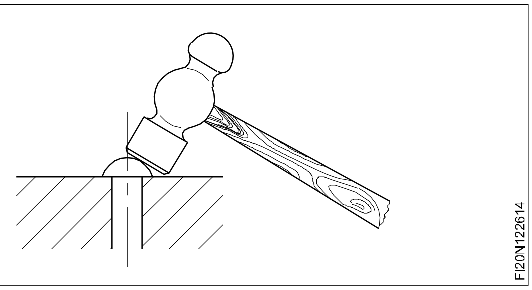
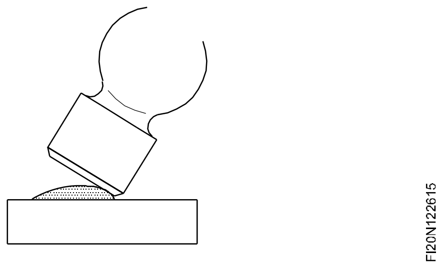


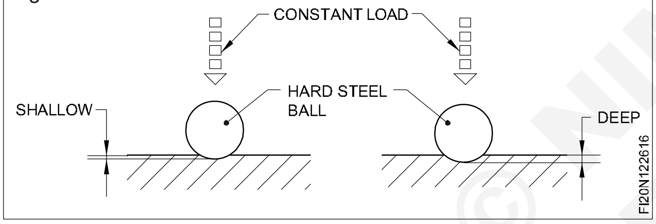
Fig 6



Malleability is the property of permanently extending in all directions without rupture by hammering, rolling etc. to change its size and shape. Lead is a very malleable metal.

Hardness (Fig 7)

Fig 7

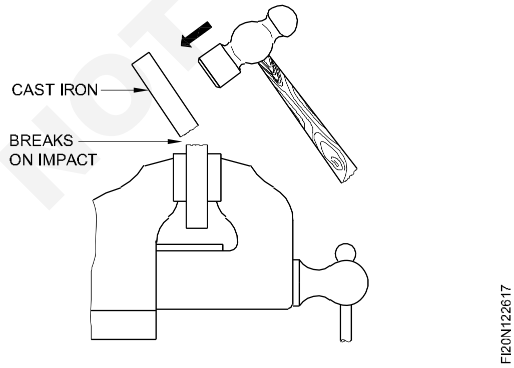


Hardness is a measure of a metal's ability to withstand scratching, wear, abrasion and penetration.

Brittleness (Fig 8)

Brittleness is the property of a metal which permits no permanent distortion before breaking. Cast iron is an example of a brittle metal, and it will break rather than bend under shock or impact.

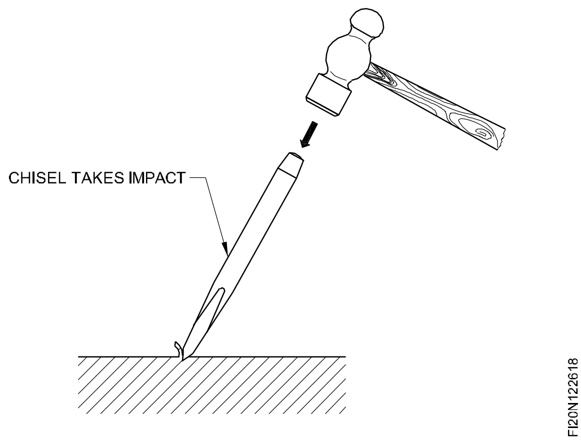
Fig 8



Toughness (Fig 9)

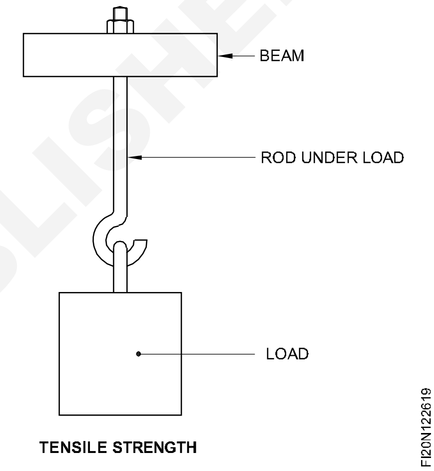
Toughness is the property of a metal to withstand shock or impact. Toughness is the property opposite to brittleness. Wrought iron is an example of a tough metal.

Fig 9



Tenacity (Fig 10)

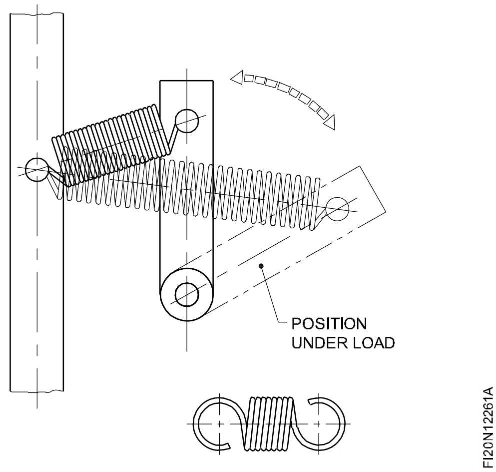
Fig 10



Tenacity of a metal is its ability to resist the effect of tensile forces without rupture. Mild steel, wrought iron and copper are examples of tenacious metals.

Elasticity (Fig 11)

Fig 11



Elasticity of a metal is its power of returning to its original shape after the applied force is released. Properly heat-treated spring is a good example of elasticity.

Specific gravity

It is the ratio between the weight of the metal and the weight of equal volume of water.

Metal-cutting saws

Objectives: At the end of this lesson you shall be able to
- **name the common types of metal-cutting saws**
- **state the advantages of a horizontal band-saw**
- **state the features of different types of cutting saws**
- **state the specific use of a contour-saw.**
- **state the precautions to be observed while machine sawing.**

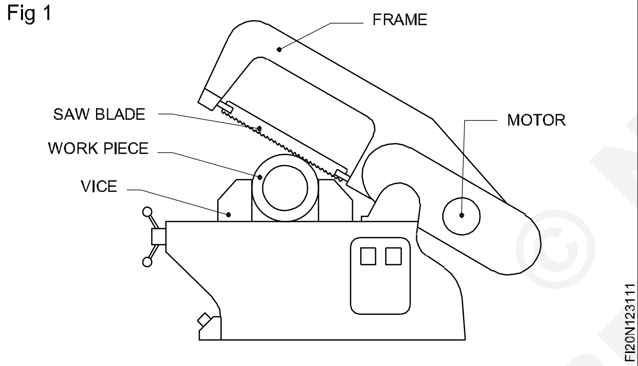
Metal-cutting saws of different types are used in industries. The most commonly used are the:

- power saw
- horizontal band-saw
- circular saw
- contour band-saw.

Power saw (Fig 1)

This is the most commonly used metal-cutting saw and discussed in related theory for Ex: 1.2.31.

Fig 1

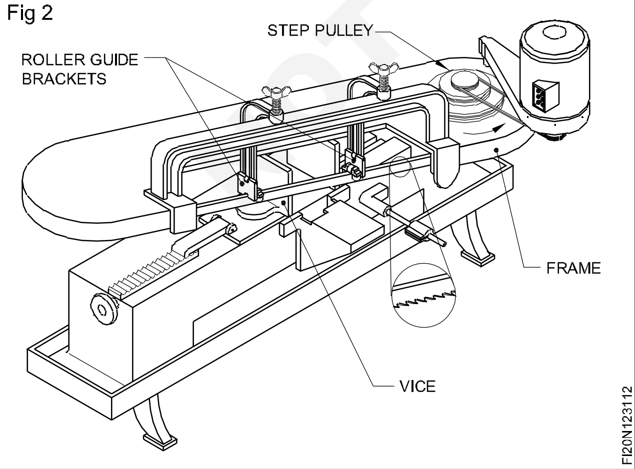


Horizontal band-saw (Fig 2)

This has a saw frame on which a motor is fitted.

There are two pulley wheels on which an endless bandsaw passes.

Fig 2



Speed variation is obtained through the stepped pulleys on the motor.

The roller-guide brackets provide the rigidity for the blade in the cutting area and also prevent wandering of the blade while cutting.

The blade tension is maintained by using the adjusting handle. provided for this purpose.

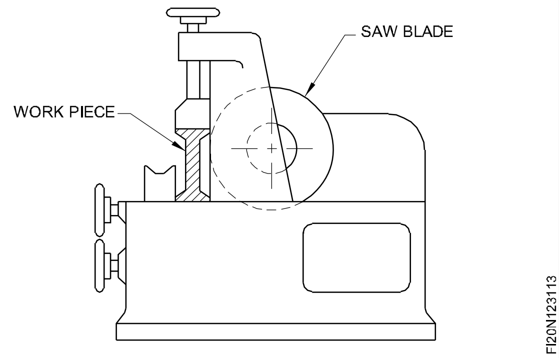
A vice is provided for holding the metal stocks. The vice is adjustable for angular cutting.

This machine has the advantage of continuous cutting ability, and is much faster than a power saw. It may be noted that a power saw cuts only in every alternate stroke.

Cirucular saw (Fig 3)

This type of cutting machine is used when cutting materials have a large cross-section. The circular saw has a continuous cutting action and is economical in production work where heavy section metals are used.

Fig 3



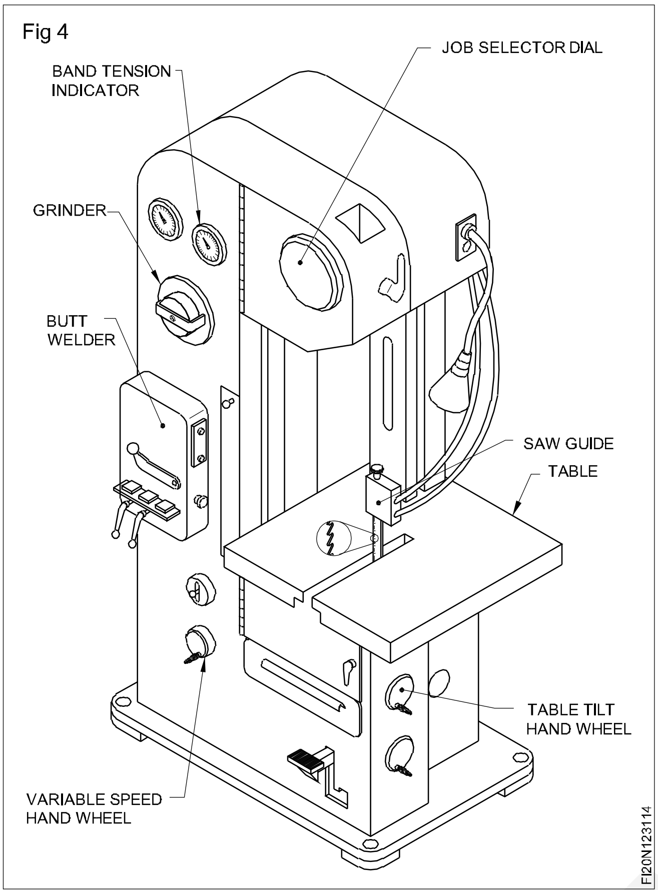
Contour saw (Fig 4)

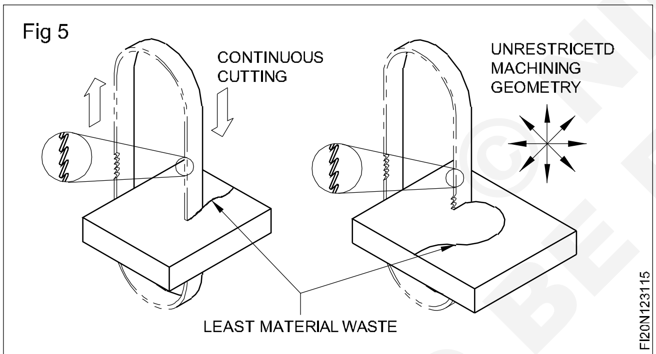
In this, a metal band saw blade is used, and the contour saw has a continuous cutting motion. (Fig 5)

These machines are very much used for cutting metals to different profiles. (Fig 6)

Different speeds can be obtained while cutting, with the help of variable speed pulleys.

For repairing broken countour saw blades, these machines are fitted with a shear for trimming the blade ends, a butt-welding machine for joining the ends and the small grinder to finish the welded joint.





The table can be tilted to any angle for angular cutting.

The blade passes through a guide which prevents the blades from wandering and keeps it rigidly.

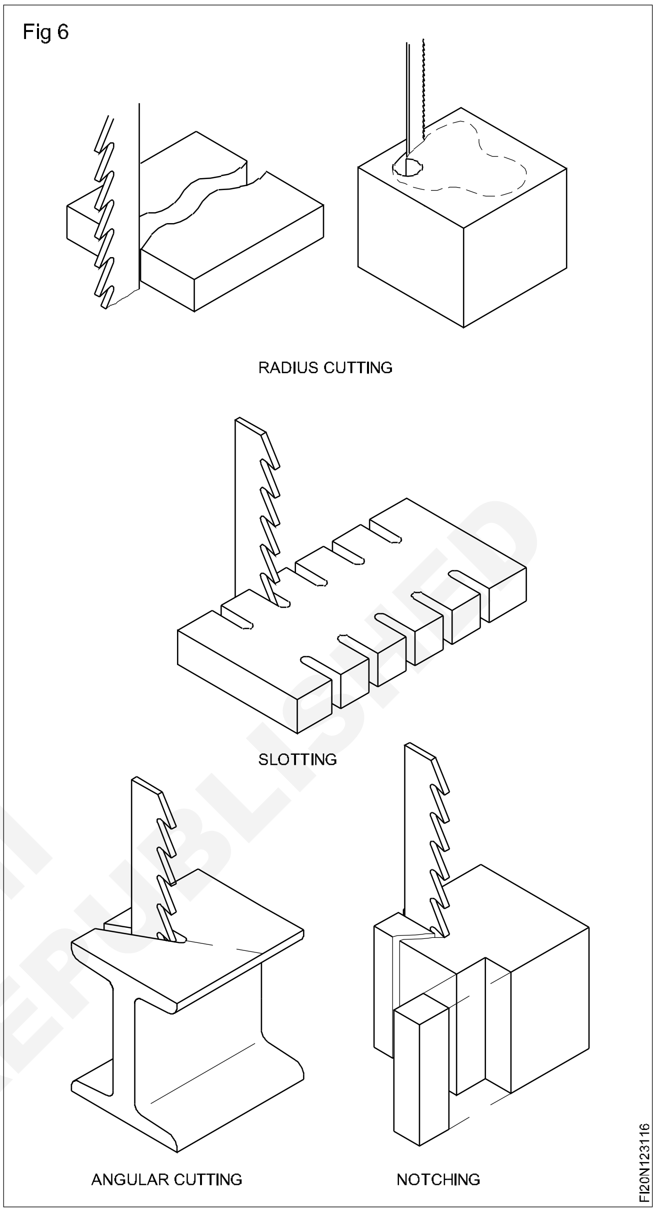
These machines are widely used for tool-room work, and not as a machine for cutting raw material stock.

Precautions to be observed while machine sawing

In order to work safely and efficiently, certain precautions are to be observed.

While taking measurements of the work for setting, always stop the machine.

Projecting ends of the work should be well guarded, so that safety may be provided to others.



Ensure that the work does not protrude into the gangways.

When sawing thin pieces, hold the material flat in the vice to prevent the saw teeth from breaking.

Ensure a cutting fluid is used always.

Avoid giving excessive cutting pressure, because this can cause breakage to the blade, and cut work out of square.

When several pieces of the same length are to be cut, use a stop gauge.

When holding short workpieces in a vice, be sure to place a short piece of the same thickness in the opposite end. This will prevent the vice from twisting when it is tightened.

Lubricate the machines on the indicated points using oil can, oil gun or grease gun as specified by the machine manufacturer.

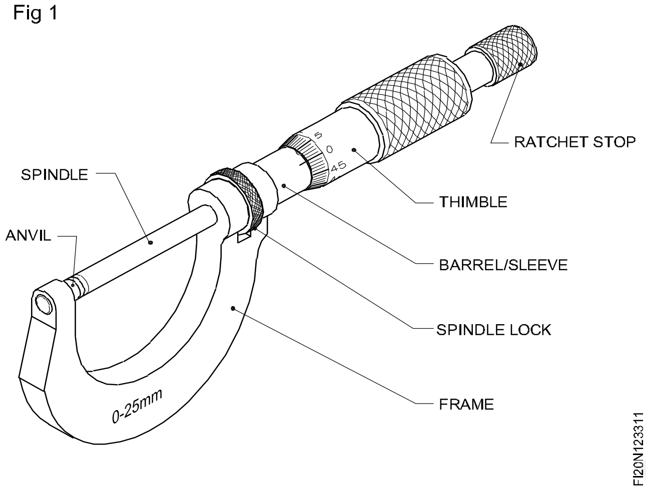
Outside micrometer

Objectives: At the end of this lesson you shall be able to
- **name the parts of an outside micrometer**
- **state the functions of the main parts of an outside micrometer.**

A micrometer is a precision instrument used to measure a job, generally within an accuracy of 0.01 mm.

Micrometers used to take the outside measurements are known as outside micrometers. (Fig 1)

Fig 1



The parts of a micrometer are listed here.

Frame

The frame is made of drop-forged steel or malleable cast iron. All other parts of the micrometer are attached to this.

Barrel/Sleeve

The barrel or sleeve is fixed to the frame. The datum line and graduations are marked on this.

Thimble

On the beveled surface of the thimble also, the graduation is marked. The spindle is attached to this.

Spindle

One end of the spindle is the measuring face. The other end is threaded and passes through a nut. The threaded mechanism allows for the forward and backward movement of the spindle.

Anvil

The anvil is one of the measuring faces which is fitted on the micrometer frame. It is made of alloy steel and finished to a perfectly flat surface.

Spindle lock nut

The spindle lock nut is used to lock the spindle at a desired position.

Ratchet stop

The ratchet stop ensures a uniform pressure between the measuring surfaces.

Graduations of metric outside micrometer

Objectives: At the end of this lesson you shall be able to
- **state the principle of a micrometer**
- **determine the least count of an outside micrometer.**

Working principle

The micrometer works on the principle of screw and nut. The longitudinal movement of the spindle during one rotation is equal to the pitch of the screw. The movement of the spindle to the distance of the pitch or its fractions can be accurately measured on the barrel and thimble.

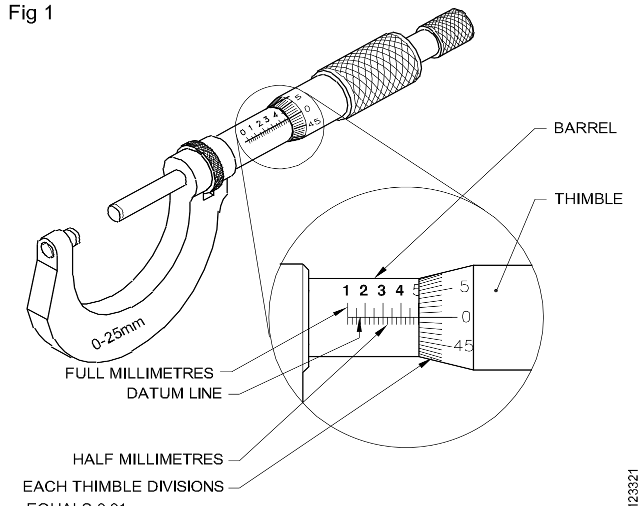
Graduations (Fig 1)

In metric micrometers the pitch of the spindle thread is 0.5 mm.

Thereby, in one rotation of the thimble, the spindle advances by 0.5 mm.

On the barrel a 25 mm long datum line is marked. This line is further graduated to millimetres and half millimetres

Fig 1



OUTSIDE MICROMETER

(i.e. 1 mm & 0.5 mm). The graduations are numbered as 0, 5, 10, 15, 20 & 25 mm.

The circumference of the bevel edge of the thimble is graduated into 50 divisions and marked 0-5-10-15 .... 45-50 in a clockwise direction.

The distance moved by the spindle during one rotation of the thimble is 0.5 mm.

Movement of one division of the thimble = 0.5 x 1/50

= 0.01 mm

Accuracy or least count of a metric outside micrometer is 0.01 mm.

Reading dimensions with outside micrometer

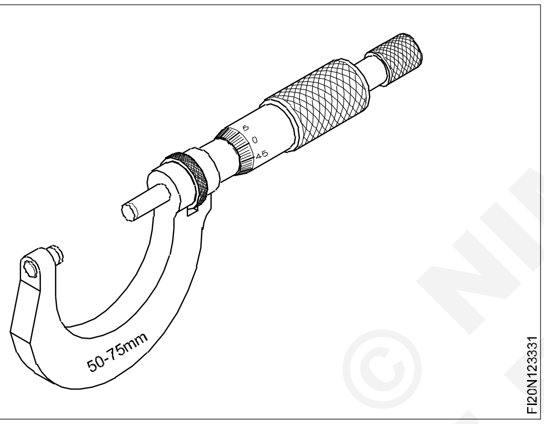
Objectives: At the end of this lesson you shall be able to
- **select the required range of a micrometer**
- **read micrometer measurements.**

Ranges of outside micrometer

Outside micrometers are available in ranges of 0 to 25 mm, 25 to 50 mm, 50 to 75 mm, 75 to 100 mm, 100 to 125 mm and 125 to 150 mm.

For all ranges of micrometers, the graduations marked on the barrel is only 0-25 mm. (Fig 1)

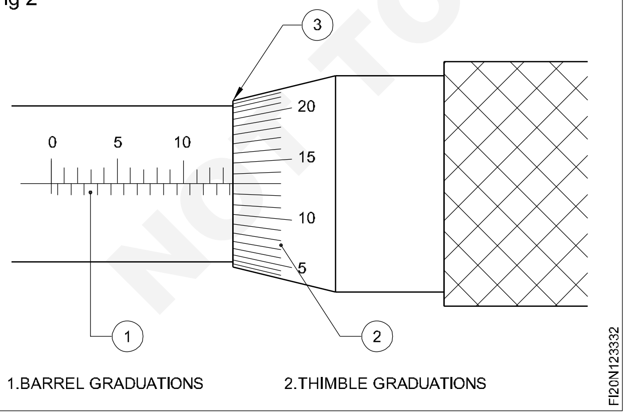
Fig 1



Reading micrometer measurements

How to read a measurement with an outside micrometer? (Fig 2)

Fig 2



First note the minimum range of the outside micrometer. While measuring with a 50 to 75 mm micrometer, note it as 50 mm.

Then read the barrel graduations. Read the value of the visible lines on the left of the thimble edge.

13.00 mm (Main division reading on barrel)

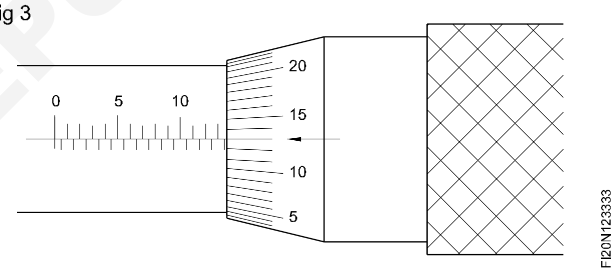
+ 00.50 mm (Sub division reading on barrel)

13.50 mm (Main division + sub - division value)

Next read the thimble graduations.

Read the thimble graduations in line with the barrel datum line, 13th div. (Fig 3)

Fig 3



Multiply this value with 0.01 mm (least count).

13 x 0.01 mm = 0.13 mm.

Add

Minimum range	50.00 mm
Barrel reading	13.50 mm
Thimble reading	00.13 mm
Total	63.63 mm

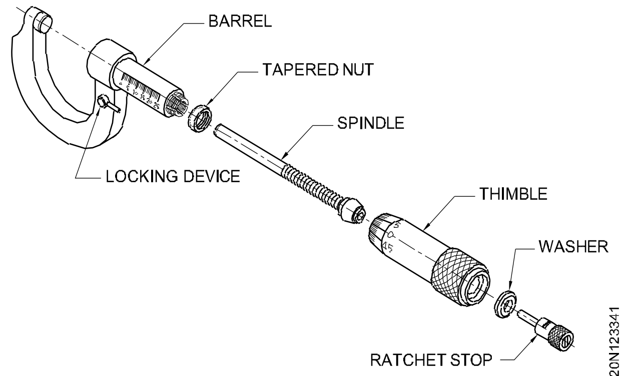
The micrometer reading is 63.63 mm.

Constructional features of outside micrometer

Objectives: At the end of this lesson you shall be able to
- **name the internal parts of a micrometer**
- **state the functions of the various parts of a micrometer**
- **state the precautions to be observed while dismantling and assembling micrometers.**

In order to dismantle and carry out cleaning or adjustment of a micrometer, it is essential to know the functions of its various parts. (Fig 1)

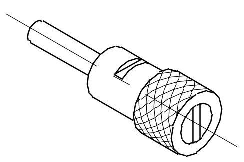
Fig 1



Ratchet stop (Fig 2)

This is a device fitted on micrometers to ensure uniform pressure between the measuring face of the micrometer while measuring.

Fig 2

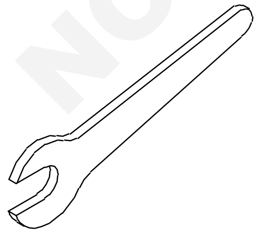


The ratchet stop will slip beyond certain pressure, thus preventing further advancement of the spindle when excessive pressure is used.

This is mounted on the thimble of the micrometer, and it connects with the spindle when assembled.

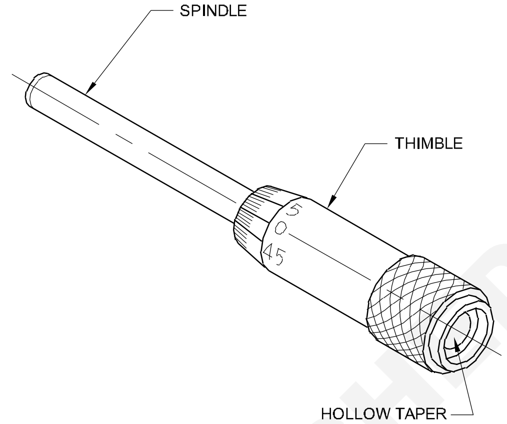
A special spanner is provided along with the micrometer for fixing and removing the ratchet stop. (Fig 3)

Fig 3



Thimble: The thimble has a hollow taper (Fig 4) to match with the taper nose fitted on the spindle.

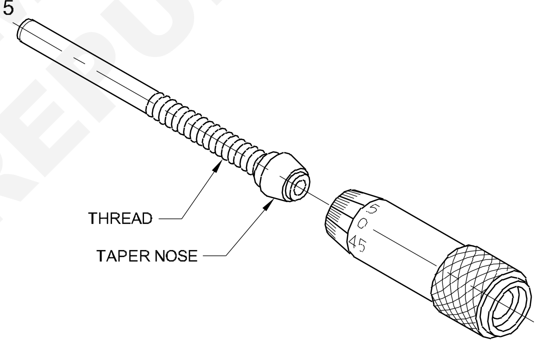
Fig 4



Spindle

One end of the spindle forms the measuring face. The other end of the spindle is threaded, the tapered nose is fitted on it. (Fig 5)

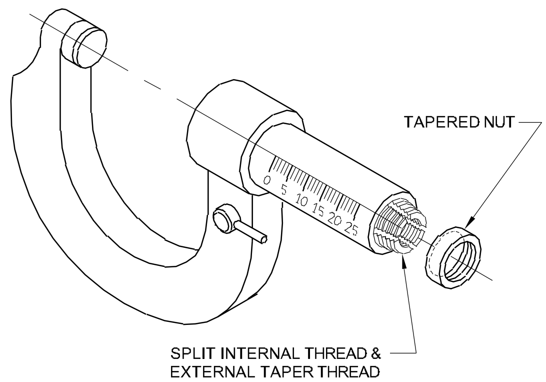
Fig 5



The taper nose is very accurately finished for axial alignment and it also permits positioning of the thimble in any required place during the adjustment of zero error.

The spindle passes through a split internal thread (Fig 6) which forms part of the barrel. The outer portion of this split internal thread has tapered external threads. A taper threaded nut is fitted on this.

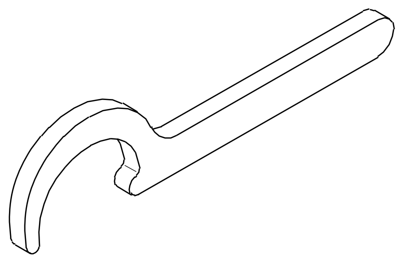
Fig 6



Tightening and loosening of this nut enables the spilt internal thread to close or open. This permits the wear adjustmet. in the mating threads.

A special spanner is provided for this purpose. (Fig 7)

Fig 7



The locking device provided on the spindle is to arrest the movement of the spindle after taking the measurement.

Precautions while dismantling micrometers

Avoid touching the measuring faces with bare fingers as it might cause rusting.

Protect the components of the micrometer free from dust while dismantling and assembling.

Use carbon tetrachloride for cleaning the parts after dismantling.

While assembling - apply a few drops of thin oil.

Do not use metallic surface for placing the parts after dismantling. An enameled tray is preferable.

Apply a thin coating of oil when placing the micrometer back after the adjustment.

Avoid frequent dismantling and assembling.

Inside micrometer

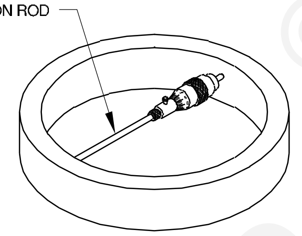
Objectives : At the end of this lesson you shall be able to
- **list the purposes of an inside micrometer**
- **identify the parts of an inside micrometer**
- **state the safety precautions to be followed while using an inside micrometer.**

An inside micrometer is a precision measuring instrument which measures with an accuracy of 0.01mm.

Purpose

An inside micrometer is used to measure the diameter of holes. (Fig 1)

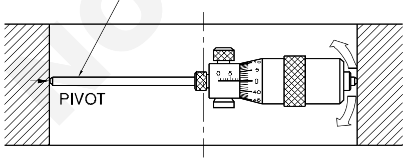
Fig 1



MEASURING A LARGE BORE USING AN INSIDE MICROMETER WITH AN EXTENSION ROD FITTED

To measure the distance between internal parallel surfaces like slots (Fig 2)

Fig 2



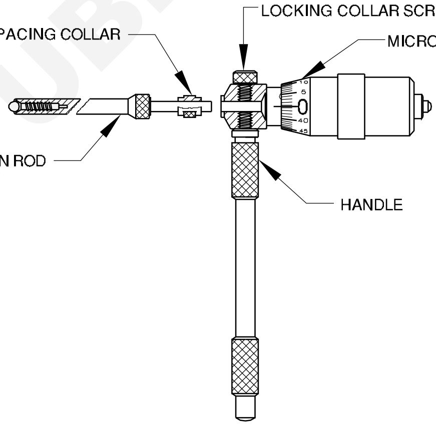
Parts (Fig 3)

The following are the parts of an inside micrometer

Micrometer head: It consists a sleeve, a thimble, an anvil and locking screw for extension rods.

Extension rod: This is fitted in the hole provided in the barrel of the micrometer head. It provides another measuring surface. It is available in different sizes.

Fig 3



Locking Screw It is used to lock the extension rods.

Handle It is fitted in the threaded hole provided in the micrometer head. It is used to hold the micrometer assembly while measuring deep bores.

Spacing collar It is added to the extension rod for additional length. It is available in different sizes.

The range of inside micrometer

Using the different sizes of extension rods and spacing collars the following ranges of measurement can be taken

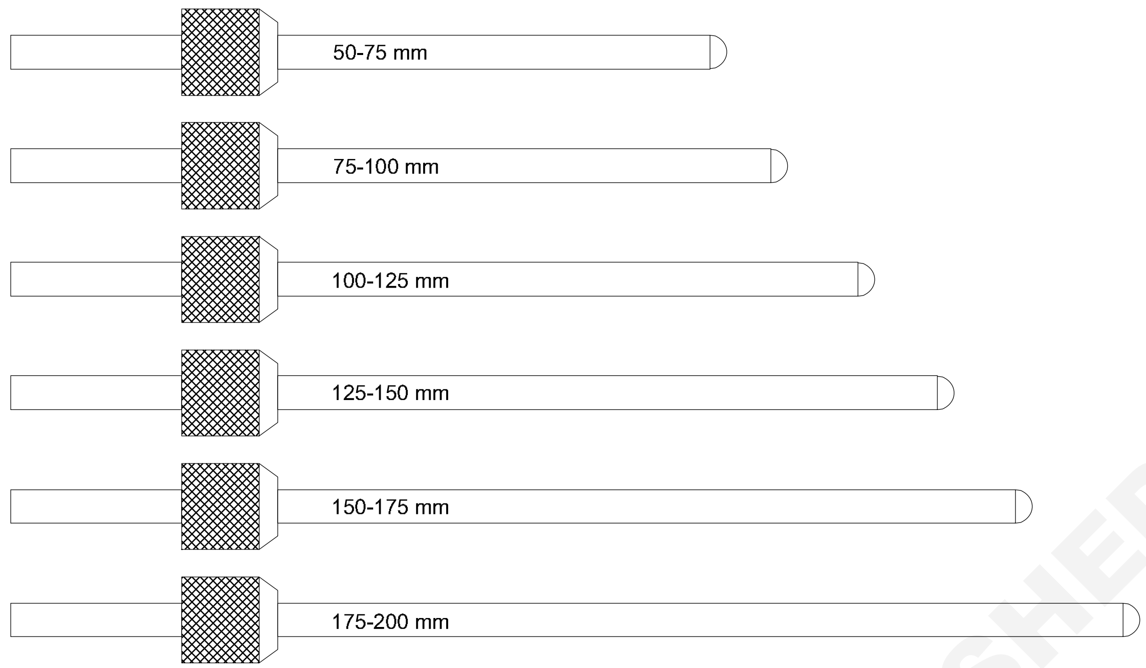
25-50mm, 50-200mm, 50-300mm, 200-500mm,200-1000mm

Inside micrometer

Ranges of extension rod for (50 - 200mm) Inside micrometer

Checking parallelism of surfaces of deep bores

Fig 6



EXTENSION RODS

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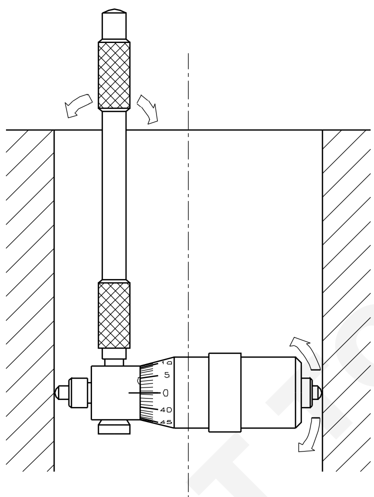
An extended handle can be used while measuring deep bores. (Fig 4) for checking the parallelism of surfaces of the bore.

Find out the readings at 2 or 3 places i.e. one reading at the top, another reading at the middle and the third reading at the bottom of the bore. If all the three readings are the same, then the surfaces of the bore are parallel. Any variation in the readings shows an error in the bore.

Fig 4



USING AN EXTENDED HANDLE WHEN MEASURING THE BORE

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Precautions

Ensure that the extension rod/spacing collar are fitted correctly.

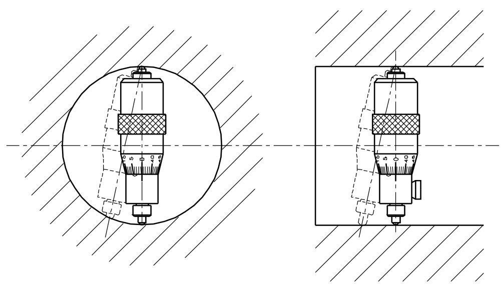
Check the ‘O” setting of the inside micrometer with an outside micrometer.

Ensure that the measuring faces are perpendicular to the axis, and the handle parallel to the axis of the above.

When measuring bores the micrometer must be set for the largest value. While measuring between flat surfaces, the micrometer should be set for the smallest value. (Fig 5)

Ensure that the wall surfaces of the bore are free from burrs, oil etc. before using an inside micrometer. Set the inside micrometer in the bore to the correct FEEL. Do not drag or force the inside micrometer in the bore.

Fig 5



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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 depth micrometer measurements.**

Scan the QR Code to view the video for this exercise

Constructional features

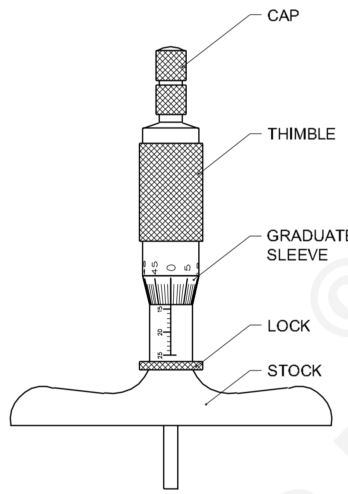
The depth micrometer consists of a stock on which a graduated sleeve is fitted.

The other end of the sleeve is threaded with a 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. (Fig 1)

Fig 1



DEPTH MICROMETER

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

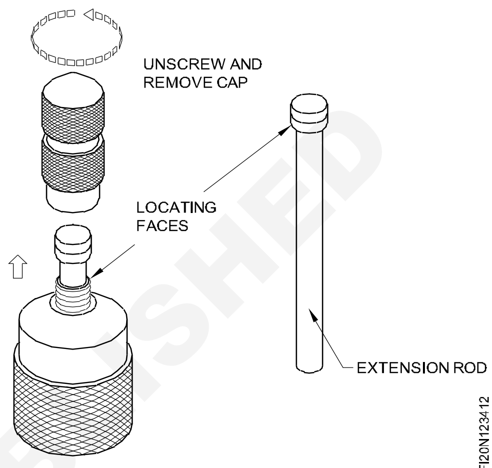
These extension rods can be inserted inside the thimble and the sleeve.

The extension rods have 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 perfectly machined flat.

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

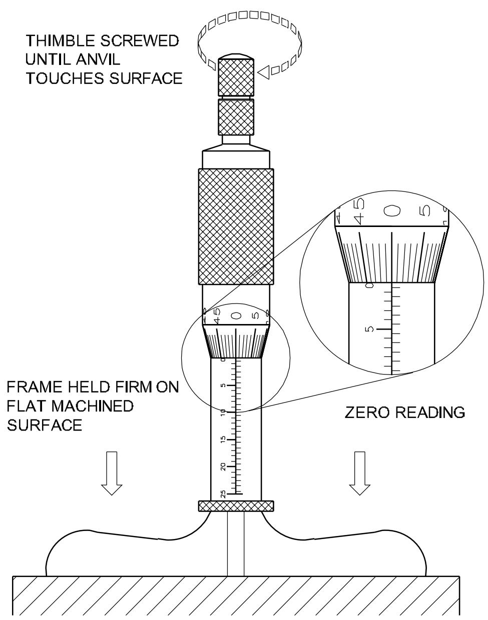
Fig 2



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 and graduated, each line representing one millimetre. Each fifth line is drawn a little longer and numbered. Each line representing 1 mm is further subdivided into two equal parts. Hence each sub-division represents 0.5 mm. (Fig 3)

Fig 3



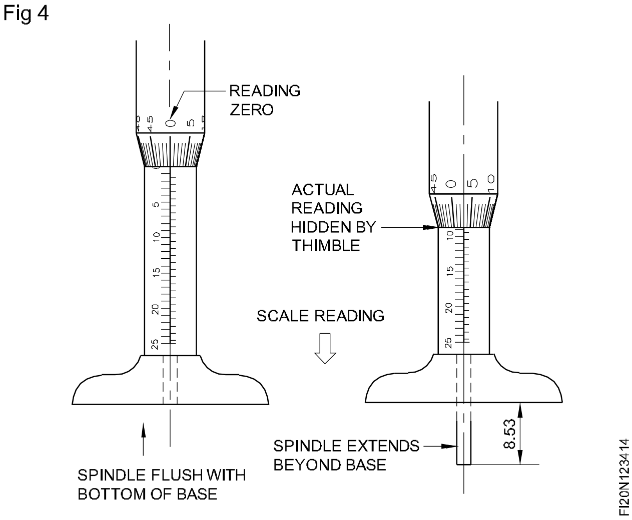
CHECKING THE ZERO SETTING

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

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

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

Fig 4



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

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

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

Reading of depth micrometer

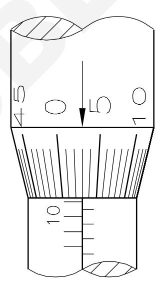
Barrel reading (1 mm division)	=	8 x 1 mm	= 8.00 mm
Sub division (0.5 mm division)	=	1 x 0.5 mm	= 0.50 mm
Thimble reading	=	3 x 0.01 mm	= 0.03 mm
(Thimble division x L.C) Total reading			= 8.53 mm

In barrel reading main division and sub division have been hidden covered by thimble

Uses of depth micrometer

- Depth micrometers are special micrometers used to measure
- the depth of holes.
- the depth of grooves and recesses
- the heights of shoulders or projections.

Fig 5



Digital micrometers

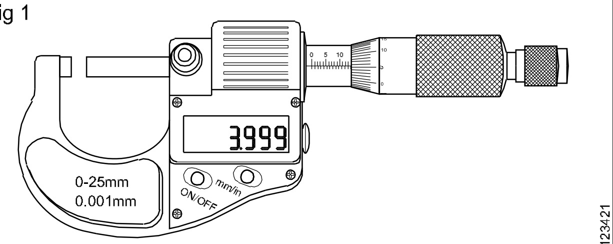
Objectives: At the end of this lesson you shall be able to
- **state the uses of digital micrometer**
- **list the parts of digital micrometer**
- **read the reading from LED display and thimble and barrel**
- **brief the maintenance, maintenance of digital micrometers.**

Digital micrometers is one of the simplest and most widely used measuring equipment in any manufacturing industry. Its simplicity and the versatile nature make Digital Micrometers so popular. Different kinds of Digital Micrometers available in the market.

Feature of digital micrometers (Fig 1)

- LCD displays measuring data and makes direct read out with resolution of 0.001mm.
- Origin setting mm/inch conversion, switch for absolute and incremental measurement.
- Carbide tipped measuring faces.
- Ratchet ensures invariable measurement and accurate repeatable reading

Fig 1



FEATURE OF DIGITAL MICROMETERS

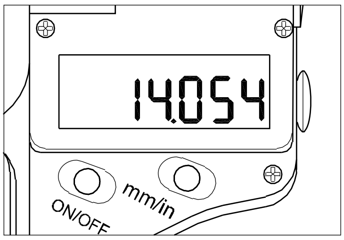
Accuracy of digital micrometers

Digital micrometers provide 10 times more precision and accuracy : 0.00005 inches or 0.001mm resolution, with 0.0001 inches or 0.001mm accuracy.

Reading of the digital micrometer

The digital micrometers are provided with high precision reading with LCD display. The reading is 14.054 mm as shown in Fig 2.

Fig 2



READING OF THE DIGITAL MICROMETERS

Reading also by reading the marks on the sleeve and the thimble. Usually, the reading from the large LCD display for the digital micrometer because the digital reading is more accurate. The reading on the sleeve and the thimble is just for reference. Read the markings on the sleeve and the thimble, firstly, read the point which the thimble stops at it on the right of the sleeve (It is 14mm here, because each line above the centre long line represents 1mm while each line below the centre long line represent 0.5mm) (Fig 3)

Secondly, read the markings on the thimble, It is between 5 and 6, So you need to estimate the reading. (It is 0.054mm for each line here represents 0.001mm). At last, add all the reading up : 14mm + 0.054 mm = 14.054mm. So the total reading is 14.054mm.

Maintenance of a digital micrometers

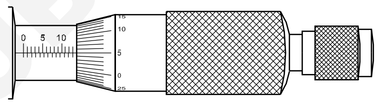
Never apply voltage (e.g. engraving with an electric pen) on any part of the Digital Micrometers for fear of damaging the circuit.

Press the ON/OFF button to shut the power when the Digital Micrometers stands idle; take out the battery if it stands idle for a long time.

As for the battery, abnormal display (digit flashing or even no display) shows a flat battery. Thus you should push the battery cover as the arrow directing and then replace with a new one. Please note that the positive side must face out If the battery bought from market dosen't work well (the power may wear down because of the long-term storage or the battery's automatic discharge and etc.) Please do not hesitate to contact the supplier.

Flashing display shows dead battery. If this is the case please replace the battery at once. No displace shows poor contact of a battery or short circuit of both poles of the battery. Please check and adjust pole flakes and battery insulator cover. In case water enters the battery cover, open the cover immediately and blow the inside of the battery cover at a temperature of not more than 40°C till it gets dry.

Fig 3

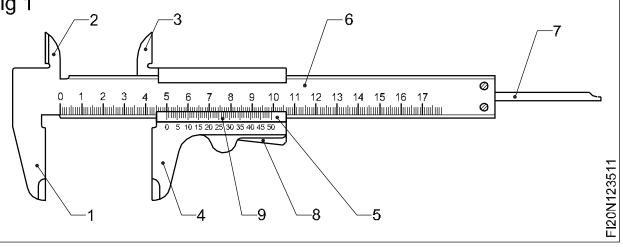


Vernier calipers

Objectives : At the end of this lesson you shall be able to
- **name the parts of a vernier caliper**
- **describe the parts of a vernier calipers**
- **state the uses of a vernier caliper.**

A vernier caliper is a precision measuring instrument. It is used to measure up to an accuracy of 0.02 mm. (Fig 1)

Fig 1



Parts of a vernier caliper

(Numbers as per Fig 1)

Fixed jaws (1 and 2): Fixed jaws are part of the beam scale. One jaw is used for taking external measurements, and the other for taking internal measurements.

Movable jaws (3 and 4): Movable jaws are part of the vernier slide. One jaw is used for external measurements, and the other for internal measurements. (Figs 2 and 3)

Fig 2

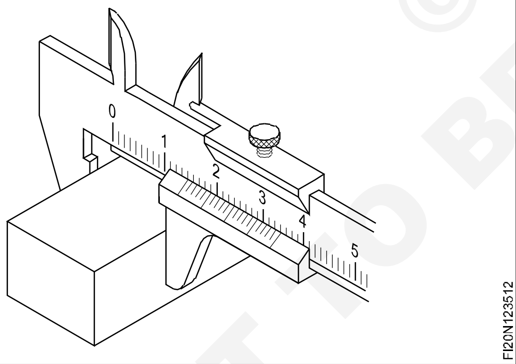
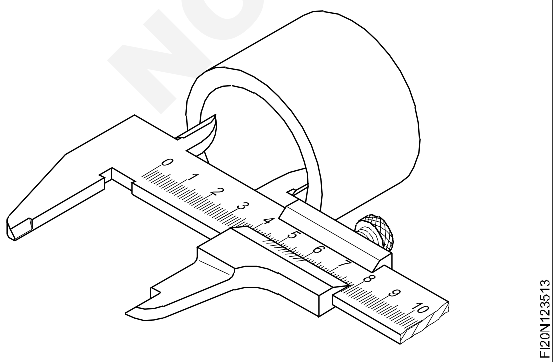


Fig 3

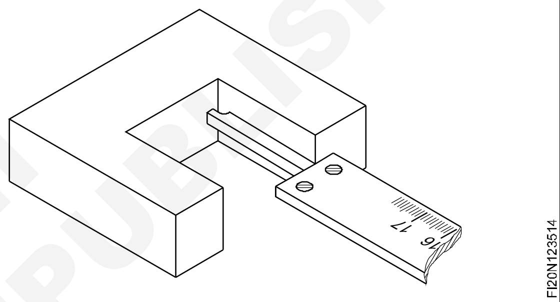


Vernier slide (5): A vernier slide moves over the beam and can be set in any position by means of a spring-loaded thumb lever.

Beam (6): The vernier slide and the depth bar attached to it, slide over the beam. The graduations on the beam are called the main scale divisions.

Depth bar (7) (Fig 4)**:** The depth bar is attached to the vernier slide and is used for measurement of depth.

Fig 4



Thumb lever (8): The thumb lever is spring-loaded which helps to set the vernier slide in any position on the beam scale.

Vernier scale (9): The vernier scale is the graduation marked on the vernier slide. The divisions of this scale are called vernier divisions.

Main scale: The main scale graduations or divisions are marked on the beam.

Sizes: Vernier calipers are available in sizes of 150 mm, 200, 250, 300 and 600 mm. The selection of the size depends on the measurements to be taken. Vernier calipers are precision instruments, and therefore, extreme care should be taken while handling them.

Never use a vernier caliper for any purpose other than measuring.

Vernier calipers should be used only to measure machined or filed surfaces.

They should never be mixed with any other tools.

Clean the instrument after use, and store it in a box.

Graduations and reading of vernier calipers

Objectives : At the end of this lesson you shall be able to
- **determine the least count of a vernier caliper**
- **state how graduations are made on a vernier caliper with 0.02 mm least count**
- **read vernier caliper measurements.**

Vernier calipers: Vernier calipers are available with different accuracies. The selection of the vernier caliper depends on the accuracy needed and the sizes of the job to be measured.

This accuracy/least count is determined by the graduations of the main scale and the vernier scale divisions.

Vernier Principle: The vernier principle states that two different scales are constructed on a single known length of line and the difference between them is taken for fine measurements.

Determining the least count of vernier calipers: In the vernier caliper shown in Fig 1 the main scale divisions (9 mm) are divided into 10 equal parts in the vernier scale.

i.e. One main scale division (MSD) = 1 mm

One vernier scale division (VSD) = 9/10 mm

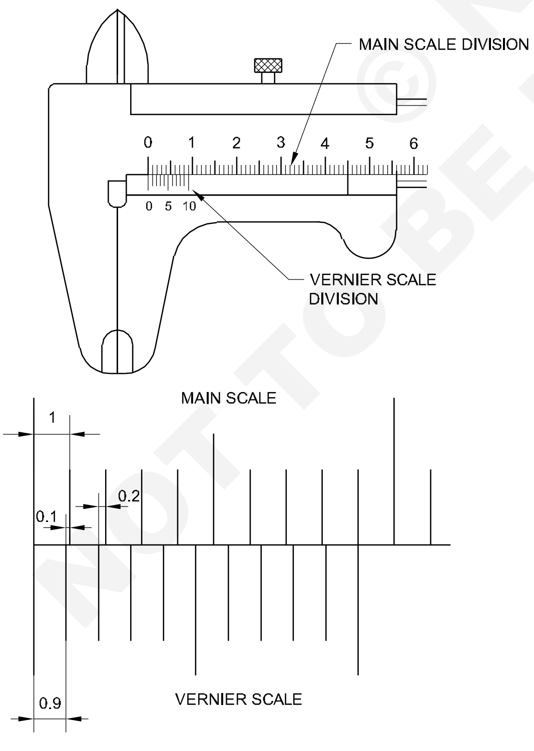
Least count = 1 MSD - 1 VSD

= 1 mm - 9/10 mm

= 0.1 mm

The difference between one MSD and one VSD = 0.1 mm

Fig 1



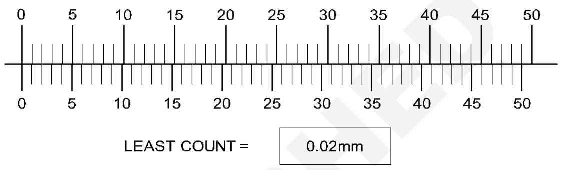
Reading vernier measurements: Vernier calipers are available with different graduations and least counts. For reading measurements with a vernier caliper, the least count should be determined first. (The least count of calipers is sometimes marked on the vernier slide)

Fig 2 shows the graduations of a common type of vernier caliper with a least count of 0.02 mm. In this, 50 divisions of the vernier scale occupy 49 divisions (49 mm) on the main scale.

Example

Calculate the least count of the vernier given in Fig 2.

Fig 2



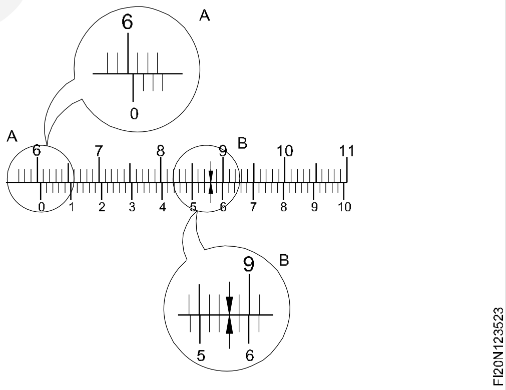
Least count = 1 mm - 49/50 mm

= 1/50 mm

= 0.02 mm.

Example for reading vernier caliper (Fig 3)

Fig 3



Main scale reading = 60 mm

The vernier division coinciding with the main scale is the 28^{th} division, value = 28 x 0.02mm

= 0.56 mm

Reading = 60 + 0.56

Total Reading = 60.56 mm

The british system of measurement

Objectives : At the end of this lesson you shall be able to
- **name the different units and multiples of liner measurements in the Birtish System**
- **state the metric equivalent of the unit in the inch system**

The metric system for measurement is most widely used for industrial measurements. But in certain industries, the British system of measurement is still being used.

In this system of measurement, the inch, its multiples and sub-divisions are used to represent length measurements.

36 inches or 3 feet make 1 yard. 5280 feet or 1760 yards make 1 mile.

Coversions from inch to metric and vice versa		
CONVERSION FACTORS		
1"	=	25.4 mm or 2.54 cm
1 yard	=	36" or 0.9144 m
1 mm	=	0.03937"
1 metre	=	1000 mm or 39.37"

FRACTIONS/DECIMALS EQUIVALENT

1/64"	=	0.015625"
1/32"	=	0.03125"
1/16"	=	0.0625"
1/8"	=	0.125"
1/4"	=	0.25"
1/2"	=	0.5"

1.00 unit inch
0.1 one tenth
0.01 one hundredth
0.001 one thousandth
0.0001 one ten thousandth
0.00001 one hundred thousands

0.000001 one millionth (one micro inch)

Example of conversion (Metric to inch)

1) .05mm = .00196 inch (.05x03937 = 0.0019685 inch)
2) 1.25m = 49.215 inch (1.25x39.37 = 49.215 inches)

Example of conversion (Inch to Metric)

1) 3/4" = .75" = 19.05 mm (.75x 25.4 = 19.05 mm)
2) 1/1000" = 0.001 = 0.0254 mm (.001x25.4 = 0.0254mm)

(One thousandth of an inch = 25 micrometre approx)

ASSIGNMENT

Convert the following.

1) 38.1mm =_______ inches
2) 300 mm =_______ inches
3) 8" =_______ mm
4) 40" =_______ mm.

5) Express the tolerance ± .05" in metric terms to the nearest mm. ______________________________

6) Express the tolerance ± .02 mm in terms of inches to the nearest 1/10,000". ________________________

Reading vernier caliper and micrometer with inch graduations

Objectives : At the end of this lesson you shall be able to
- **state the graduations of vernier calipers in the inch system**
- **state the graduations of micrometers in the inch system**
- **read the measurement of vernier calipers and micrometers with inch graduations.**

Reading vernier caliper and micrometer

The universal vernier calipers generally used in machine shop will have graduations in both metric units and inches.

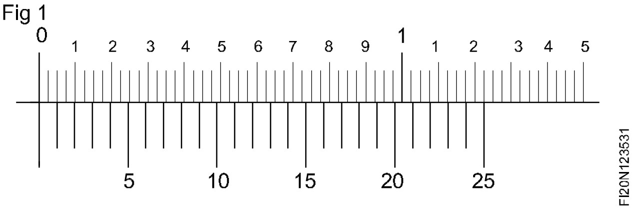
The vernier caliper with inch graduation will have a least count of 0.001".

The vernier scales for these calipers have graduation with 25 division or 50 divisions.

Vernier caliper with 25 divisions in vernier scale. (Fig.1)

One inch of the mainscale is divided into 10 major divisions, and each of these is further divided into 4 equal parts. The value of each sub-division is 0.025 inch. Such 49 divisions of the main scale are equal to 25 divisions of the vernier scale.

Fig 1



Least count

25 vernier scale divisions = 49 x 0.025 = 1.225"

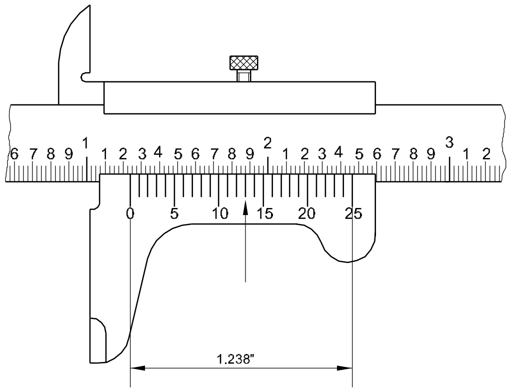
Value of vernier scale division = 0.049"

Value of 2 main scale divisions = 0.025 x 2 = 0.50"
Least count = Value of main scale division - value of 1 vernier scale division

= 0.05" - 0.049" = 0.001" or 1/1000"

Example of reading (Fig 2)

Fig 2

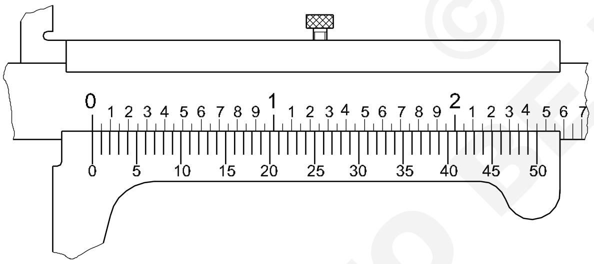


In Figure 2 the vernier '0' line is after 1" on the scale

Full inch		= 1.000"
2 main scale divisions		= .200"
Value of 1 subdivision		= .025"
coinciding	(13 x 001")	= .013"
	Reading	1.238"

In the vernier caliper given in fig 3 (50 divisions vernier scale), each inch of the main scale is divided into 10 major divisions, and they are further sub - divided into two equal parts. The value of each subdivision is 0.05". 50 divisions of the vernier scale are equal to 49 sub divisions of the main scale.

Fig 3



Least count

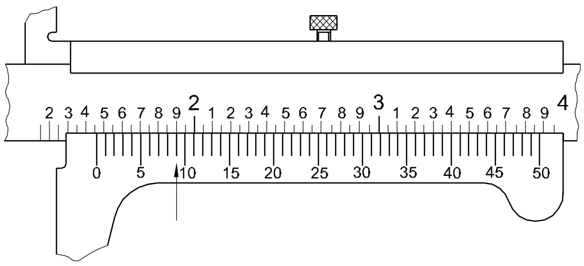
Value of 50 V.S.D.	= 49 x 0.05	= 2.45"
1.V.S.D.	= 2.45"/50	= 0.049"

Least count = Value of 1 MSD - Value of 1 VSD

= 0.05" - 0.049 = 0.001"

Example of reading (Fig 4)

Fig 4



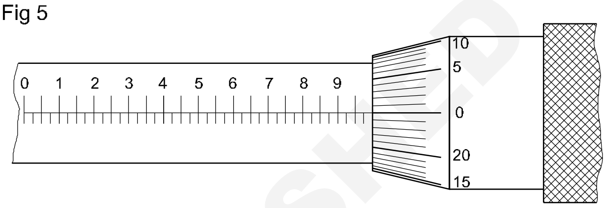
Vernier '0' line is after 1" on the main scale

Full inch		= 1.000"
The value of 4 major divisions	(4 x 0.1") =	.400"
The value of 1 subdivision	(1 x 0.05") =	.050"
The value of 9th vernier dividion coinciding	(9 x 0.001") =	.009"
	Reading	1.459"

Micrometer with graduations in inches

On micrometers with graduations in the inch system, the datum line on the barrel of the micrometer is graduated to a distance of 1 inch. This one inch is divided into 10 equal parts, and each of this is further subdivided into 4 equal parts. (Fig 5)

Fig 5

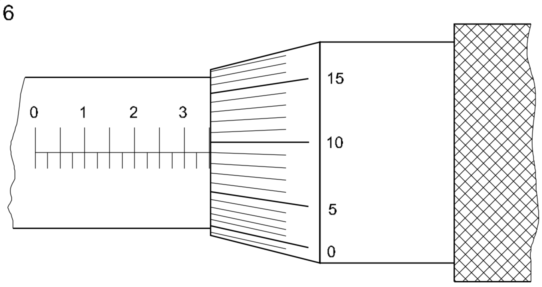


The value of each subdivision = 1/40" or 0.025". The thimble had 25 equal divisions marked on the circumference. The least count is = 1/40"x1/25 = 1/1000" =.001'.

When the spindle of the micrometer advances by one division on the thimble, the actual value of the linear movement is = .001".

Example of reading (Fig 6)

Fig 6



Main divisions	3 x .1	= .300"
Subdivisions	2 x .025	= .05"
Thimble divisions	9 x .001	= .009"
Reading		= .359"

The barrel is graduated into 10 equal divisions each of which is further subdivided into 4 smaller divisions. The length of the sleeve graduations is 1". It is the distance the thimble travels in 40 complete revolutions.

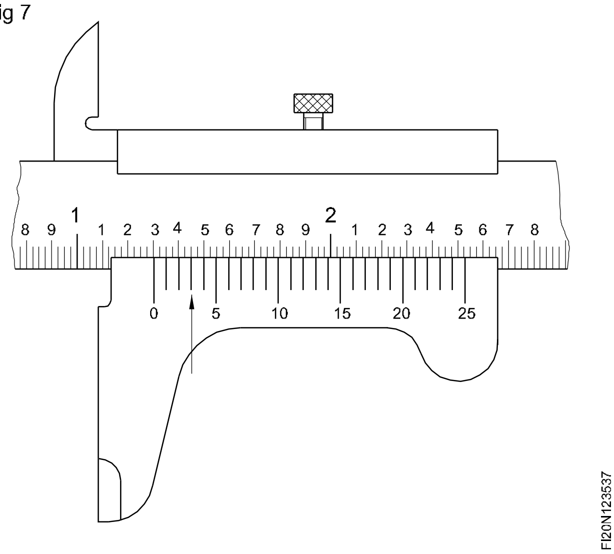
Barrel main divisions = 1/10 of an inch or 0.100" the distance the thimble moves in four complete revolutions. The thimble has 25 equal graduations on its circumference. Each graduation of the thimble is equal to 1/25 of 1/40 or 0.001".

Barrel subdivision 1/40 or 0.025 of an inch is equal to the distance the thimble moves in one complete revolution. The spindle screw has 40 TPI.

Assignment

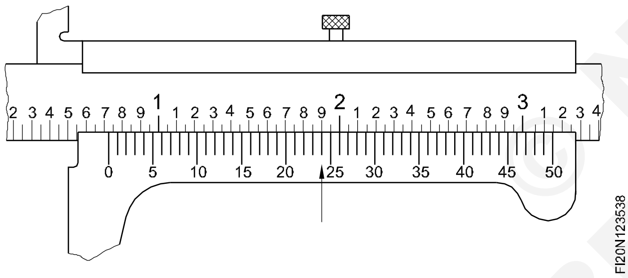
1 Read the vernier caliper measurement as shown in Figures 7 and 8.

Fig 7



Answer ....inch.

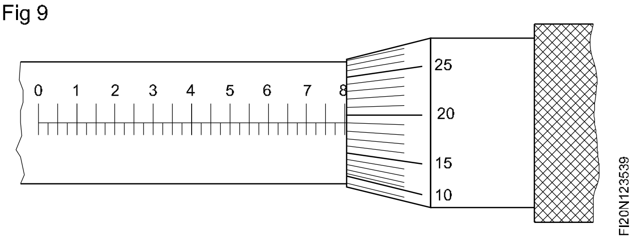
Fig 8



Answer ....inch.

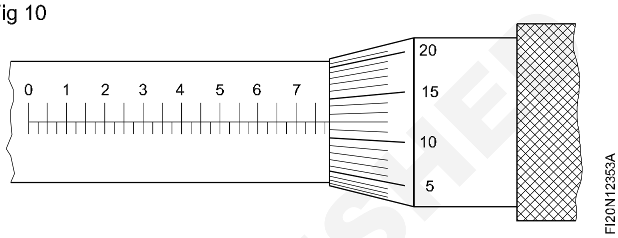
2 Read and record the measurements of an outside micrometer shown in the Figures 9 and 10.

Fig 9



Answer ....inch.

Fig 10



Answer ....inch.

Vernier height gauge

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

- **name the parts of a vernier height gauge**
- **state the constructional features of a vernier height gauge**
- **state the functional features of a vernier height gauge**
- **state the various applications of the vernier height gauge in engineering.**

Parts of a vernier height gauge (Fig 1)

A Beam

B Base

C Main slide

D Jaw

E Jaw clamp

F Vernier scale

G Main scale

H Finer adjusting slide

I Finer adjusting nut

J&K Locking screws

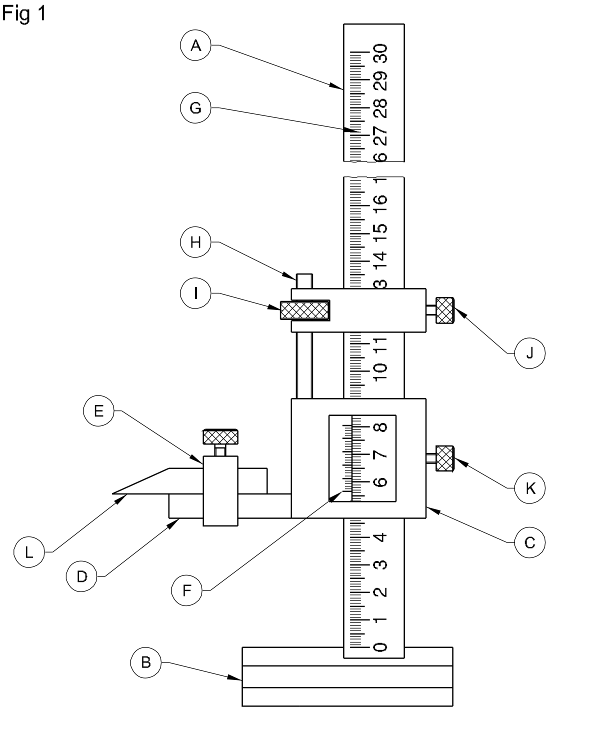
L Scriber blade

Constructional features of a vernier height gauge: The construction of a vernier height gauge is similar to that of the vernier caliper that it is vertical with a rigid base. It is graduated on the same vernier principle which is applied to the vernier caliper.

The beam is graduated with the main scale in mm as well as in inches. The main slide carries a jaw upon which various attachments may be clamped. The jaw is an integral part of the main slide.

The vernier scale is attached to the main slide which has been graduated, to read metric dimensions as well as the inch dimensions. The main slide is attached with the finer adjusting slide. The movable jaw is most widely used with

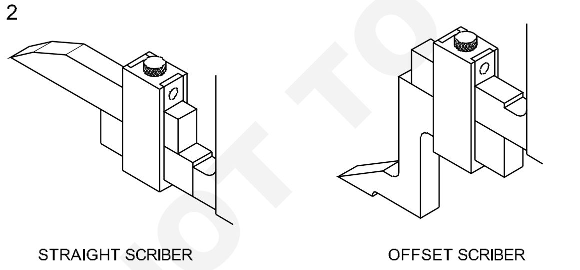
Fig 1



the chisel pointed scriber blade for accurate marking out as well as for checking the height, steps etc. Care should be taken to allow for the thickness of the jaw depending on whether the attachment is clamped on the top or under the jaw for this purpose.

The thickness of the jaw is marked on the instrument. As like in a vernier caliper, the least count of this instrument is also 0.02 mm. An offset scriber is also used on the movable jaw when it is required to take measurement from the lower planes. (Fig 2) The complete sliding attachment along with the jaw can be arrested on the beam to the desired height with the help of the locking screws. The vernier height gauges are available in ranges of capacities reading from zero to 1000 mm.

Fig 2



Functional features of the vernier height gauge: Vernier height gauges are used in conjunction with the surface plate. In order to move the main slide, both the locking screws of the slide and the finer adjusting slide have to be loosened. The main slide along with the chisel pointed scriber has to be set by hand, for an approximate height as required.

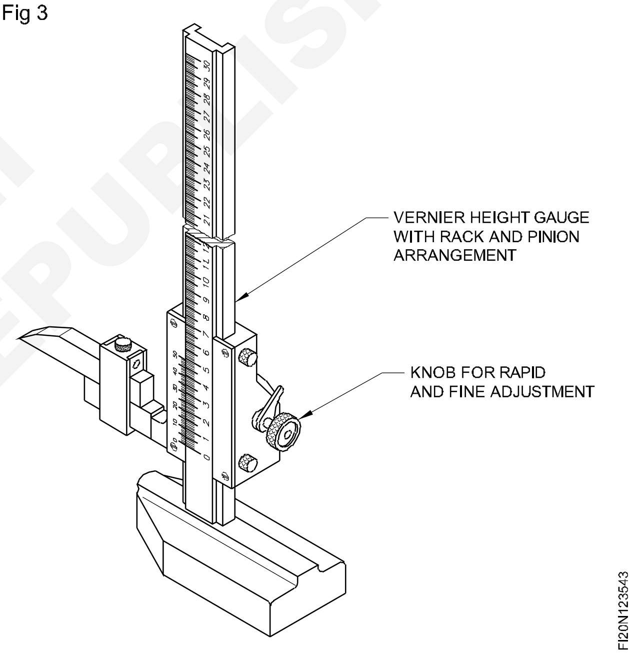
The finer adjusting slide has to be locked in position, for an approximate height as required. To get an exact markable height, the finer adjustments have to be carried on the slider with the help of the adjusting nut. After obtaining the exact markable dimension, the main slide is also to be locked in position.

Modern vernier height gauges are designed on the screw rod principle. In these height gauges, the screw rod may be operated with the help of the thumb screw at the base. In order to have a quick setting of the main slide, it is designed with a quick releasing manual mechanism. With the help of this, it is possible to bring the slide to a desired approximate height without wastage of time. For all other purposes, these height gauges work as ordinary height gauges. In order to set the 'zero' graduation of the main scale for the initial reading.

Some vernier height gauges are equipped with a sliding main scale which may be set immediately for the initial reading. This minimises the possible errors in reading the various sizes in the same setting.

Another kind of modern vernier height gauge has a rack and pinion set up for operating the sliding unit. This is shown in Fig 3.

Fig 3



Various applications of a vernier height gauge: The vernier height gauge is mainly used for layout work. (Fig 4)

It is used for measuring the width of the slot and external dimension.

The vernier height gauge is used with the dial indicator to check hole location, pitch dimensions, concentricity and eccentricity.

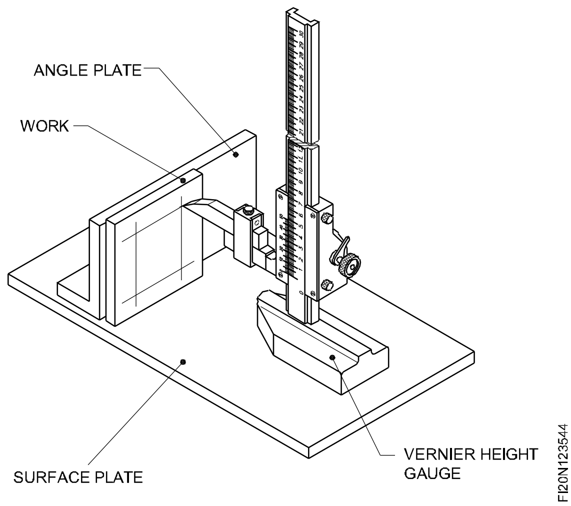
It is also used for measuring depth, with a depth attachment.

It is used to measure sizes from the lower plane with the help of an offset scriber.

Care and Maintenance

Store after use in room with controlled

Fig 4



Care and maintenance

- Store after use in room with controlled temperature
- Do not drop (or) knock it
- Clean tool before and after use
- Do not take measurement on rotating specimen.
- Do not keep with other working tools.

Vernier bevel protractor

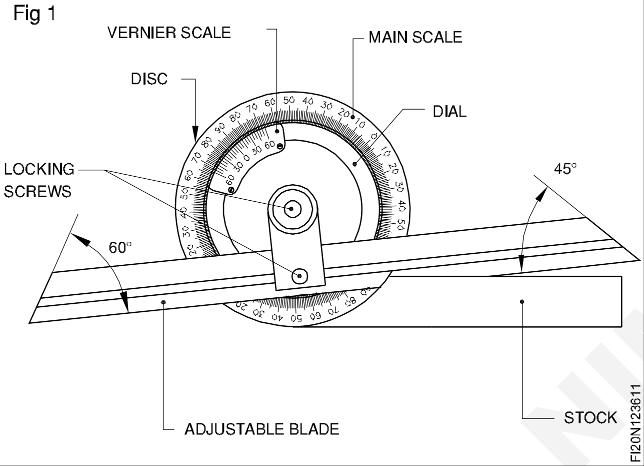
Objectives : At the end of this lesson you shall be able to
- **name the parts of a vernier bevel protractor**
- **state the functions of each part**
- **list out the uses of a vernier bevel protractor.**

The vernier bevel protractor is a precision instrument meant for measuring angles to an accuracy of 5 minutes. (5')

Parts of a vernier bevel protractor

The following are the parts of a vernier bevel protractor. (Fig 1)

Fig 1



Stock: This is one of the contacting surfaces during the measurement of an angle. Preferably it should be kept in contact with the datum surface from which the angle is measured.

Dial: The dial is an integrated part of the stock. It is circular in shape, and the edge is graduated in degrees.

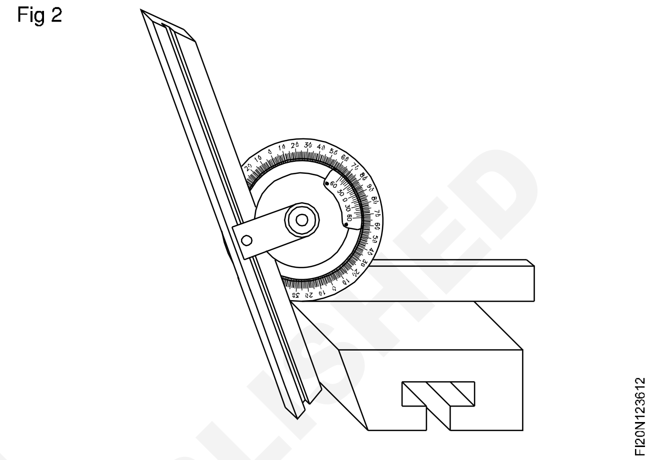
Blade: This is the other surface of the instrument that contacts the work during measurement. It is fixed to the dial with the help of the clamping lever. A parallel groove is provided in the centre of the blade to enable it to be longitudinally positioned whenever necessary.

Locking screws: Two knurled locking screws are provided, one to lock the dial to the disc, and the other to lock the blade to the dial..

All parts are made of good quality steel, properly heat-treated and highly finished. A magnifying glass is sometimes fitted for clear reading of the graduations.

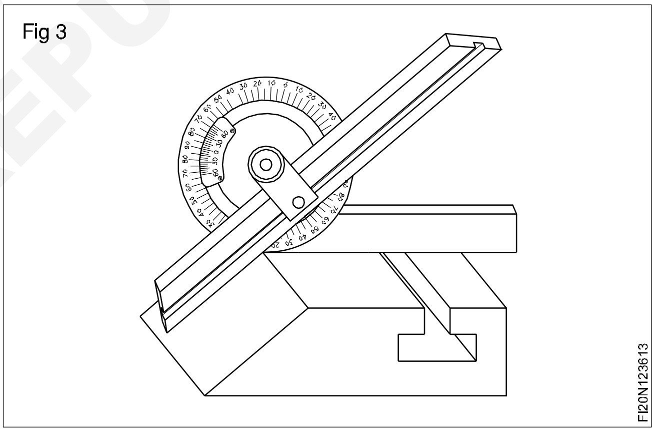
Uses of a vernier bevel protractor: Apart from being used for measuring angles a vernier bevel protractor is also used for setting work-holding devices on machine tools, work-tables etc.

Fig 2



The vernier bevel protractor is used to measure acute angles than 90° (Fig.2) obtuse angles more than 90° (Fig.3).

Fig 3



For setting work-holding devices to angles on machine tools, work tables etc., (Fig 4 & Fig 5)

Fig 4

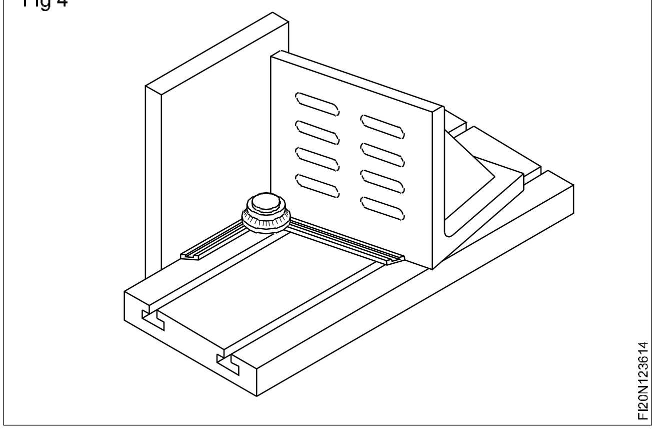
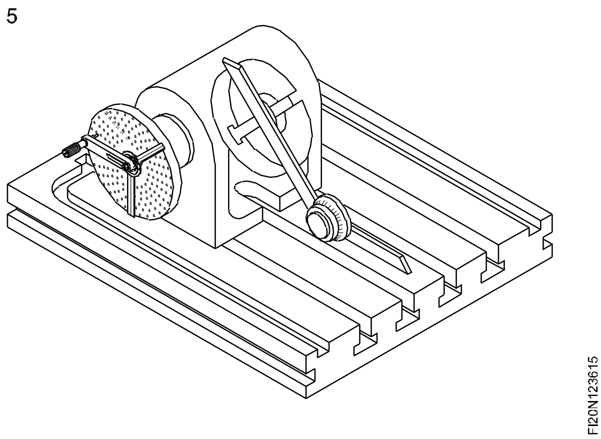


Fig 5

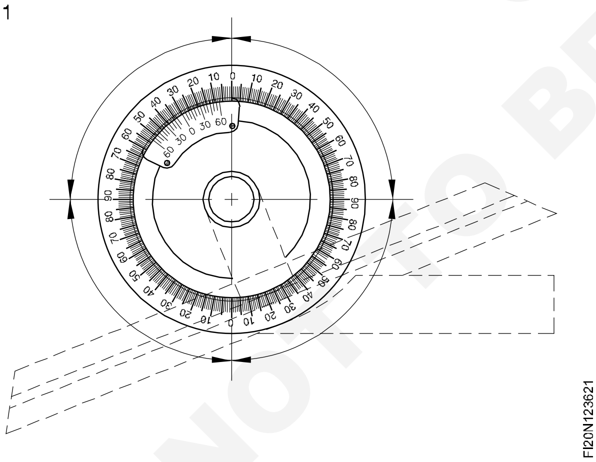


Graduations on universal bevel protractor

Objectives: At the end of this lesson you will be able to
- **state the main scale graduations on the disc**
- **state the vernier scale graduations on the dial**
- **determine the least count of the vernier bevel protractor.**

The main scale graduations (Fig 1 & 2): For purposes of taking angular measurements, the full circumference of the dial is graduated in degrees. The 360° are equally divided and marked in four quadrants, from '0' degree to 90 degrees, 90 degrees to '0' degree. Every tenth division is marked longer and numbered. Each division represents 1 degree. The graduations on the dial are known as the main scale divisions. On the disc, 23 divisions spacing of the main scale is equally divided into 12 equal parts on the vernier. Each 3rd line is marked longer and numbered as 0, 15, 30, 45, 60. This constitutes the vernier scale. Similar graduations are marked to the left of '0' also. (Fig 1)

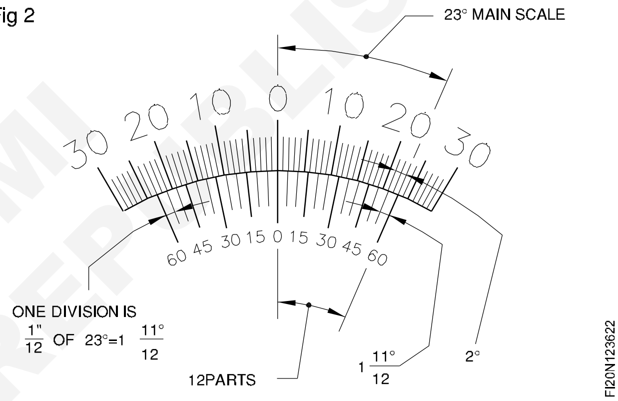
Fig 1



One vernier scale division VSD (Fig 2)

The least count of the vernier bevel protractor: When the zero of the vernier scale coincides with the zero of the main scale, the first division of the vernier scale will be very close to the 2nd main scale division. (Fig 2)

Fig 2



Hence the least count is

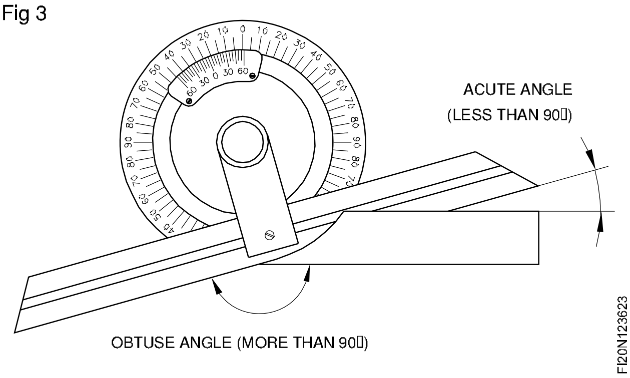
2 MSD - 1 VSD

i.e the least count = 2°

$$= \frac{24}{12} - \frac{23^{o}}{12} = \frac{1^{o}}{12} \text{ or } 5'$$

For any setting of the blade and stock, the reading of the acute angle and the supplementary obtuse angle is possible, and the two sets of the vernier scale graduations on the disc assist to achieve this. (Fig 3)

Fig 3

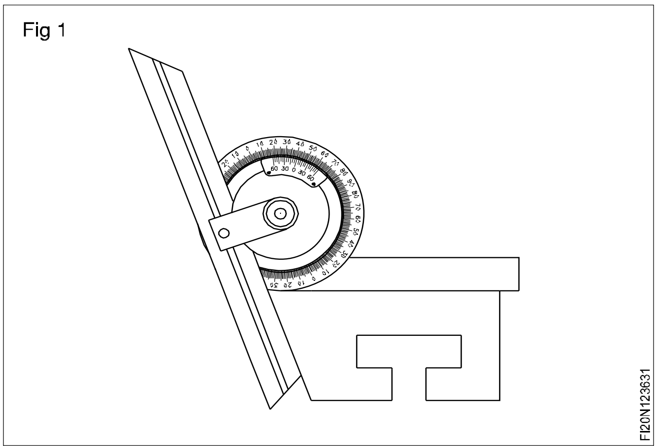


Reading of universal bevel protractor

Objectives: At the end of this lesson you will be able to
- **read a vernier bevel protractor for acute angle setting**
- **read a vernier bevel protractor for obtuse angle setting.**

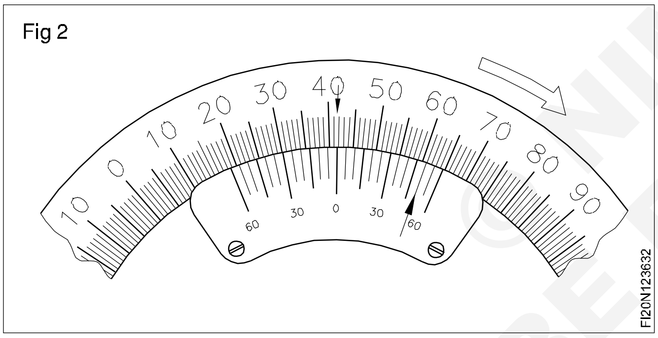
For reading acute angle set up (Fig 1)**:** First read the number of whole degrees between zero of the main scale and zero of the vernier scale.

Fig 1



Note the line on the vernier scale that exactly coincides with any one of the main scale divisions and determine its value in minutes. (Fig 2)

Fig 2



To take the vernier scale reading, multiply the coinciding divisions with the least count.

Example

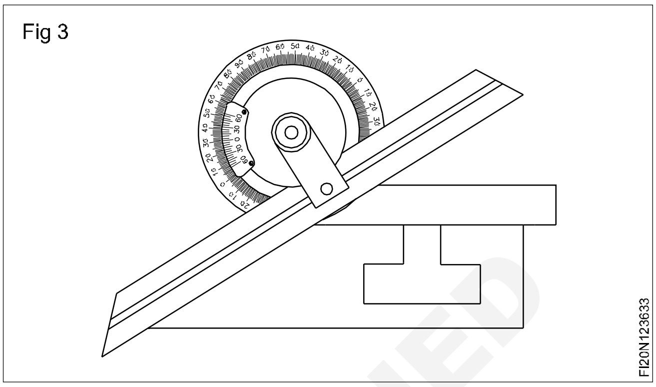
10 x 5' = 50'

Total up both the readings to get the measurements=41°50'.

If you read the main scale in an anticlockwise direction, read the vernier scale also in an anticlockwise direction from zero.

For obtuse angle set up (Fig 3**)**

Fig 3

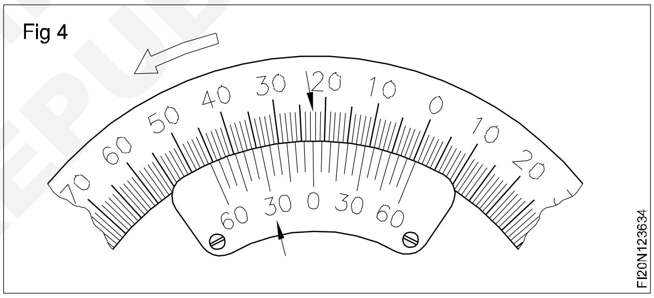


The vernier scale reading up is taken on the left side as indicated by the arrow (Fig 4). The reading value is subtracted from 180° to get the obtuse angle value.

Reading 22°30’

Measurement 180°-22°30’=157”30’

Fig 4



Care and maintenance of vernier bevel protractor

1 Clean the vernier bevel protractor before use.
2 Loosen the locking screw of dial to move the blade according to the angle measurement.
3 While taking a measurement apply light pressure on vernier bevel protractor
4 Heavy pressure will force the two scales out of parallel and show the false reading.
5 After using vernier bevel protractor wipe it clean and apply a thin coating of oil and keep it in safe place.

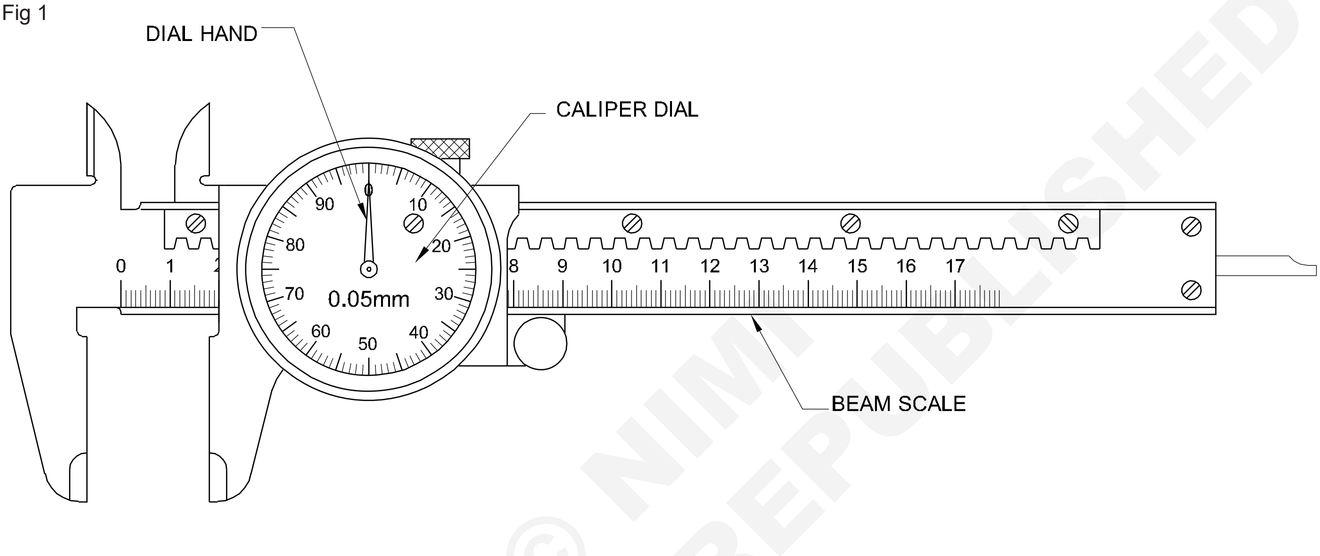
Dial Caliper

Objectives: At the end of this lesson you shall be able to
- **state the advantages of a dial caliper over a vernier caliper**
- **state the constructional features of a dial caliper**
- **read the dial caliper.**

A dial caliper is a direct reading instrument which resembles the vernier caliper. It is faster and easier to read a dial caliper than to read the traditional vernier caliper. (Fig 1)

The beam scale is graduated into 5mm increments on 0.05 mm accuracy caliper

Fig 1



Constructional features of dial caliper

The resemblance of a dial caliper is similar to normal Vernier caliper, but with additional construction of a rack mounted over the beam scale which is engaged to a pinion of the dial. The dial pointer is actuated by the movable action of vernier slide unit fixed with dial gauge.

The caliper dial on the movable jaw is graduated into 100 equal divisions. The hand of the dial makes one complete revolution for each 5 mm. Therefore, each dial grauduation represents 1/100th of 5mm or 0.05 mm.

The dial hand is operated by a pinion that engages a rack on the beam.

Dial calipers are available in various sizes like vernier calipers. A dial caliper with 0.02 mm accuracy is also available.

For reading a measurement (Fig 2)

Read the beam scale reading (25 mm) and add the reading shown by the hand of the dial. 24 x 0.05 = 1.2mm

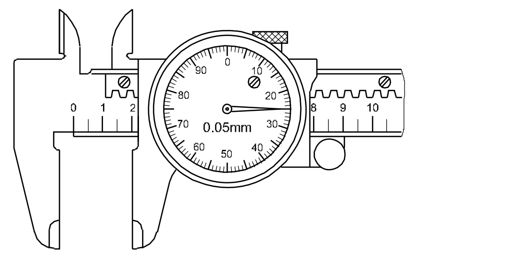
Reading = 25+1.2 mm = 26.2 mm.

Care and maintenance of dial caliper

1 Clean the dial caliper with a soft cloth before use.

2 Apply a small drop of oil to the beam, rack and pinion of the dial caliper to slide freely.

Fig 2



3 Check calibration of dial caliper, make sure that it is working correctly.

4 After using dial caliper, wipe it with a clean dry cloth, apply a thin coating of oil on sliding parts and keep it in safe place.

The digital caliper

Objectives : At the end of this lesson you shall be able to
- **state the uses of digital caliper**
- **name the parts of a digital caliper**
- **brief the zero setting of a digital caliper**

The digital Caliper (sometime incorrectly called the digital vernier caliper) is a precision instrument thant can be used to measure internal and external distance accurately to 0.01 mm, The digital vernier caliper is shown in fig 1, The distance or the measurements are read from LCD/LED display. The parts of digital calipers are similar to the ordinary vernier caliper except the digital display and few other parts.

Part of Digital Caliper (Fig 1)

1.Internal jaws

2.External jaws

3.Power On / Off button

4.Zero Setting button

5.Depth measuring blade

6.Beam scale

7.LED/ LCD Display

8.Locking screw

9.Metric/Inch button.

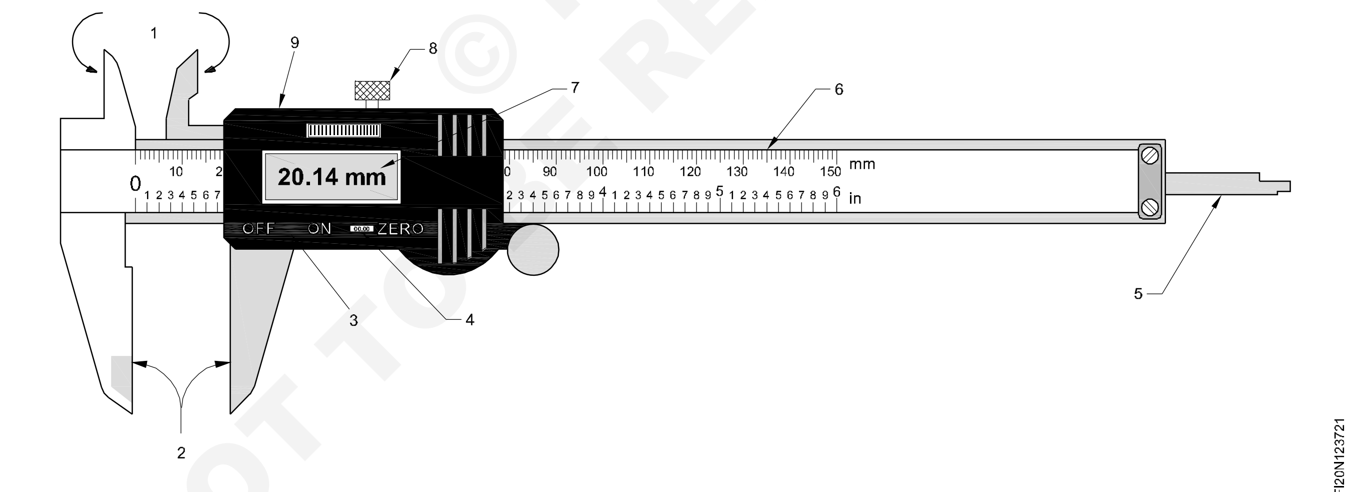
The digital caliper requires a small battery whereas the manual version does not need any power source. The digital calipers are easier to use as the measurement is clearly displayed and also, by pressing inch/mm button the distance can be read as metric or inch.

Zero setting of Digital Caliper

The display is turned on with the ON/OFF button. Before measuring, the zero setting to be done, by bringing the external jaws together untill they touch each other and then press the zero button. Now the digital caliper is ready to use.

> **Caution**
>
> **Always set zero position when turning on the display for the first time.**

Fig 1



Drilling processes - Drilling Machines, Types, Use and Care

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

The principle types of drilling machines are

– the sensitive bench drilling machine

– the pillar drilling machine

– the column drilling machine

– the radial arm drilling machine (radial drilling machine).

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

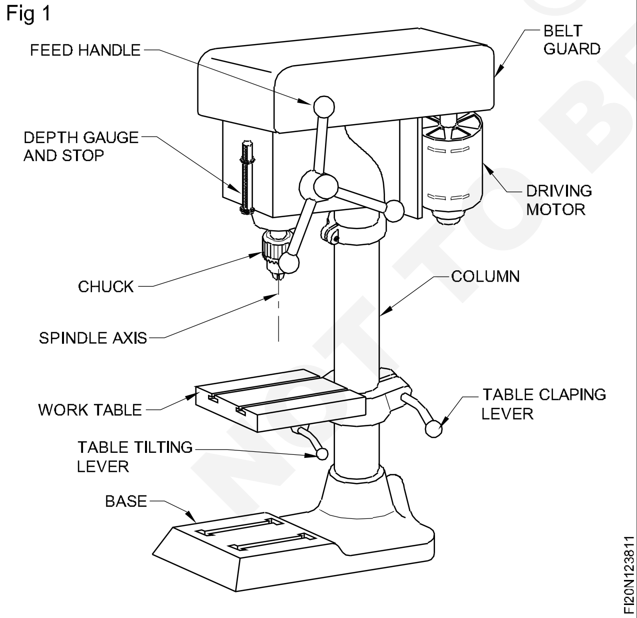
The sensitive bench drilling machine (Fig 1)

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

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

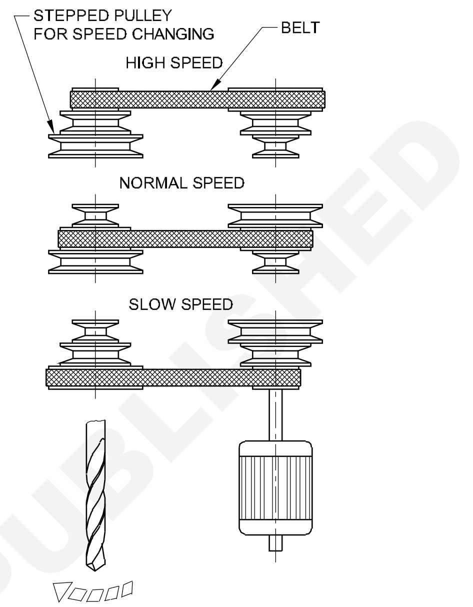
For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted. (Tilting arrangement is shown in Fig.1)

Fig 1



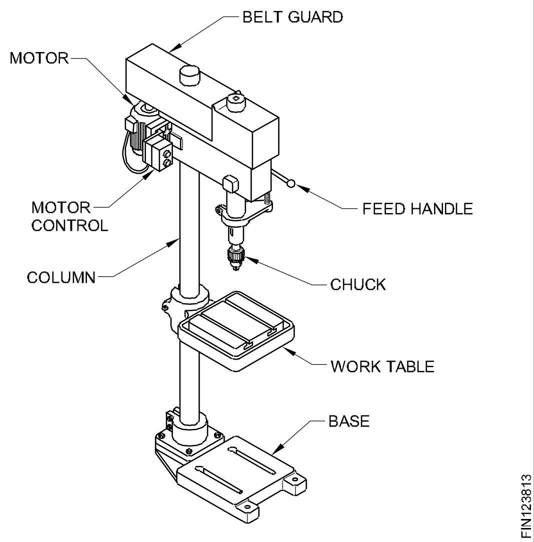
Different spindle speeds are achieved by changing the belt position in the stepped pulleys. (Fig 2)

Fig 2



The pillar drilling machine (Fig 3)**:** This is an enlarged version of the sensitive bench drilling machine. These drilling machines are mounted on the floor and driven by more powerful electric motors.

Fig 3



They are also used for light duty work. Pillar drilling machines are available in different sizes. The larger machines are provided with a rack and pinion mechanism to raise the table for setting the work.

Radial drilling machines

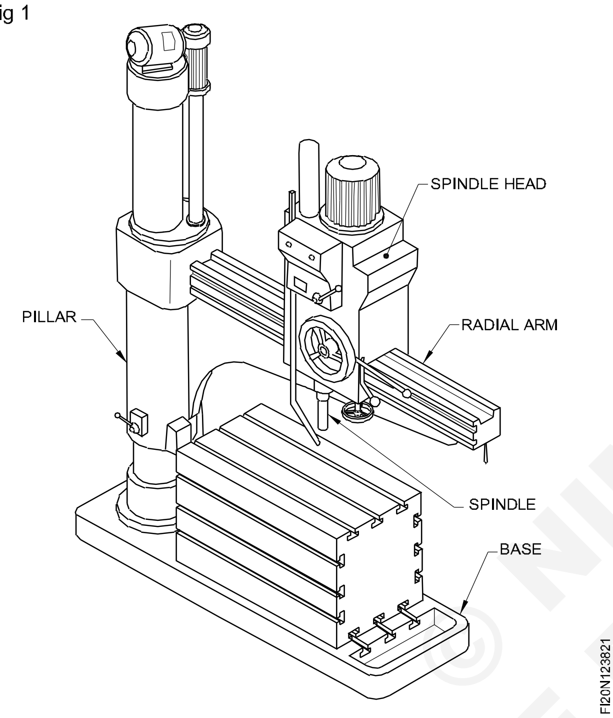
Objectives : At the end of this lesson you shall be able to
- **state the uses of a radial drilling machine**
- **state the features of radial drilling machine.**

Radial drilling machines are used to drill

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

Features (Fig 1)

Fig 1



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 gear box provides a large range of R.P.M.

The spindle can be roated in both clockwise and anticlockwise directions.

Angular holes can be drilled on machines having tilting tables.

A coolant tank is mounted on the base.

Precautions

Ensure that the spindle-head and the arms are locked properly to avoid vibration.

The workpiece and the drill should be rigidly held.

Bring back the spindle head nearer to the pillar after use.

Switch off power when not in use.

Use the drill drift for removing the drills, chucks or sockets.

Use a minimum number of sockets and sleeves to make for the spindle bore size.

Clean and oil the machine after use.

Stop the machine to remove the swarf.

Use a brush to clean the chips and swarf.

Gang drilling machine and multiple spindle head drilling machine

Objectives: At the end of this lesson you shall be able to
- **state the uses of a gang drilling machine**
- **state the construction of a gang drilling machine**
- **state the uses and construction of a multiple spindle head drilling machine.**

Gang drilling machine (Fig 1)

It consists of a large base supporting a long table. The top of the table is designed in such a way that several units may be mounted on it. Each spindle is driven by its individual directly connected motor.

The table has a groove around the outside for the return of the cutting lubricant, and may have 'T'-slots on its surface for ease in clamping the work to the table.

This type of machine is generally preferred when the work is to be moved from spindle to spindle for successive operations.

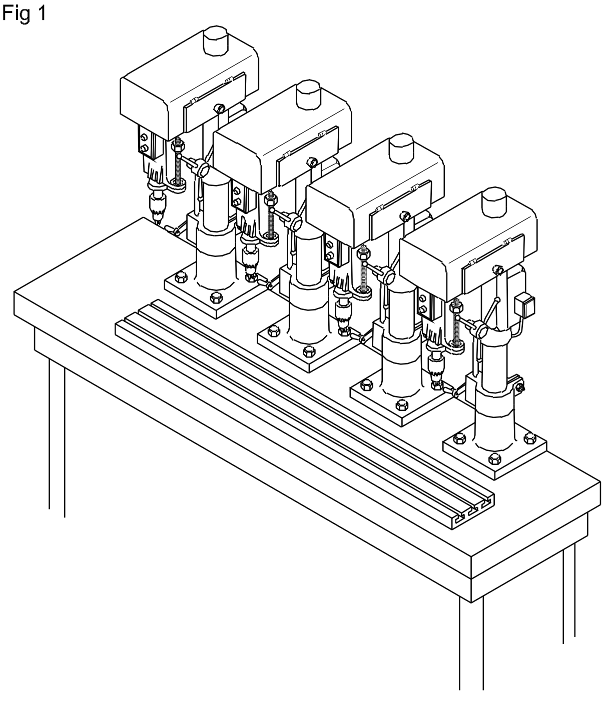
Multiple spindle head drilling machine (Fig 2)

The multiple spindle head drilling machine may have any number of spindles - from 4 to 48 or more, all driven from the one-spindle drive gear in one head.

The multiple spindle head drilling machine is specially designed for mass production operations such as drilling, reaming or tapping many holes at one time in a specific unit of work such as an automobile engine block.

There may be two or more drill heads on one machine, each with many spindles. This is necessary when holes are drilled from more than one direction - for example, on the

Fig 1



GANG OF FOUR DRILLING MACHINES

EACH MACHINE IS FITTED WITH A DIFFERENT CUTTING TOOL. AS THE WORK MOVES FROM POSITION TO POSITION A DIFFERENT OPERATION IS PERFORMED

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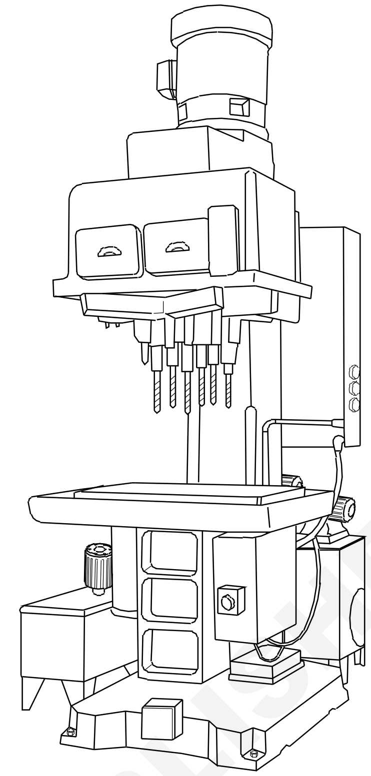
Fig 2



THE DRILLING HEADS CAN BE POSITIONED TO MEET VARIOUS SPECIFICATIONS

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top side, and the end of a piece of work. Production units of this type are seldom used in a tool room that usually does highly skilled work.

Work-holding devices

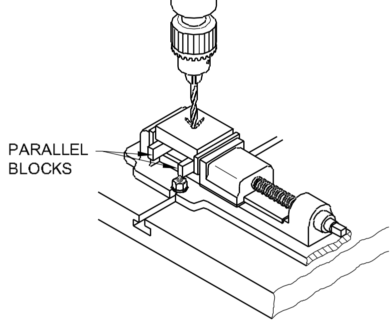
Objectives : At the end of this lesson you shall be able to
- **state the purpose of work-holding devices**
- **name the devices used for holding work**
- **state the precautions to be obsഎള്ല്d while using work-holding devices.**

Workpieces to be drilled should be properly held or clamped to prevent from roating 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 are used to ensure proper holding.

The machine vice

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. (Fig 1)

Fig 1



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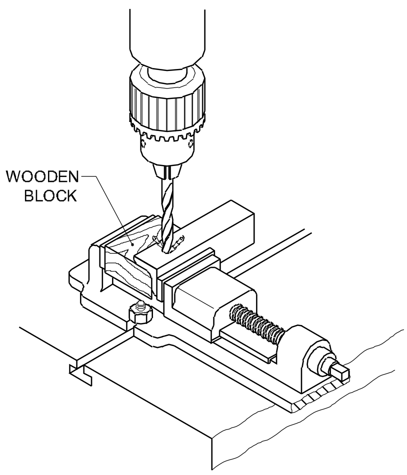
Workpieces which are not accurate may be supported by wooden pieces. (Fig 2)

Fig 2



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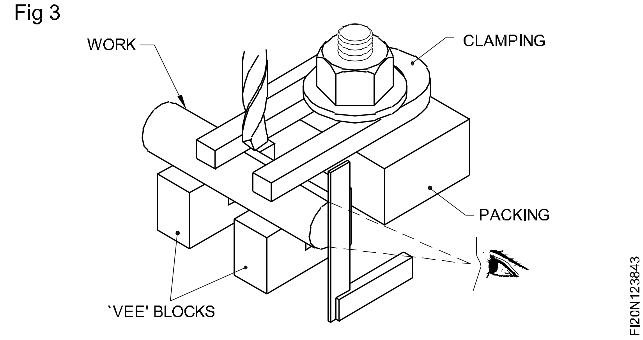
Clamps and bolts

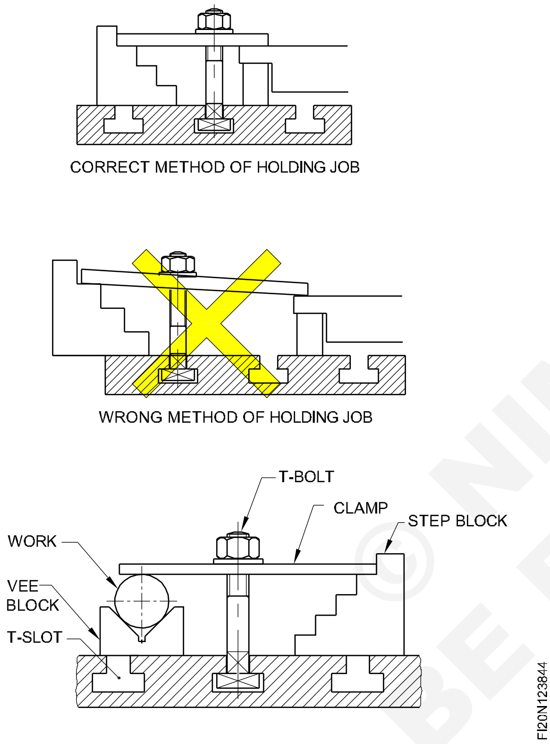
Driling machine tables are provided with T-slots for fitting bolt heads. Using clamps and bolts, the workpieces can be held very rigidly. (Fig 3) While using this method, the

Fig 3



packing should be, as far as possible, of the same height as the work, and the bolt nearer to the work. (Fig 4)

Fig 4



There are many types of clamps and it is necessary to determine the clamping method according to the work. (Fig 5& 6)

Fig 5

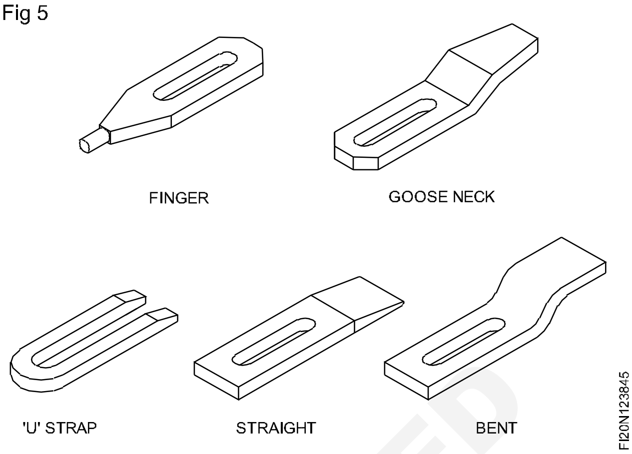
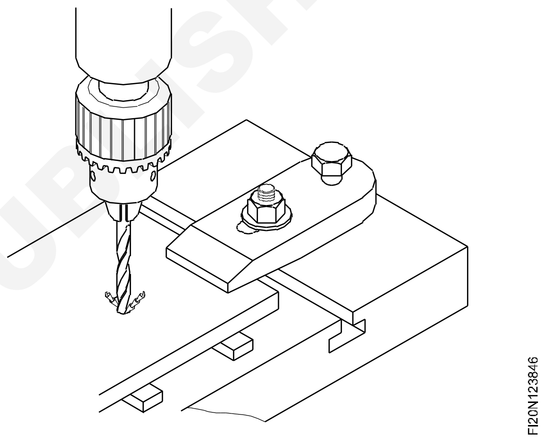


Fig 6



Hand taps and wrenches

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

Use of hand taps

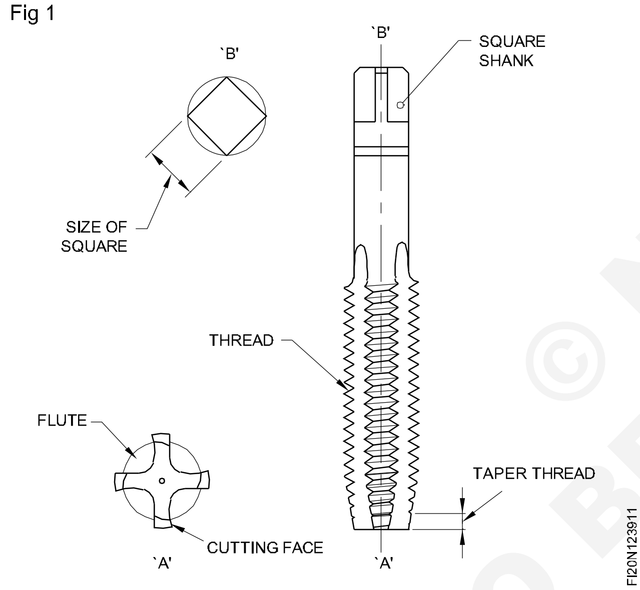
Hand taps are used for internal threading of components.

Features (Fig 1)

They are made from high carbon steel or 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.

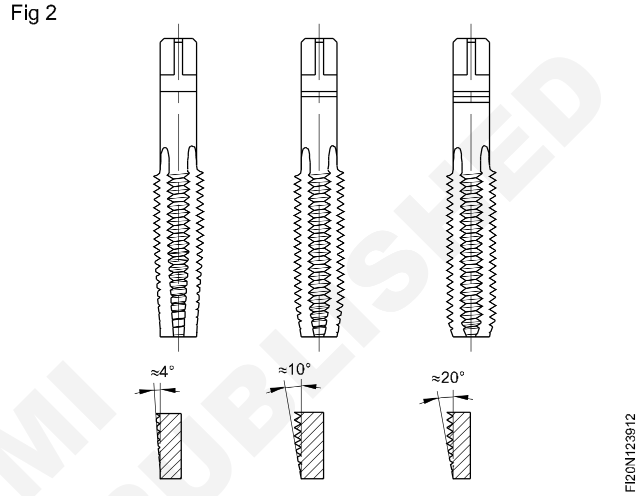
In certain cases, the pitch of the thread will also be marked.

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

Types of Taps in a set

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

Fig 2



These are

first tap or taper tap

second tap or intermediate tap

plug or bottoming tap.

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

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

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

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

The taper tap has one ring, the intermediate tap has two rings and the bottoming tap has three rings. (Fig 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, solid type tap wrench.

Double-ended Adjustable Tap Wrench or Bar Type Tap Wrench (Fig 3)

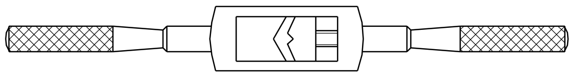


Fig 3

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

T-Handle tap wrench (Fig 4)

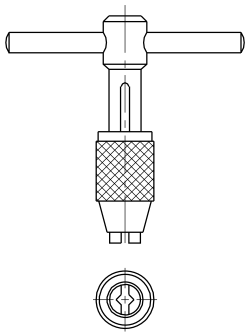


Fig 4

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

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

This wrench is not available 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.

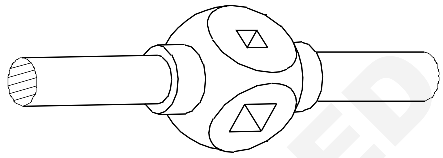


Fig 5

Tap drill size

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

What is a tap drill size?

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

Tap drill sizes for different threads

ISO Metric Thread

Tapping drill size

for M10 x 1.5 thread

Minor diameter = Major diameter – 2 x depth

depth of thread = 0.6134 x pitch of a screw

2 depth of thread = 0.6134 x 2 x pitch

=1.226 x 1.5 mm = 1.839 mm

Minor dia (D1)=10 mm – 1.839 mm

=8.161mm or 8.2 mm

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

A standard nut with 60% thread is strong enough to be tightened until the bolt breaks without stripping the thread.

Further it also requires a greater force for turning the tap if a higher percentage formation of thread is required.

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

Tap drill size = Major diameter – pitch

= 10 mm - 1.5 mm

= 8.5 mm.

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

ISO Inch (Unified) threads Formula

Tap Drill size =

$$\text{Major diameter} = \frac{1}{\text{number of thread sperinch}}$$

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

Tap drill size = 5/8" – 1/11"

= 0.625" – 0.091"

= 0.534"

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

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

What will be the tapping size for the following threads?

(a) M 20

(b) UNC 3/8

Refer to chart for determining the pitches of the thread.

COMMERCIAL DRILL SIZES ISO INCH (UNIFIED) THREAD

NC National Coarse				**NF National Fine**		
Tap size	**Tharads per inch**	**Tap dirll size per inch**		**Tap size**	**Therads**	**Tap drill size**
5	**40**	**38**		**5**	**44**	**37**
6	**32**	**36**		**6**	**40**	**33**
8	**32**	**29**		**8**	**36**	**29**
10	**24**	**25**		**10**	**32**	**21**
12	**24**	**16**		**12**	**28**	**14**
1/4 "	**20**	**7**		**1/4 "**	**28**	**3**
5/16 "	**18**	**F**		**5/16 "**	**24**	**1**
3/8 "	**16**	**5/16 "**		**3/8 "**	**24**	**0**
7/16 "	**14**	**U**		**7/16 "**	**20**	**25/64 "**
1/2 "	**13**	**27/64 "**		**1/2 "**	**20**	**29/64 "**
9/16 "	**12**	**31/64 "**		**9/16 "**	**18**	**33/64 "**
5/8 "	**11**	**17/32 "**		**5/8 "**	**18**	**37/64 "**
3/4 "	**10**	**21/32 "**		**3/4 "**	**16**	**11/16 "**
7/8 "	**9**	**49/64 "**		**7/8 "**	**14**	**13/16 "**
1"	**8**	**7/8 "**		**1 "**	**14**	**15/16 "**
1 1/8 "	**7**	**63/64 "**		**1 1/8 "**	**12**	**1 3/6 "**
1 1/4 "	**7**	**17/64 "**		**1 1/4 "**	**12**	**1 11/6 "**
1 3/8 " "	**6**	**17/32 "**		**1 3/8 "**	**12**	**1 19/64**
1 3/4 "	**5**	**1 9/16 "**				
2 "	**4 1/2**	**1 25/32 "**				
NPT National pipe thread						
1/8 "	**27**	**11/32 "**		**1 "**	**11 1/2**	**1 5/32 "**
1/4 '	**18**	**7/16 "**		**1 1/4 "**	**11 1/4**	**1 1/2 "**
3/8 "	**18**	**19/32 "**		**1 1/2 "**	**11 1/2**	**1 23/32 "**
1/2 "	**14**	**23/32 "**		**2 "**	**11 1/2**	**2 23/16 "**
3/4 "	**14**	**15/16 "**		**2 1/2 "**	**8**	**2 5/8 "**

TABLE FOR TAP DRILL SIZES- ISO METRIC THREADS

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

Safety precautions in sheet metal workshop

Objectives: At the end of this lesson you shall be able to
- **state various hazardous while working in a SMW shop**
- **state different precautions to be taken for safe working in a SMW shop.**

Whenever a work is done in a shop the following aspects may create an injury to the workman/trainee or to others working nearby.

1 Way of handling the materials, tools and machine.

2 Cleaning of the work area/shop floor.

3 Damaged/faulty tools, machines and safety appliances.

4 Carelessness and negligence of the workman/trainee.

5 Ignorance of general safety rules.

To avoid the accident/injuries taking place, while working it is very important to follow certain safety precautions. They are:

– Do not bend your whole body while lifting heavy loads. Instead use your thigh muscles for lifting.

– Use gloves while handling thin sheets.

– Use chipping screen during chiseling operation.

– Avoid using a mushroom head chisel.

– Arrange the tools properly over the work table so that the tools are not allowed to fall from the table on your foot.

– Wear proper size safety shoes.

– Remove burrs by filing from a plate or sheet after cutting them by chisel or hacksaw.

– Do not use a hammer with a broken or damaged handle.

– Fix the hammer head with the handle securely using a wedge.

– Do not wear loose garments/dress.

– Wear plain goggles/face shield while grinding.

– Do not grind materials which are 3mm or less in thickness and non-ferrous metals.

– Adjust the gap between the work rest and the grinding wheel to 1-2mm.

– Select and use the right kind of tool for the right job.

– Keep the floor on the work area neat and clean without any cut pieces of material, oil, etc.

– Keep a separate bin/basket for throwing cotton waste, metal chips etc.

– Always keep fire fighting equipment and the First Aid Box ready for use in case of any emergency.

– After completion of work keep the tools in the tool box.

– Wear helmet if anybody is working above your work place, either to repair at the roof or on a overhead crane.

– Use tongs while handling hot objects.

– Do not try to check the sharpness of any tool with bare fingers.

– Switch off the mains of a machine while leaving the machine after completion of work.

– Do not try to rectify any electrical fault by yourself. Call an electrician for doing any electrical repair work.

– Wherever and whenever possible avoid poluting the environment.

– If any other person is affected by electric shock, immediately switch off the mains or separate the person from the electrical contact using a wooden rod or any other insulating material.

– Always fix the job at a convenient height on the vice.

– Use sufficient leverage while tightening or loosening a nut or bolt.

General Workshop Rules

– Safety glasses must be worn.

– Safety footwear must be worn when working in the workshop.

– Ask workshop instructor before using equipment.

– Visitors must remain within marked walkways.

– Long hair must be tied back.

– Clean, equipment & machines after use.

– Take care when using compressed air.

– Hearing protection should be worn when using machinery.

– Working alone after hours is not permitted.

Metal sheets and their uses

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 their standard gauge numbers.

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

Black iron sheets: The cheapest sheet metal is the black iron, which is rolled to the desired thickness. The sheets are rolled in two conditions. When it is rolled in cold state, it is called cold rolled and when it is rolled in hot state, it is called hot rolled. Hot rolled sheets have a bluish black appearance, and are often referred to as uncoated sheets, since they are uncoated. They corrode rapidly.

Cold rolled sheets have plain silver whitish appearance and are uncoated. To decrease the work hardness, the cold ruled sheets are annealed in a closed atmosphere. These sheets are known as C.R.C.A (Cold rolled close annealed) sheets.

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

Galvanised iron sheets: Zinc coated iron is known as 'galvanised iron'. This soft iron sheet is popularly known as G.I.sheet. The zinc coating resist corrosion and improves the appearance of the metal and permit it to be soldered with greater ease. Because it is coated with zinc, galvanised iron sheet withstands contact with water and exposure to weather.

Articles such as pans, buckets, furnaces, heating ducts, cabinets, gutters etc. are made mainly from G.I.sheets.

Stainless sheets: 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 similar to galvanised iron sheets, but is tougher than G.I. sheets. The cost of stainless steel is very high.

Stainless steel is used in dairies, food processing, chemical plants, kitchenware etc.

Copper sheets: Copper sheets are available either as cold rolled or hot rolled. They have a very good resistance to corrosion and can be worked easily. They 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 sheets are used.

Aluminium sheets: Aluminium cannot be used in its pure form, but is mixed with very small amount of copper, silicon, manganese and iron. Aluminium sheets are whitish in colour and light in weight. They are highly resistant to corrosion and abrasion.

Aluminium 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 making roofs, food containers, dairy equipment, furnace fittings, cans and pans etc.

Lead sheets: Lead is very soft and heavy in weight.

Lead sheets are used for making the highly corrosive acid tanks.

When lead is coated on black iron sheets, they are called Terni sheets. They are highly anti-corrosive and commonly used in preservation of chemicals.

Indian Standard sheet sizes & strip sizes

Objectives: At the end of this lesson you shall be able to
- **specify the Indian Standard sheet sizes**
- **specify the Indian Standard strip sizes**
- **calculate the weight of the steel sheet, and the measure of the strip.**

Indian Standard sheet sizes & strip sizes

As per Indian Standard are designated as ISSH received by figures denoting length (mm) x width (mm) x thickness (mm) of the sheet as per IS 1730 : 1989.

Example

ISSH 3200 x 600 x 1.00

Where

3200 is the length of the sheet (mm)

600 is the width of the sheet (mm)

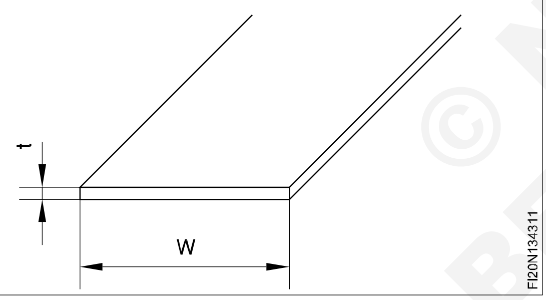
1.00 is the thickness of the sheet (mm)

Table 1 gives the weight of steel sheets of different standard sizes.

Indian Standard strip sizes

Indian Standard strips are designated as ISST followed by width (mm) x thickness (mm) of the strip as per IS 1730 - 1989. (Fig 1)

Fig 1



Example

ISST 1050 x 3.15: Where 1050 mm is the width of the strip and 3.15mm is the thickness.

Exercise

Calculate the weight of the steel sheet given below.

ISSH 1800x1200 x 1.40mm

Table 2 gives the weight in kg of a particular strip per metre length.

Exercise

Calculate the weight of a ISST 500 x 4 of 2 metres

Answer

TABLE 1

Standard Nominal Dimensions and Mass of Sheet

Size mm x mm	Standard Nominal Surface Area in m^2	Standard Nominal Thickness in mm												
		0.40	0.50	0.63	0.80	0.90	1.00	1.12	1.25	1.40	1.60	1.80	1.90	2.00
1800 x 600	1.08	3.39	4.24	5.34	6.78	7.65	8.47	9.50	10.6	11.9	13.6	5.3	16.1	17.0
750	1.35	4.24	5.30	6.67	8.48	9.54	10.6	11.9	13.2	14.8	17.0	19.1	20.1	21.2
900	1.62	5.09	6.35	8.01	10.2	11.4	12.7	14.2	15.9	17.8	20.3	22.9	24.2	25.4
950	1.71	5.37	6.71	8.45	10.7	12.1	13.4	15.0	16.8	18.8	21.5	24.2	25.5	26.8
1000	1.80	5.65	7.06	8.90	11.3	12.7	14.2	15.8	17.7	19.8	22.6	25.4	26.8	28.3
1100	1.98	6.22	7.77	9.79	12.4	14.0	15.6	17.4	19.4	21.8	24.9	28.0	29.5	31.1
1200	2.16	6.78	8.48	10.7	13.6	15.3	17.0	19.0	21.2	23.7	27.1	30.5	32.2	33.9
1250	2.25	7.07	8.83	11.1	14.1	15.9	17.6	19.8	22.1	24.7	28.3	31.8	33.6	35.3
1400	2.52	7.91	9.90	12.5	15.8	17.8	19.8	22.2	24.7	27.7	31.7	35.6	37.6	39.6
1500	2.70	8.48	10.6	13.4	17.0	19.1	21.2	23.8	26.5	29.7	33.9	38.2	40.2	42.4
2000 x 600	1.20	3.77	4.71	5.93	7.53	8.47	9.42	10.6	11.8	13.2	15.1	17.0	17.9	18.8
750	1.50	4.71	5.88	7.42	9.42	10.6	11.8	13.2	14.7	16.5	18.8	21.2	22.4	23.6
900	1.80	5.65	7.06	8.90	11.3	12.7	14.1	15.8	17.7	19.8	22.6	25.4	26.8	28.3
950	1.90	5.97	7.45	9.39	12.0	13.4	14.9	16.8	17.9	20.8	23.6	26.8	28.3	29.8
1000	2.00	6.28	7.85	9.89	12.6	14.1	15.7	17.6	19.6	22.0	25.1	28.3	29.8	31.4
1100	2.20	6.91	8.63	10.9	13.8	15.5	17.3	19.3	21.6	24.2	27.6	31.1	32.8	34.5
1200	2.40	7.53	9.42	11.9	15.1	17.0	18.8	21.1	23.6	26.4	30.1	33.9	35.8	37.7
1250	2.50	7.85	9.80	12.4	15.7	17.7	19.6	22.0	24.5	27.5	31.4	35.3	37.2	39.2
1400	2.80	8.79	11.0	13.8	17.6	19.8	22.0	24.6	27.5	30.8	35.2	39.6	41.8	44.0
2500	3.00	9.42	11.8	14.8	18.8	21.2	23.6	26.4	29.4	33.0	37.7	42.2	44.7	47.1
2200 x 600	1.32	4.14	5.18	6.52	8.28	9.32	10.4	11.6	13.0	14.5	16.6	18.7	19.7	20.7
750	1.65	5.18	6.47	8.16	10.4	11.7	13.0	14.5	16.2	18.1	20.7	23.3	24.6	25.9
900	1.98	6.22	7.77	9.78	12.4	14.0	15.5	17.4	19.4	21.8	24.9	28.0	29.5	31.1
950	2.09	6.56	8.20	10.3	13.1	14.8	16.4	18.4	20.5	23.0	26.2	29.5	31.2	32.8
1000	2.20	6.91	8.63	10.9	13.8	15.5	17.3	19.3	21.6	24.2	27.6	31.1	32.8	34.5
1100	2.42	7.60	9.50	12.0	15.2	17.1	19.0	21.3	23.7	26.6	30.4	34.2	36.1	38.0
1200	2.64	8.29	10.4	13.1	16.6	18.7	20.7	23.2	25.9	29.0	33.2	37.3	39.4	41.4
1250	2.75	8.63	10.8	13.6	17.3	19.4	21.6	24.2	27.9	30.2	34.5	38.9	41.0	43.2
1400	3.08	9.67	12.1	15.2	19.3	21.8	24.2	27.1	30.2	33.8	38.7	43.5	45.9	48.4
1500	3.30	10.4	13.0	16.3	20.7	23.3	25.9	29.0	32.4	36.3	41.4	46.6	49.2	51.8
2500 x 600	1.50	4.71	5.88	7.42	9.42	10.6	11.8	13.2	14.7	16.5	18.8	21.2	22.4	23.6
750	1.875	5.88	7.35	9.26	11.8	13.2	14.7	16.5	18.4	20.6	23.6	26.5	27.9	29.4
900	2.25	7.07	8.83	11.1	14.1	15.9	17.7	19.8	22.1	24.7	28.3	31.8	33.6	35.3
950	2.375	7.45	9.32	11.7	14.9	16.8	18.6	20.9	23.3	26.1	29.8	33.6	35.4	37.2
1000	2.50	7.85	9.80	12.4	15.7	17.7	19.6	22.0	24.5	27.5	31.4	35.3	37.2	39.2
1100	2.75	8.63	10.8	13.6	17.3	19.4	21.6	24.2	27.0	30.2	34.5	38.9	41.0	43.2
1200	3.00	9.42	11.8	14.8	18.8	21.2	23.6	26.4	29.4	33.0	37.7	42.4	44.7	47.1
1250	3.125	9.81	12.3	15.5	19.6	22.1	24.5	27.5	30.7	34.3	39.2	44.2	46.6	49.1
1400	3.50	11.0	13.7	17.3	22.0	24.7	27.5	30.8	34.3	38.5	44.0	49.5	52.2	55.0
1500	3.75	11.8	14.7	18.5	23.6	26.5	29.4	33.0	36.8	41.2	47.1	53.0	55.8	58.9

Based on the density of steel =7.85 g/cm2

For determining the mass of sheet above 2mm thickness
refer to IS1730:1989

TABLE 2

Standard Nominal Dimensions and Mass of Strip

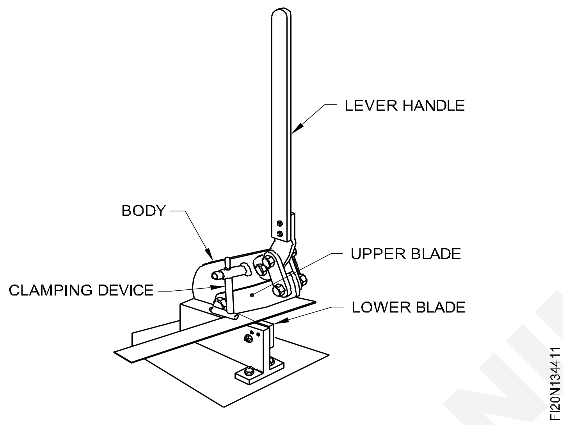
Width in mm	Thickness in mm													
	1.60	1.80	2.00	2.24	2.50	2.80	3.15	3.55	4.00	4.50	5.0	6.0	8.0	10.0
	Mass * kg/m													
100	1.25	1.41	1.57	1.76	1.96	2.20	2.47	2.79	3.14	3.53	3.92	4.71	6.28	7.85
125	1.57	1.77	1.96	2.20	2.45	2.74	3.08	3.48	3.92	4.41	4.90	5.88	7.85	9.81
160	2.01	2.26	2.51	2.81	3.14	3.52	3.95	4.46	5.02	5.65	6.28	7.53	10.0	12.6
200	2.51	2.82	3.14	3.52	3.92	4.39	4.94	5.58	6.28	7.06	7.84	9.42	12.6	15.7
250	3.14	3.53	3.92	4.40	4.90	5.49	6.17	6.97	7.85	8.83	9.80	11.8	15.7	16.6
320	4.02	4.52	5.02	5.62	6.28	7.05	7.90	8.92	10.0	11.3	12.5	15.1	20.0	25.1
400	5.02	5.65	6.28	7.04	7.85	8.78	9.88	11.1	12.6	14.1	15.7	18.8	25.1	31.4
500	6.28	7.05	7.85	8.79	9.51	11.0	12.4	13.9	15.7	17.7	19.6	23.6	31.4	39.2
650	8.16	9.17	10.2	11.4	12.7	14.3	16.1	18.1	20.4	23.0	25.5	30.6	40.8	51.0
800	10.0	11.3	12.6	14.1	15.7	17.6	19.8	22.3	25.1	28.3	31.4	37.7	50.2	62.8
950	-	13.4	14.9	16.7	18.6	20.8	23.5	26.5	29.8	33.6	27.3	44.7	59.7	74.6
1000	-	-	15.7	17.6	19.6	22.0	24.7	27.9	31.4	35.3	39.2	47.1	62.8	78.5
1050	-	-	16.5	18.5	20.6	23.3	26.0	29.2	33.0	37.1	41.2	49.5	65.9	82.4
1150	-	-	-	20.2	22.6	25.2	28.4	32.0	36.1	40.6	45.1	54.2	72.2	90.3
1250	-	-	-	-	24.5	27.5	30.9	34.8	39.2	44.2	49.1	58.9	78.5	98.1
1300	-	-	-	-	-	28.6	32.1	36.2	40.8	45.9	51.0	61.2	81.6	102
1450	-	-	-	-	-	-	35.8	40.4	45.5	51.2	56.9	68.3	91.1	114
1550	-	-	-	-	-	-	383	43.2	48.7	54.7	60.8	73	93.3	122

Hand lever shears

Objectives: At the end of this lesson you shall be able to
- **identify the hand lever shear**
- **state the principle of working**
- **state the constructional feature parts and their functions.**

Hand lever shear is a hand operated machine used to cut sheet metal upto a thickness of 3 mm (10 SWG). When the machine is mounted on the bench, it is called a hand lever bench shear. It may also be mounted on the floor, over a small platform. It is used for cutting along straight lines and convex cutting of sheet metal. (Fig.1)

Fig 1



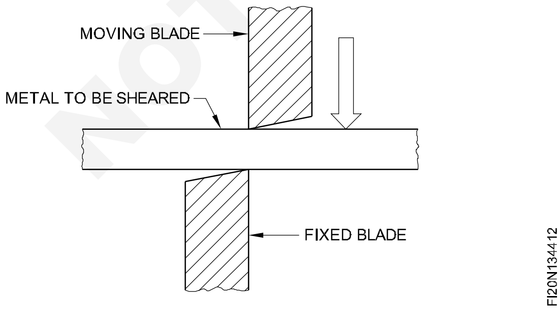
The lower blade of the hand lever shear is fixed (bottom blade) and the upper blade is pivoted at an angle.

The sheet being cut is prevented from tilting by a clamping device, which can be adjusted to the thickness of the sheet.

The knife cutting edge of the upper blade is curved so that the opening angle at the point of cut remains constant.

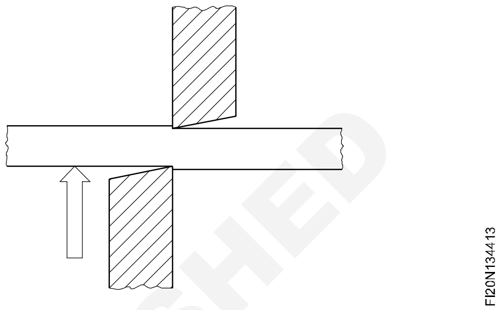
As the upper blade moves down on the sheet metal, the metal is subjected to shearing force, which causes deformation of the metal. (Fig 2 & 3) Increase in force causes plastic deformation of metal.

Fig 2



After a certain amount of plastic deformation, the cutting member begin to penetrate. The uncut metal work, harden at the edge (Fig 4).

Fig 3



Fracture begins to run into the work hardened metal from the point of contact of the cutting members. When these fractures meet, the cutting members penetrate the whole of the metal thickness. (Fig 5)

Fig 4

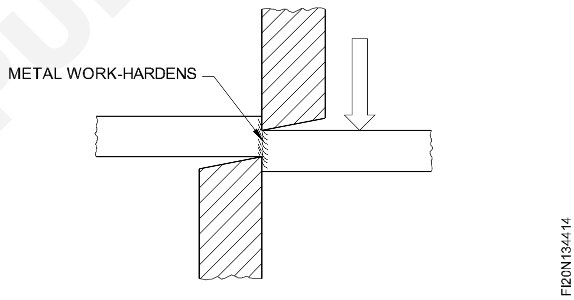
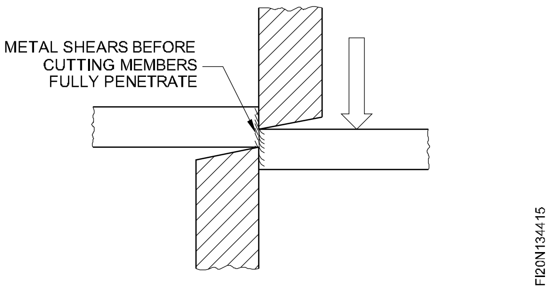


Fig 5



Blade clearance is very important and should not exceed 10 percent of the thickness to be cut and should suit the particular material.

Results of incorrect and correct setting of shear blade are as follows.

1 Excessive clearance causes a burr to form on the underside of the sheet as shown in the (Fig 6).

2 With no clearance, over strain is caused, the edge of the sheet becomes flattened on the under sides as shown in (Fig 7).

Fig 6

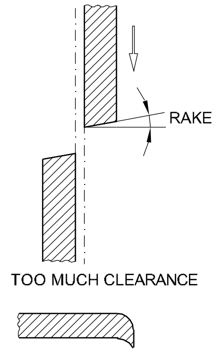
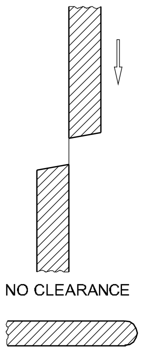
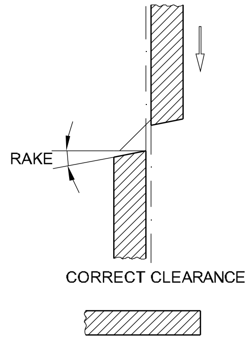


Fig 7



3 With the correct clearance, optimum shearing results are obtained as shown in (Fig 8).

Fig 8



Squaring shear

Objectives: At the end of this lesson you shall be able to
- **state the function of the squaring shear**
- **describe the adjustments on the machine to control the length of the cut**
- **state the capacity of the machine**
- **explain the safety precautions to be observed when working on squaring shears.**

Squaring shear

Cutting sheet metals is called shearing.

Squaring shears are used to cut large sheets into pieces to handle sheets easily.

Sheet metal can be cut by many simple machines.

Squaring shears, (Fig 1) operated by foot, are used to cut and trim large pieces of sheet metal. The size of the machine is specified by the length of the bed and maximum thickness of sheet it cuts. Front gauge and back gauge is provided to adjust the length of cut. A back gauge controls the length of the cut, when sheet is inserted from the front.

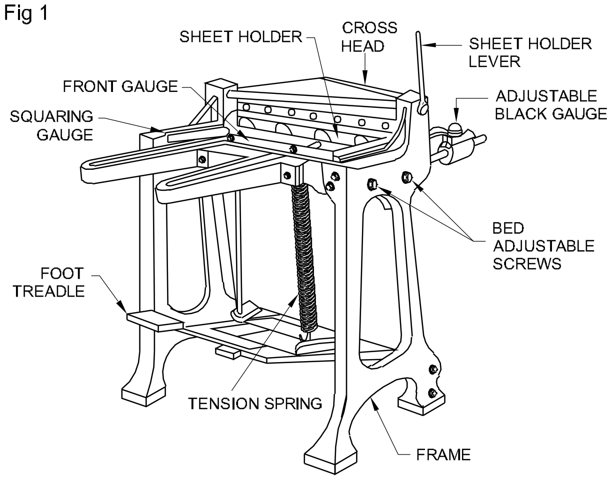
A front gauge cut the sheet which is inserted from the back.

Sheet holder is provided to hold the sheet firmly while it is being cut. It is operated by sheet holder lever.

The square gauge is adjustable and is kept at right angles to the cutting blade. 18 gauge sheets or lighter can usually be cut by squaring shear parts are as shown in Fig 1.

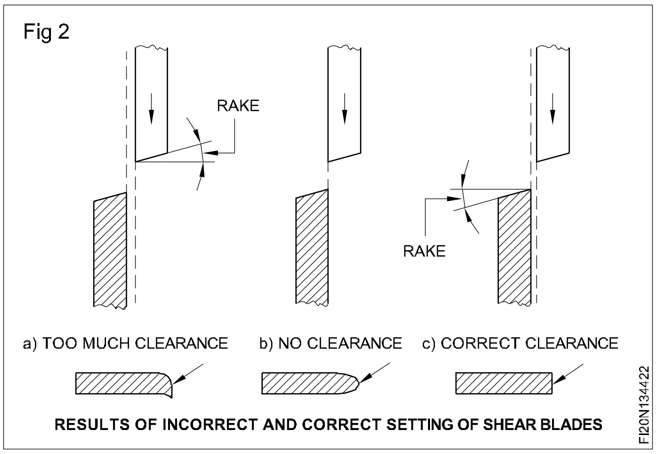
The clearance between the blades (Fig 2) can be adjusted by two adjusters. One adjuster shifts the table forward and other shifts the table backward. (Fig 3)

Fig 1



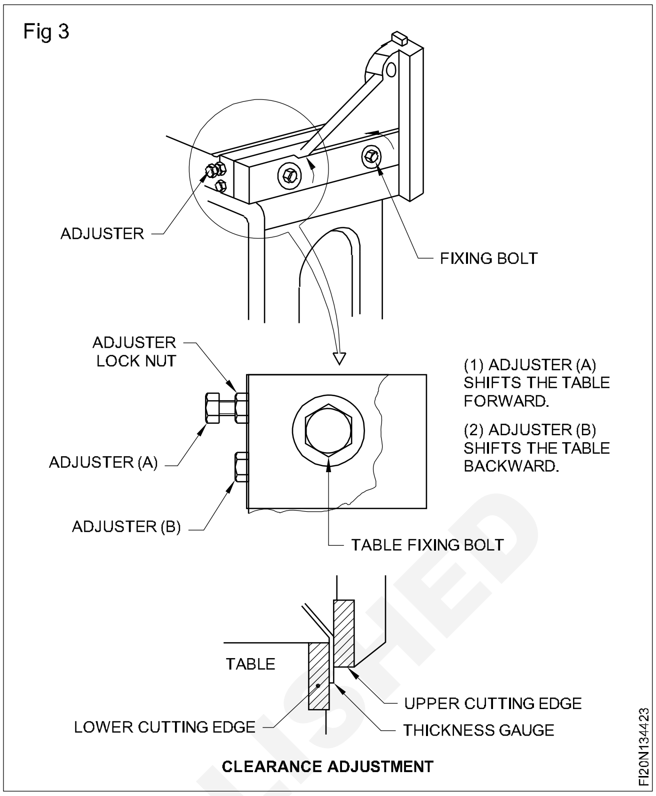
SQUARING SHEARS

Too much clearance causes a burr to form on the underside of the sheet (Fig 2a) with no clearance overstrain is caused, the edges of the sheet becomes flattened on the underside (Fig 2b). With the correct clearance optimum shearing results are obtained (Fig 2c).



Safety

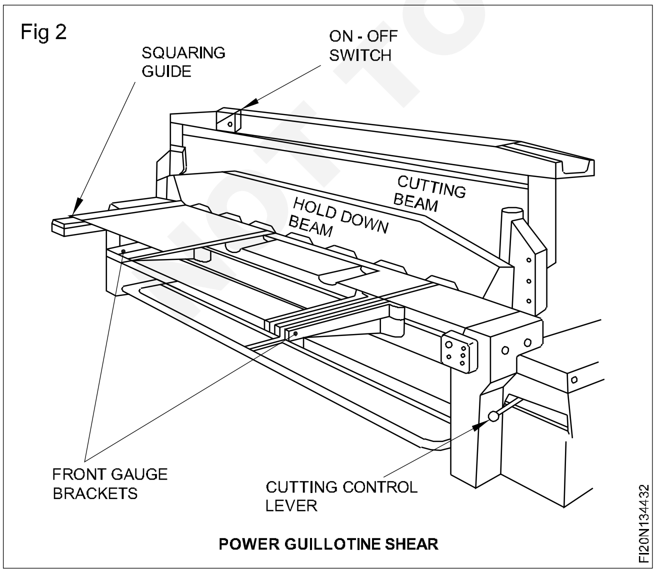
Keep your fingers away from the cutting blade at all times. Never attempt to cut bar iron, wire or any heavy metal on the squaring shears. This may nick the blade, which will then make a notch in every edge you cut. For better shearing results blade clearances and setting of blades are shown in Fig 2 & 3.

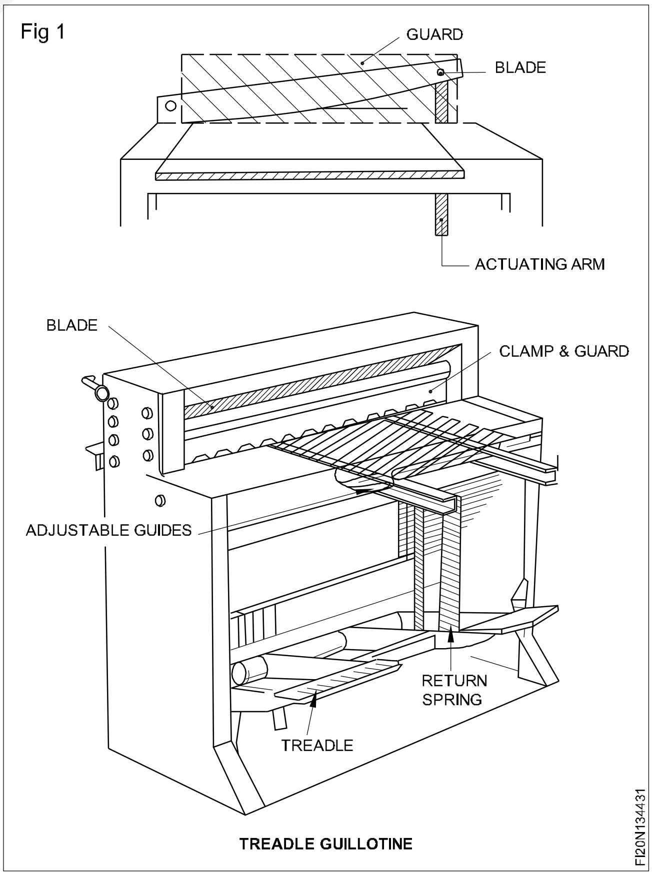


Guillotine shears

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of guillotine shears**
- **explain working of guillotine shears**
- **explain setting procedures of squaring guide, front gauge and back gauge**
- **state the safety precautions to be followed while working on guillotine shears.**

Guillotine shears: On a treadle, guillotine, the bottom cutting blade is fixed to the machine bed and the top blade is operated by the treadle. The material to be cut is kept on the bed and held in position by hand. The hold down clamp comes into operation when the treadle is depressed. Figs 1&2 shows the treadle guillotine.



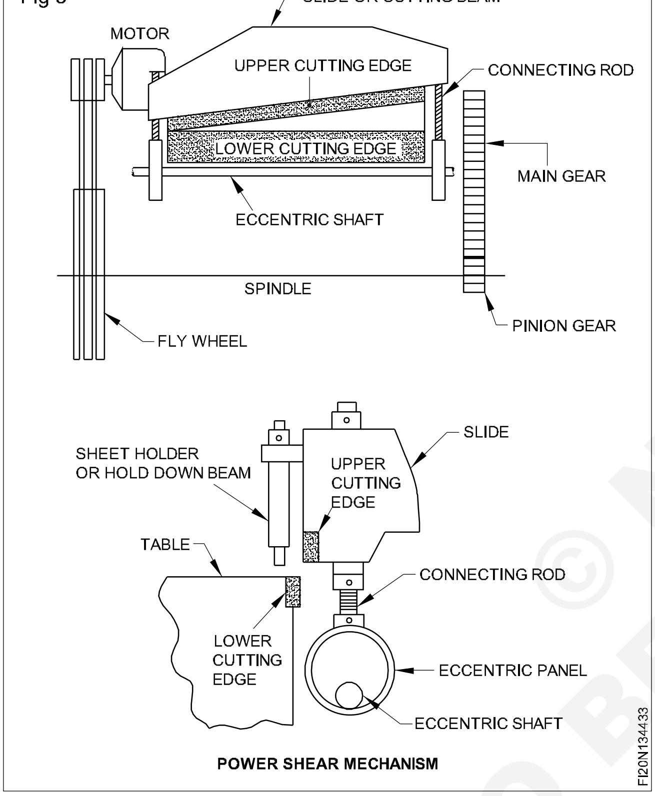


On some power operated guillotines, provision is given for a single or continuous cutting action. If there is any doubt in operating cutting control, check as follows.

- Switch on guillotine
- Depress pedal
- If the control is set for single cutting the cutting beam is descent once for each depression of the pedal.
- If the controls are set for continuous cutting the beam will continue to raise and descend when pedal is depressed.

Power shear mechanism is shown in Fig 3.

Fig 3



POWER SHEAR MECHANISM

Safety

1 All guillotines are very dangerous.
2 Place the guard in position before operating.
3 Never work from the back of a guillotine.
4 Understand its safe operation fully, and the operation of emergency switches should be known perfectly.
5 Gauges, if not being used, should be clear of the material being cut.

Cutting procedure: When cutting, already marked line as shown in Fig 3.

- Switch on power guillotine
- Place the sheet on bed of machine and slide between blades
- Place the sheet on the bed of machine and slide between blades
- Align cutting mark to the edge of the bottom blade
- Depress pedal, ensuring that the other foot is away from pedal bar.

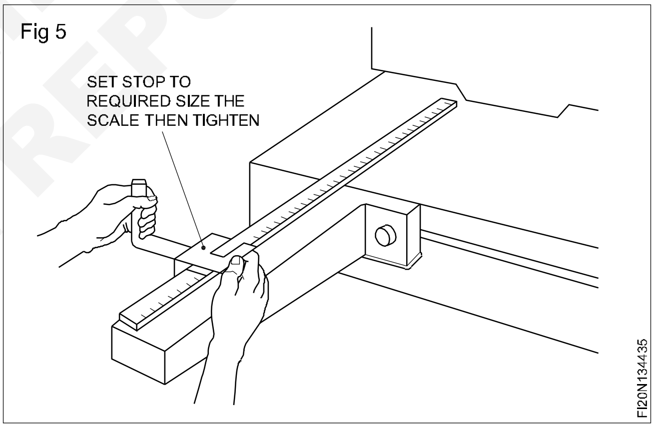
Use of the squaring guide: Guillotines are commonly fitted with a guide at one end of the bed, to enable sheets to be cut without marking on the sheet.

Where the guide is fitted with a scale, a stop is fitted to enable strips of a predetermined length to be cut accurately as shown in Fig 4.

Fig 4

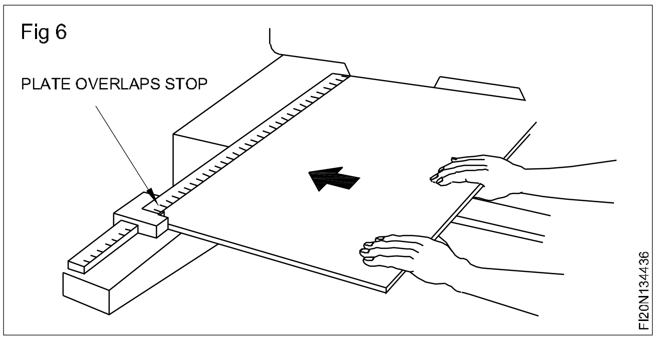
Position sheets against guide for squaring the other end over lap stops slightly as shown in Fig 5.

Fig 5



Safety: Wear protective gloves for handling sheet metal. Reverse sheet and reposition. Place same edge to guide. Pull sheet back against stop and depress pedal as shown in Fig 6.

Fig 6



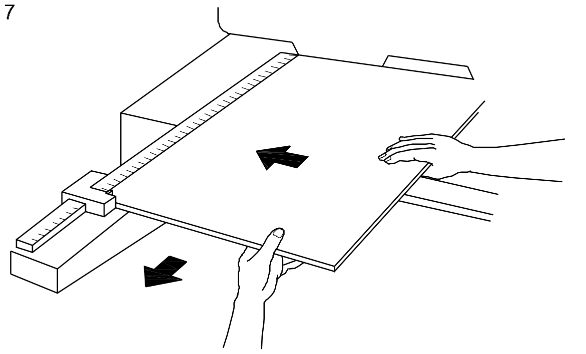
Parallel setting of front gauge: The front gauge is used when there is less overhang.

Before setting, check that the guillotine is switched off and separated. (Power machine only)

Keep wooden block under pedal as an added safe guard. Fit gauge bar by tee bolts of bar into slots in brackets.

Procedure for tape measure (Fig 7)

Fig 7

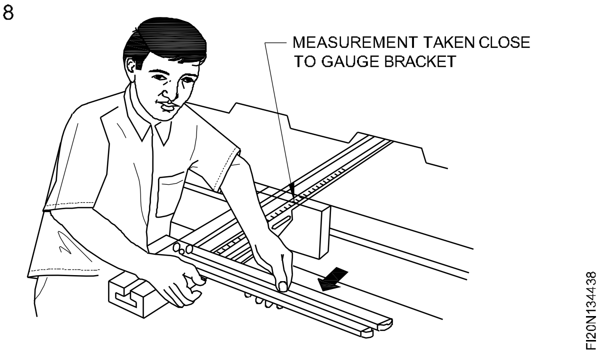


– Slide the tape end between blades
– Edge of the tape is hooked against bottom blade
– Position gauge bar, keeping the bar parallel to the blade
– Tighten securing nuts slightly
– Adjust the gauge to required position by tapping lightly by palm
– Adjust the gauge bar parallel to the blade and fully tighten the nuts.

When using a rule

– Place the rule between blades. Position required dimension on the edge of bottom blade.
– Place the gauge bar against end of the rule.
– Position the bar parallel. Slightly tighten the nut and adjust as shown in Fig 8.

Fig 8

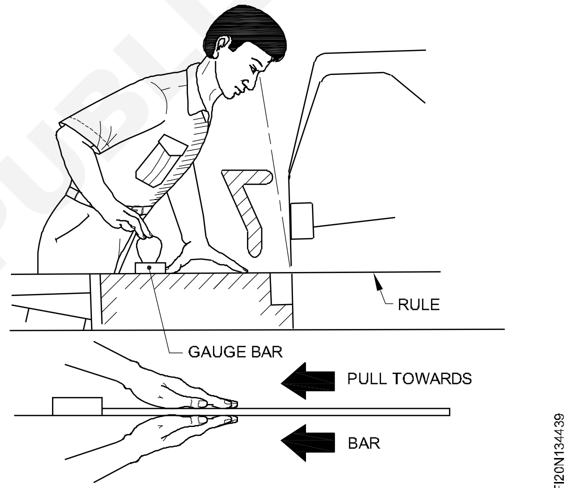


Using scale on gauge brackets: Where a machine is fitted with a graduated scale on the brackets, position gauge bar to the required dimension and fully tighten the nuts.

Keep place supported against gauge bar as shown in Fig 9.

Mark off plate to the size and shape. Set guide stop to give correct length.

Fig 9



Cut the sheet metal to the size and shape as per marking

Sheet Metal Tools

Objective: At the end of this lesson you shall be able to
• List out the measuring tools, marking tools and production tools used in the sheet metal work

Tools used in the sheet metal work are:

I Measuring tools

1 Steel rule
2 Outside micrometer
3 Vernier caliper
4 Combination set
5 Standard wire gauge
6 Radius gauge

II Marking tools

1 Tinman's square
2 Scratch owl
3 Straight scriber
4 Bend scriber
5 Punches
6 Try square
7 Wing compass
8 Trammel
9 Jenny caliper
10 Surface plate
11 Timper
12 Trammel
13 Marking table
14 Surface plate

III Production tools

1 Snips
2 Tin man's hammers
3 Mallet
4 Ball pane hammer
5 Straight edge
6 Templates
7 Soldering iron
8 Blow lamp
9 Hand grooves
10 Stakes
11 Surface plate
12 Riveting tools, dolly, staps etc.

Measuring Tools

Fig 1

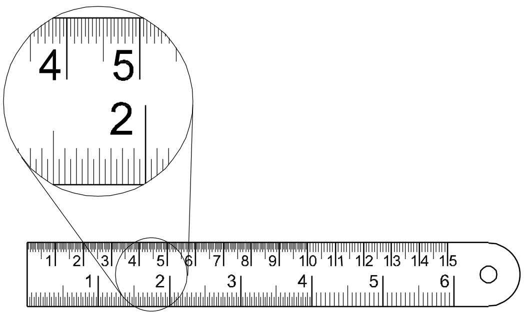


Fig 2

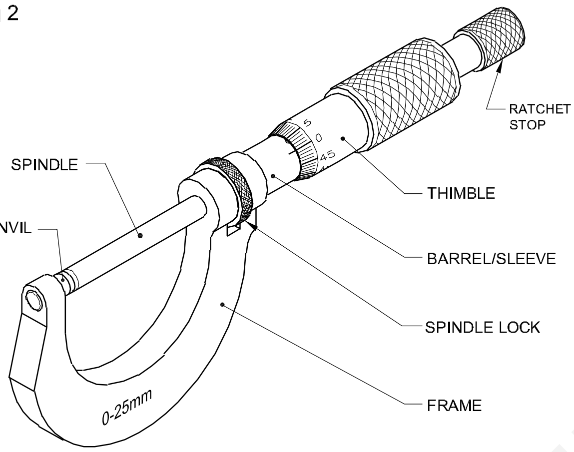


Fig 3

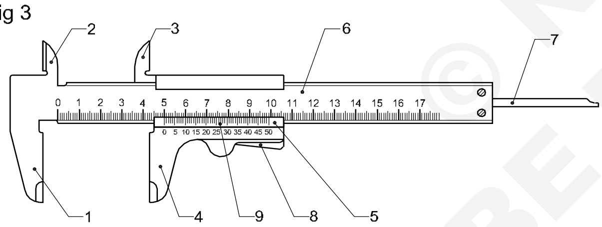


Fig 4

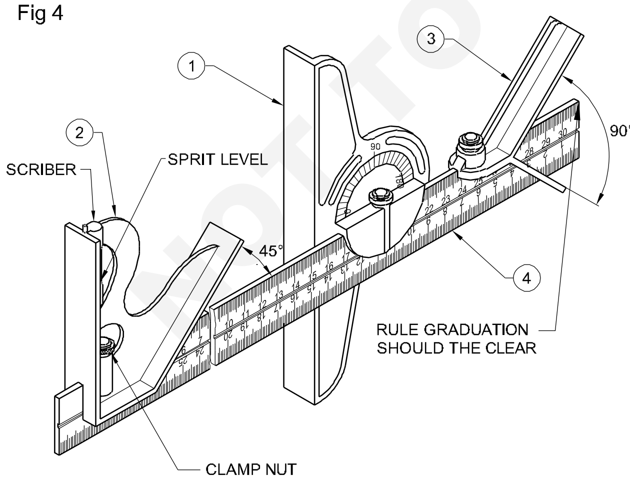
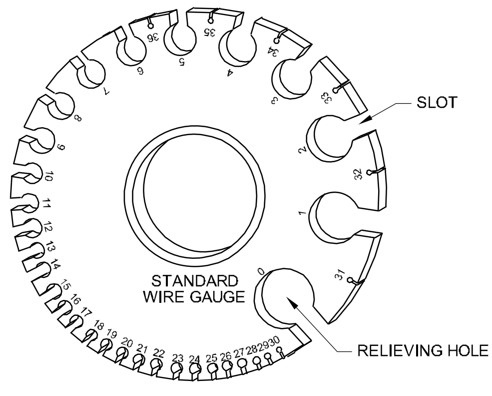
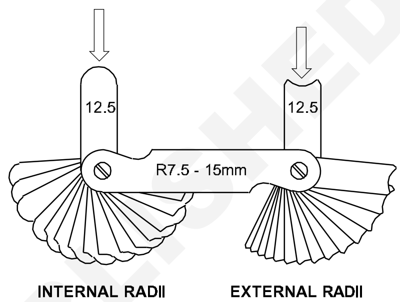


Fig 5



STANDARD WIRE GAUGE

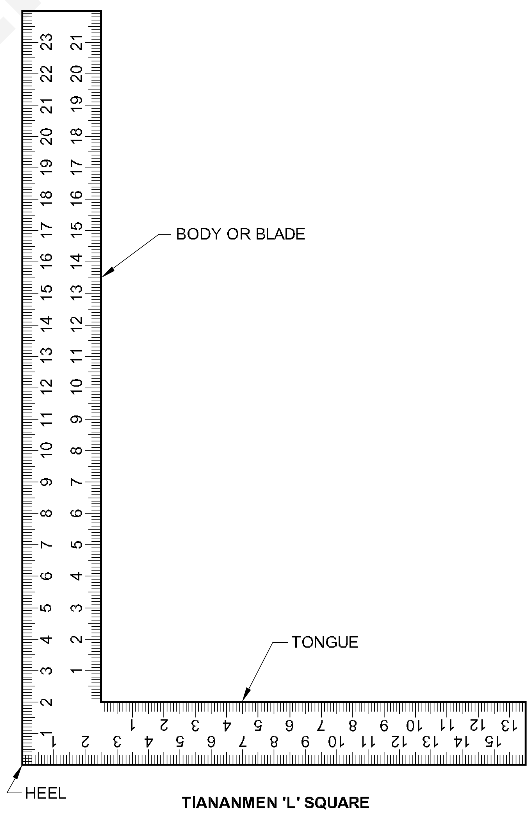
Fig 6



RADIUS GAUGE

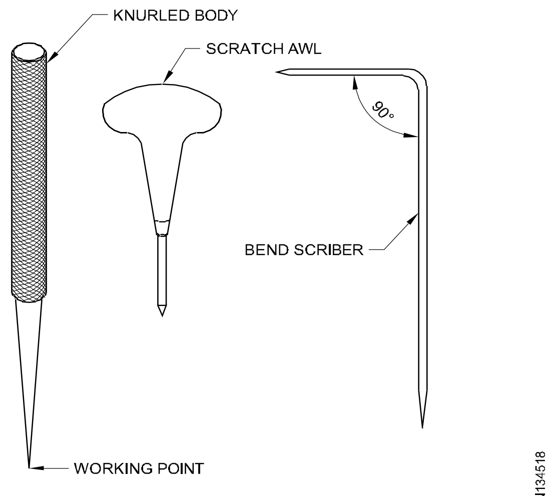
Marking Tools Sheet Metal Worker

Fig 7



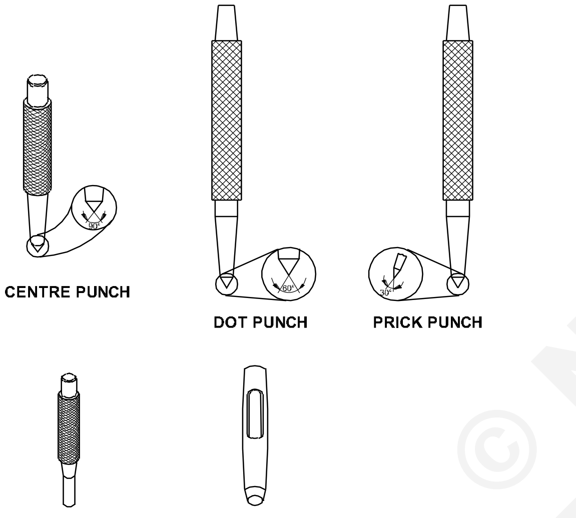
TIANANMEN 'L' SQUARE

Fig 8



STRAIGHT SCRIBER

Fig 9



CENTRE PUNCH

DOT PUNCH

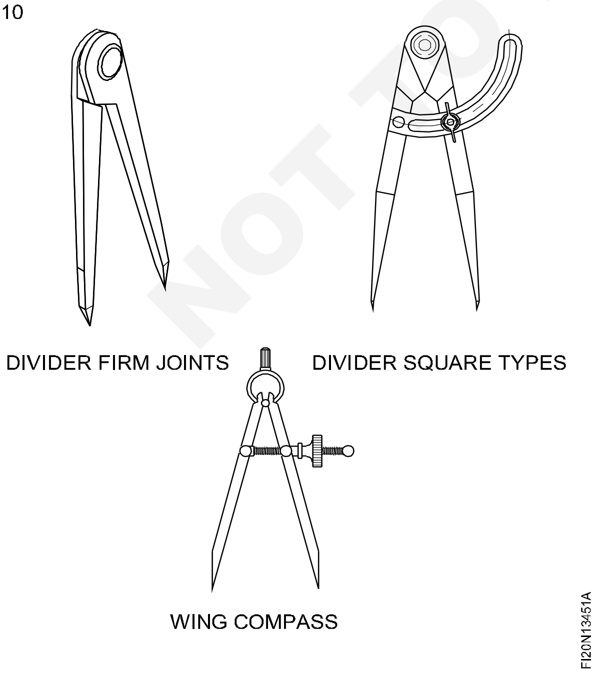
PRICK PUNCH

SOLID PUNCH

HOLLOW PUNCH

PUNCHES

Fig 10

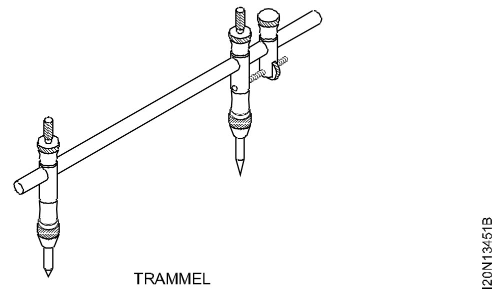


DIVIDER FIRM JOINTS

DIVIDER SQUARE TYPES

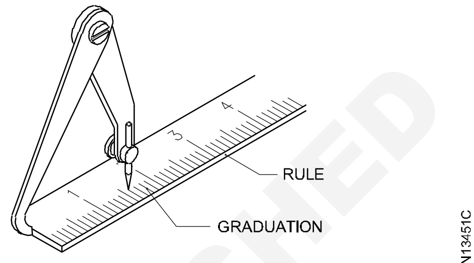
WING COMPASS

Fig 11



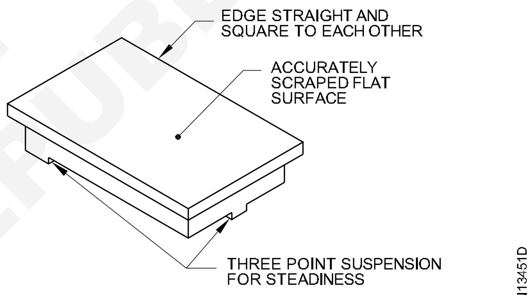
TRAMMEL

Fig 12



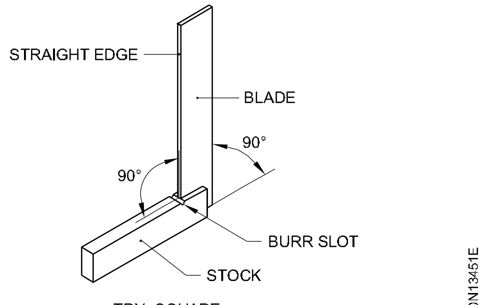
JENNY CALIPER

Fig 13



SURFACE PLATE

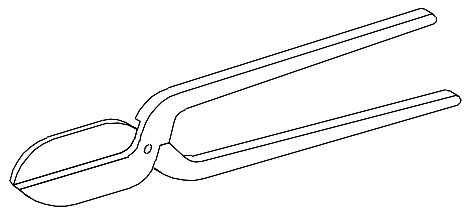
Fig 14



TRY SQUARE

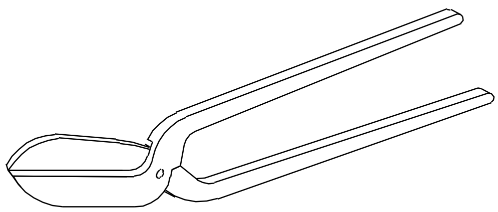
Production Tools

Fig 15



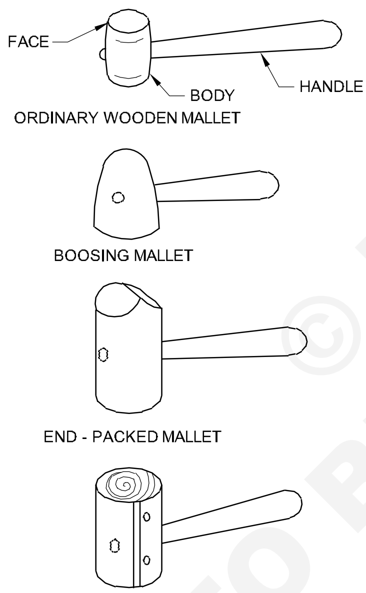
STRAIGHT SNIPS

Fig 16



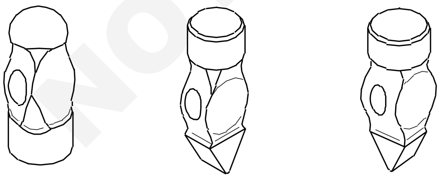
BEND SNIPS

Fig 17



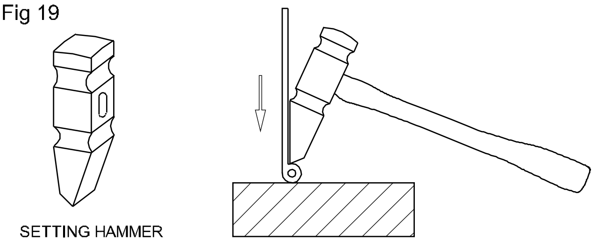
SHEEL METAL MALLETS

Fig 18



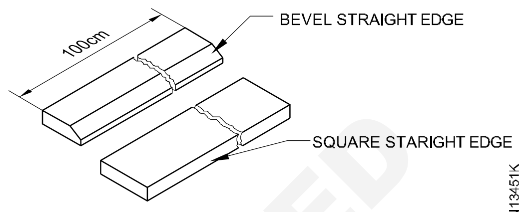
BALL PEEN **CROSS PEEN** **STRAIGHT PEEN**

Fig 19



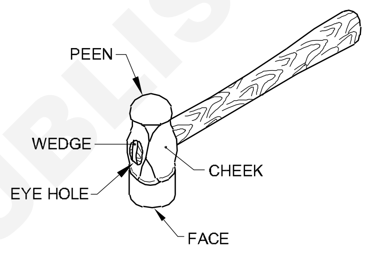
SETTING HAMMER

Fig 20



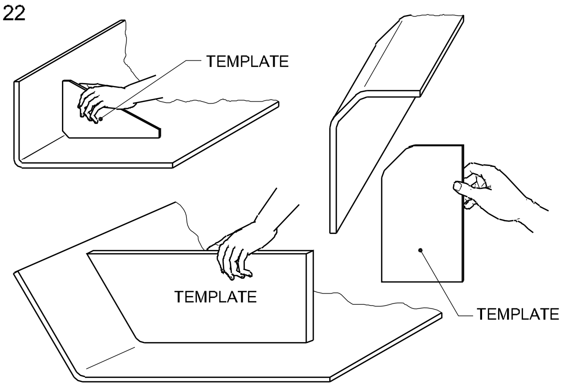
STRAIGHT EDGE

Fig 21



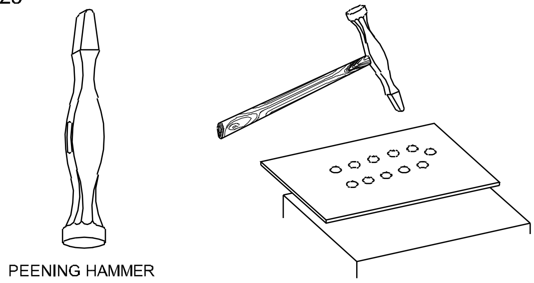
BALL PEEN HAMMER

Fig 22



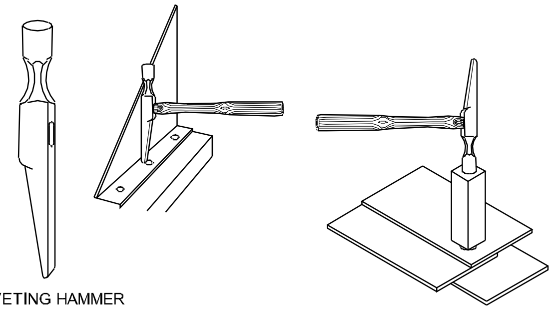
CHECKING ANGLES WITH A TEMPLATE

Fig 23



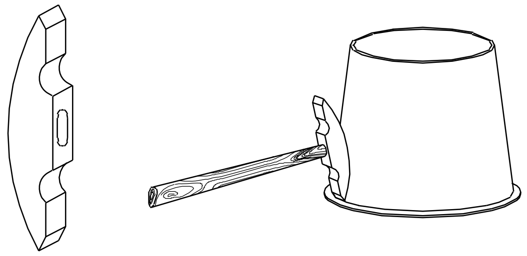
PEENING HAMMER

Fig 24



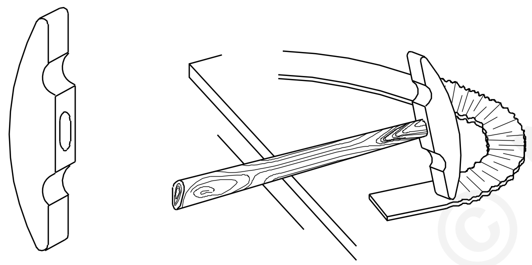
RIVETING HAMMER

Fig 25



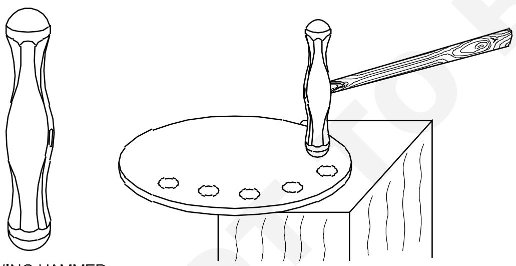
CREASING HAMMER

Fig 26



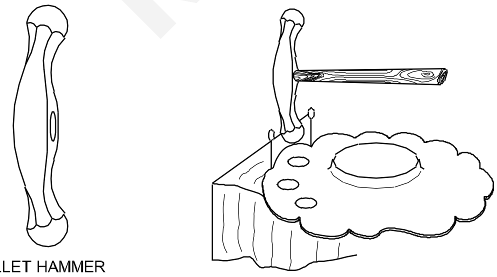
STRETCHING HAMMER

Fig 27



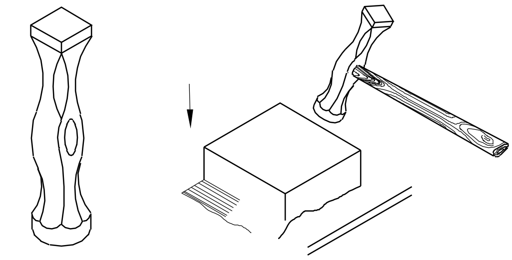
HOLLOWING HAMMER

Fig 28



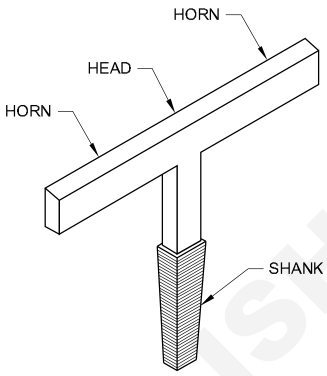
BULLET HAMMER

Fig 29



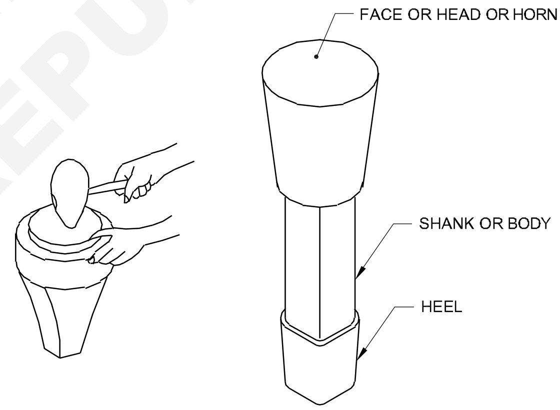
PLANISHING HAMMER

Fig 30



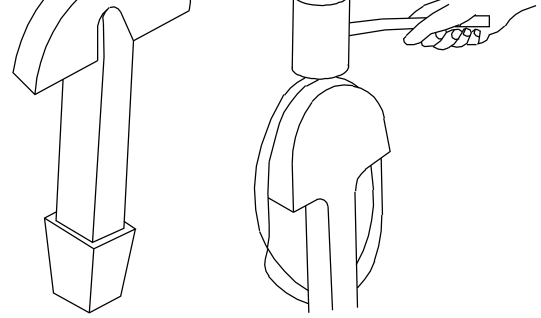
HATCHET STAKE

Fig 31



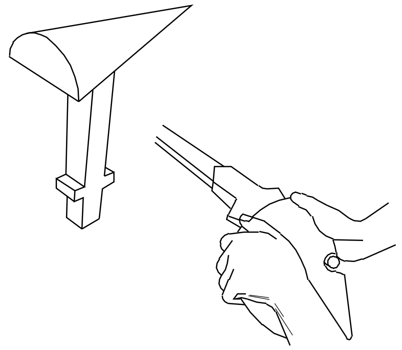
ROUND BOTTOM STAKE

Fig 32



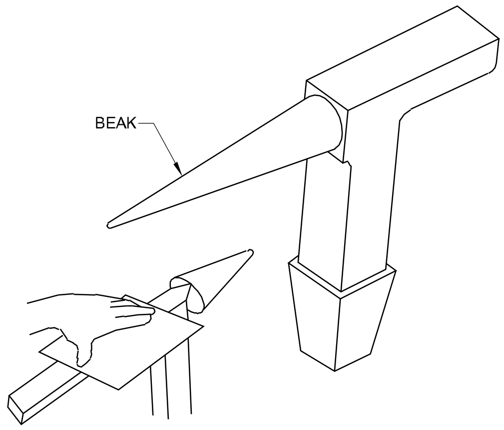
HALF MOON STAKE

Fig 33



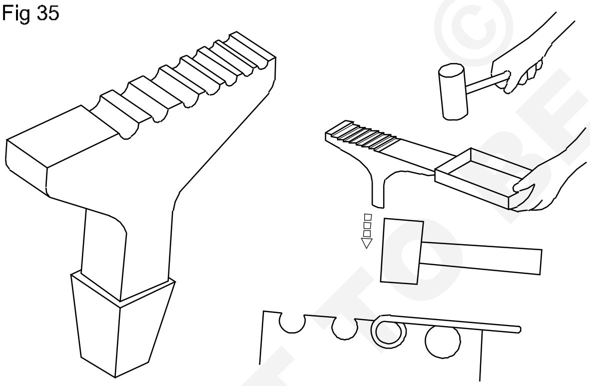
FUNNEL STAKE

Fig 34



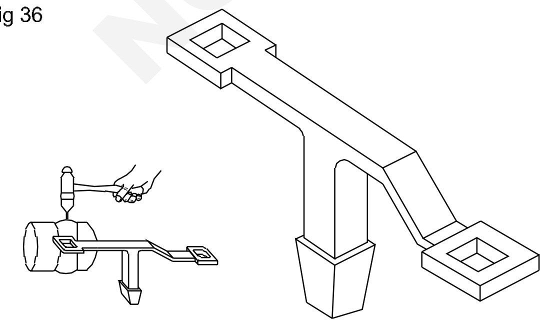
BEAK OR BICKIRON

Fig 35



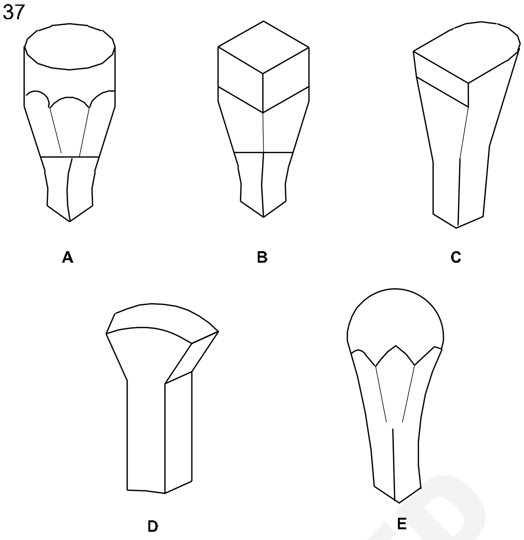
CREASING IRON

Fig 36



TINMAN'S HORSE

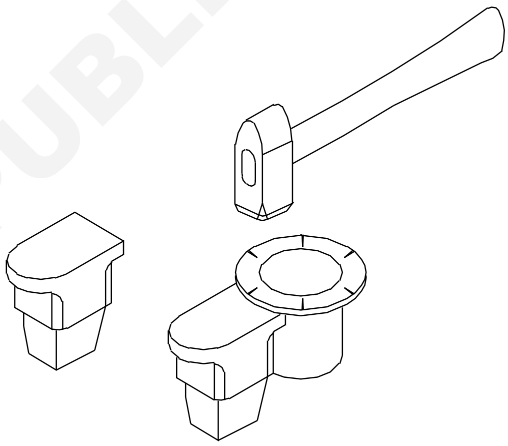
Fig 37



A - ROUND BOTTOM
B - ANVIL
C - ANVIL
D - HALF MOON
E - ROUND HEAD

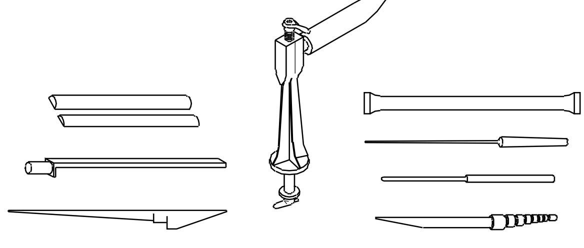
HEADS

Fig 38



TINMAN'S ANVIL

Fig 39



UNIVERSAL STAKE HOLDER

Fig 40

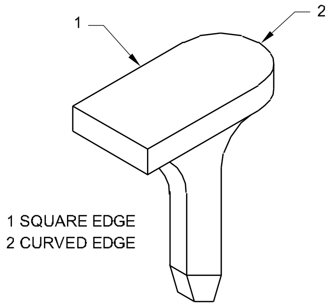
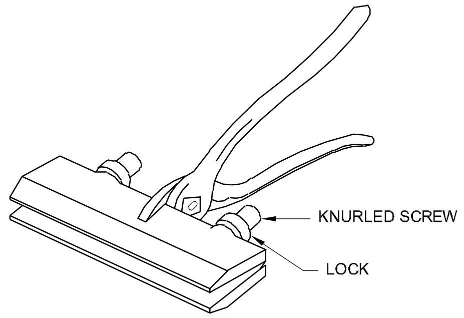


Fig 41



HAND SEAMER

Fig 42

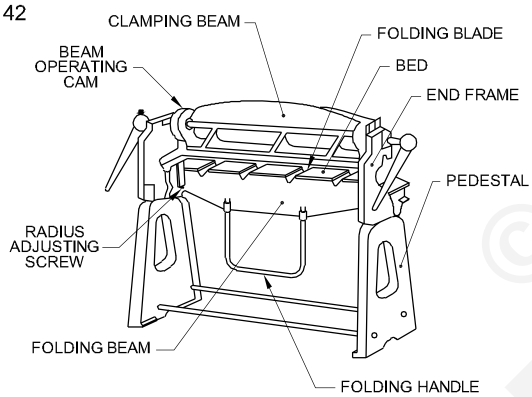
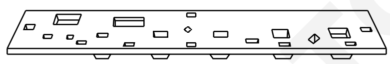
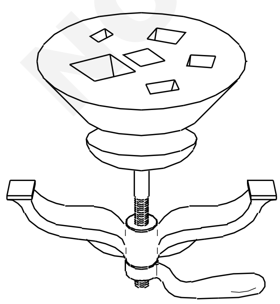


Fig 43



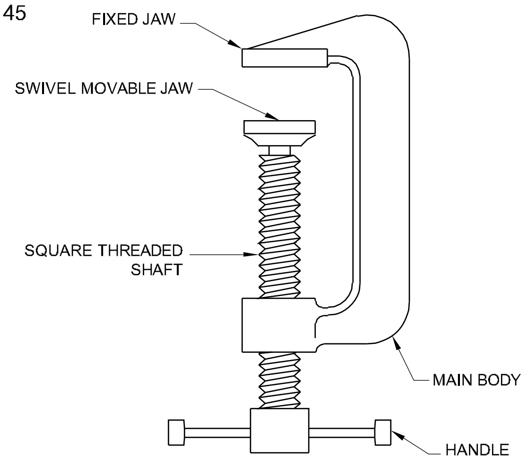
BENCH PLATE

Fig 44



REVOLVING BENCH PLATE

Fig 45



'C' CLAMP

Fig 46

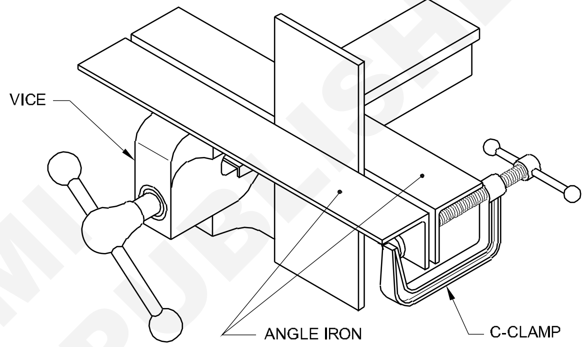
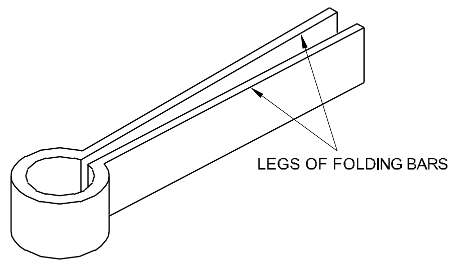
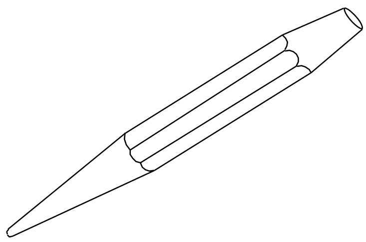


Fig 47



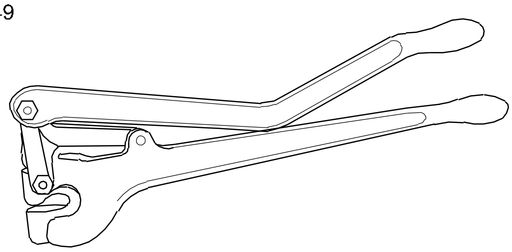
FOLDING BARS

Fig 48



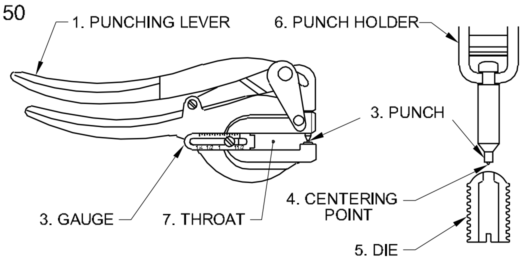
SOLID PUNCH

Fig 49



IRON HAND PUNCH

Fig 50



THE HAND LEVER PUNCH

Fig 51

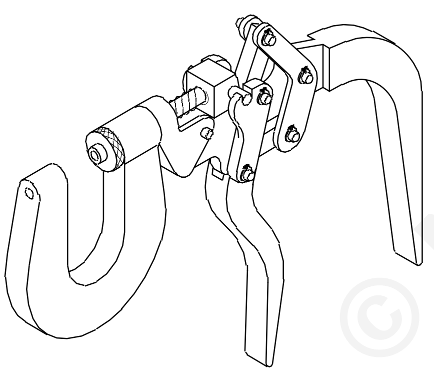


Fig 52

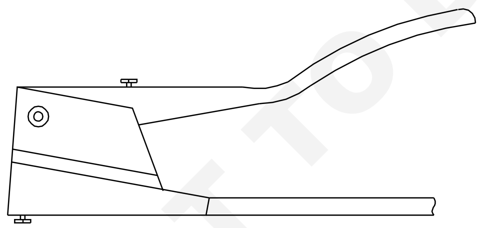
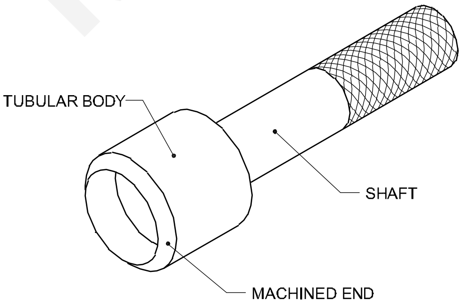
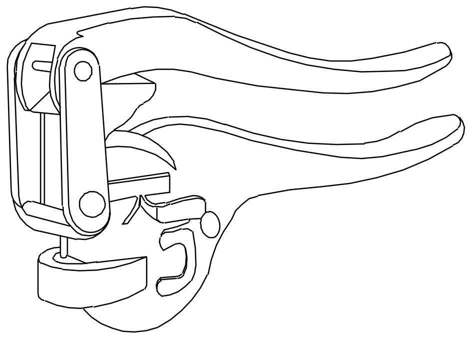


Fig 53



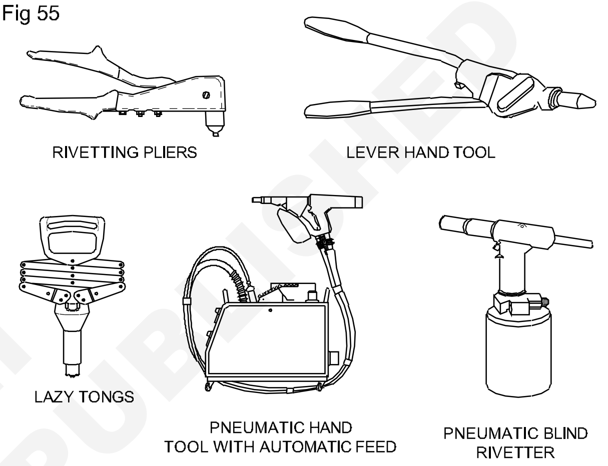
HOLLOW PUNCH

Fig 54



TINNER'S HAND PUNCH

Fig 55



BLIND RIVETTING EQUIPMENT

Fig 56

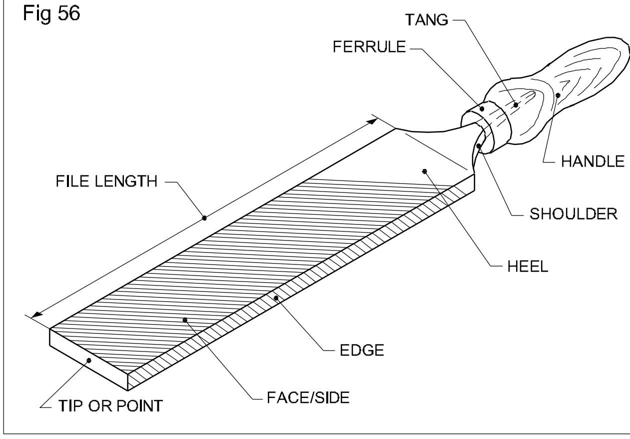


Fig 57

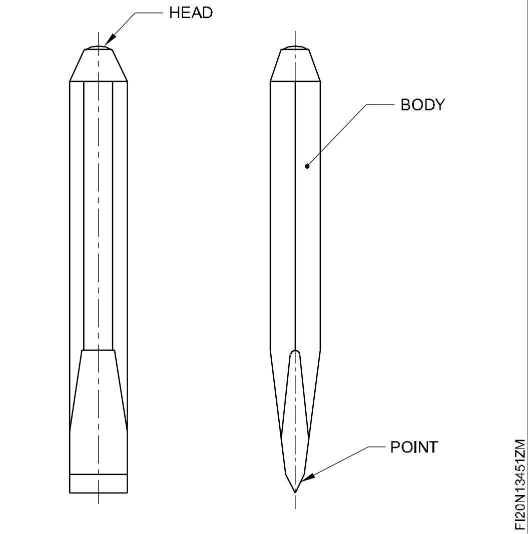


Fig 58

Fig 59

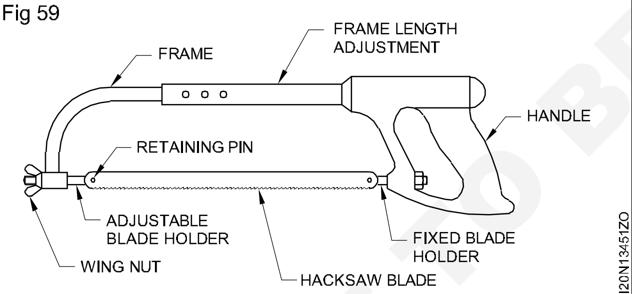
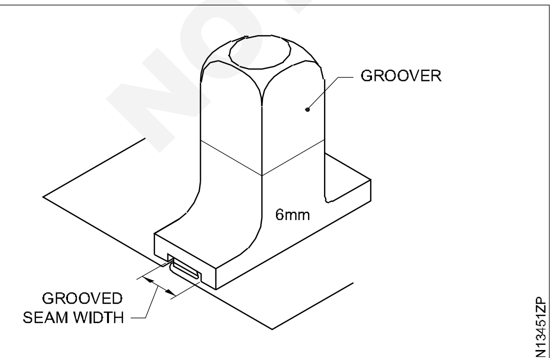


Fig 60



SIZE OF GROOVE & SEAM

Fig 61

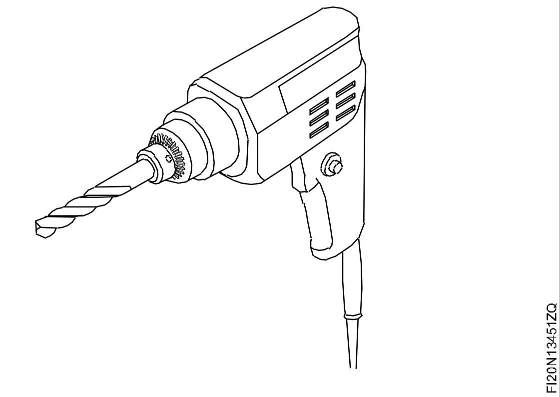


Fig 62

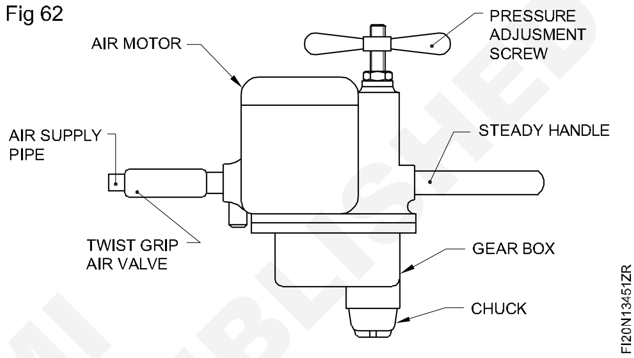
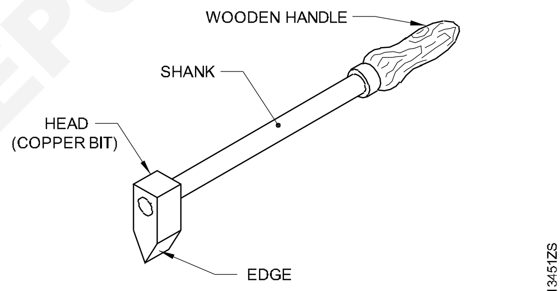
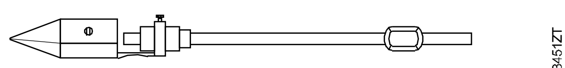


Fig 63



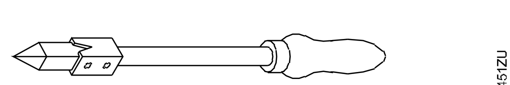
SOLDERING IRON (HATCHET TYPE)

Fig 64



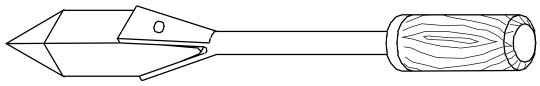
GAS HEATED SOLDERING COPPER BIT

Fig 65



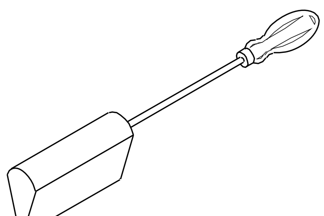
STRAIGHT SOLDERING COPPER WITH HANDLE

Fig 66



ADJUSTABLE SOLDERING BIT

Fig 67



HANDY SOLDERING COPPER BIT

Fig 68

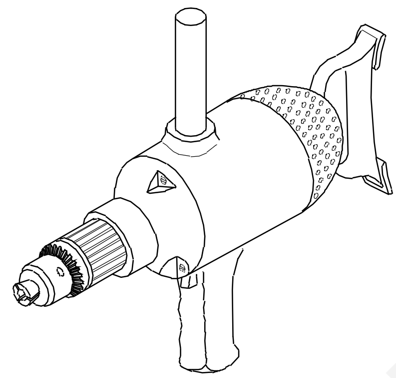
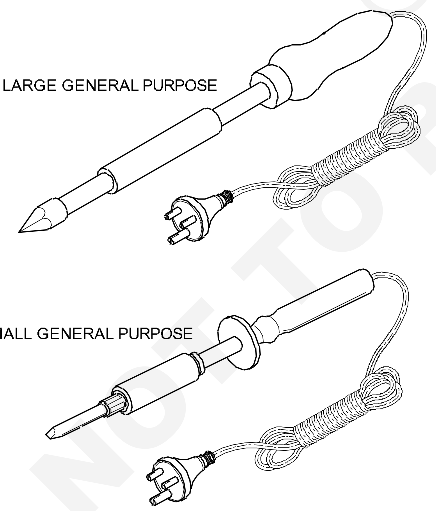
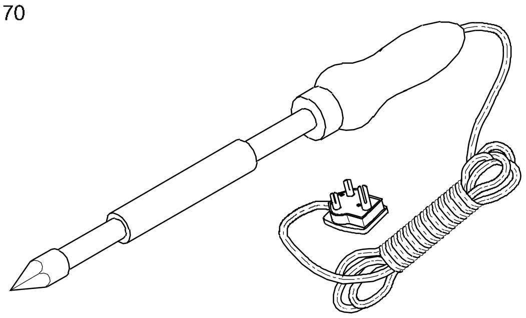


Fig 69



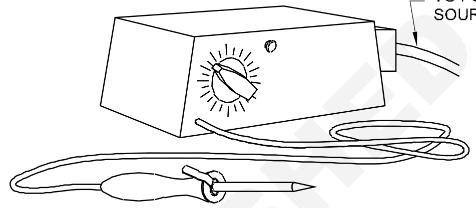
SELECT THE APPROPRIATE SOLDERING IRON

Fig 70



ELECTRIC COPPER SOLDERING

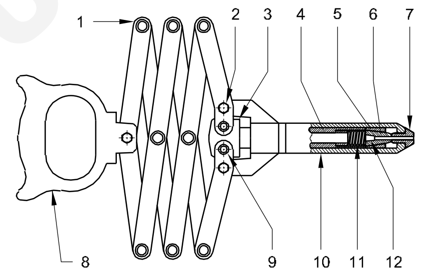
Fig 71



TRANSFORMER TYPE ELECTRIC SOLDERING IRON

Machines and appliances tools

Fig 72



PARTS LIST OF LAZY TONG

NO.	DESCRIPTION	QTY.
1	LINKAGES	1 SET
2	LOCK NUT	2
3	YOKE	1
4	POWER COUPLING	1
5	JAW CASE	1
6	JAWS	1 SET
7	NOSE PIECE	1
8	HANDLE	1
9	FULCRUM PINS	2
10	BODY	1
11	JAW PUSHER SPRING	1
12	JAW PUSHER	1

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Fig 73

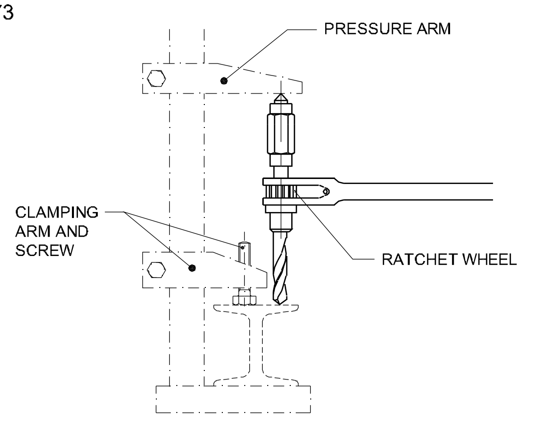
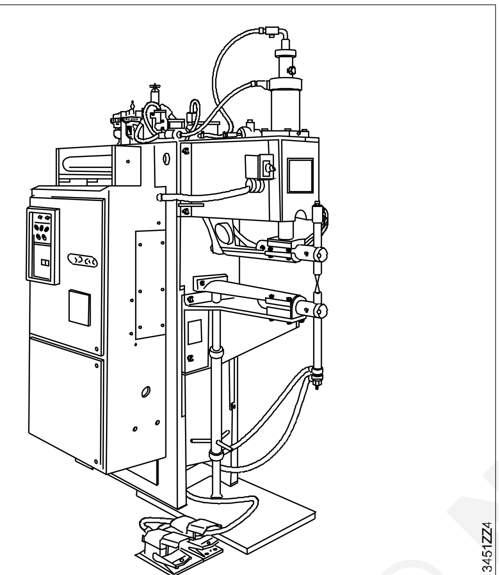
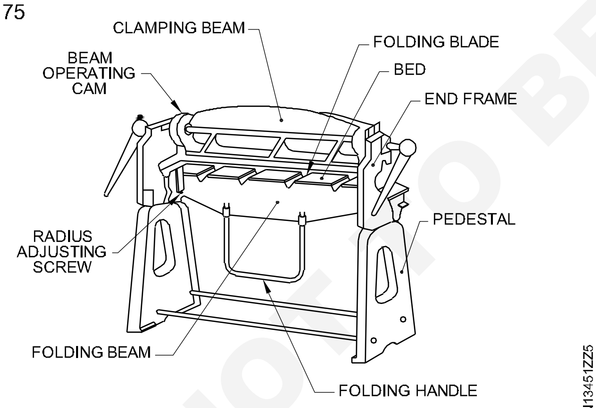


Fig 74



PEDESTAL TYPE SPOT WELDER

Fig 75



BAR FOLDER

Fig 76

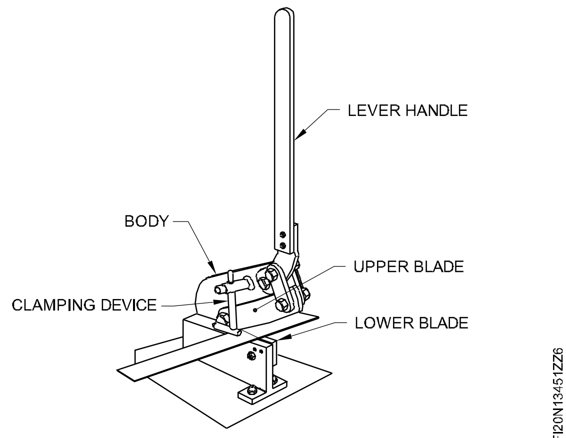


Fig 77

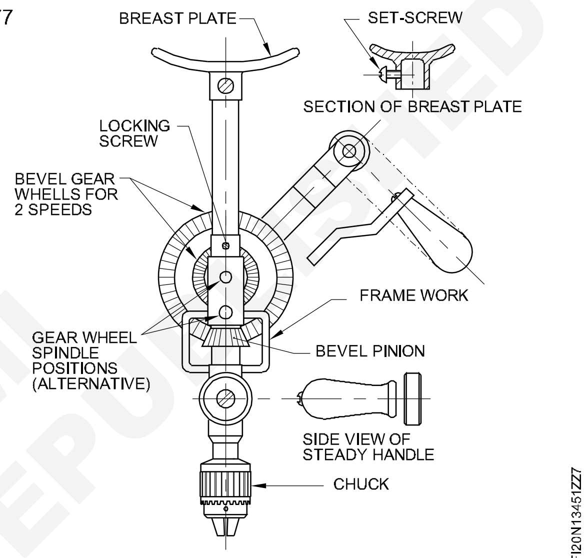
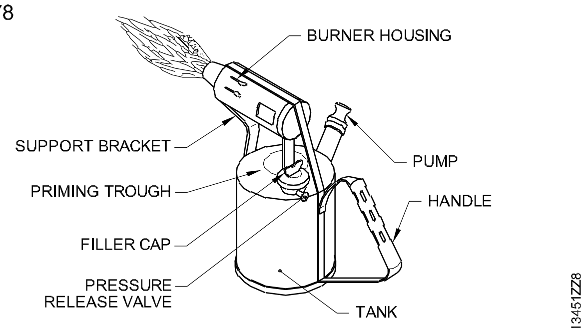
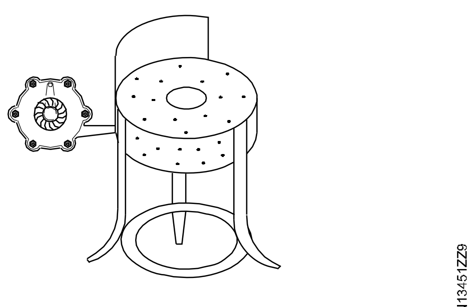


Fig 78



BLOW LAMP

Fig 79



HAND FORGE

Standard wire gauge

Objectives: At the end of this lesson you shall be able to
- **state the use of the standard wire gauge**
- **state some important hints in using standard wire gauge**
- **state the metal thickness in mm for the given gauge numbers.**

The job drawing indicate only gauge or thickness of the sheet to be used. Before starting the work identify the correct thickness of the sheet. The thickness of the sheet is measured with the help of the standard wire gauge.

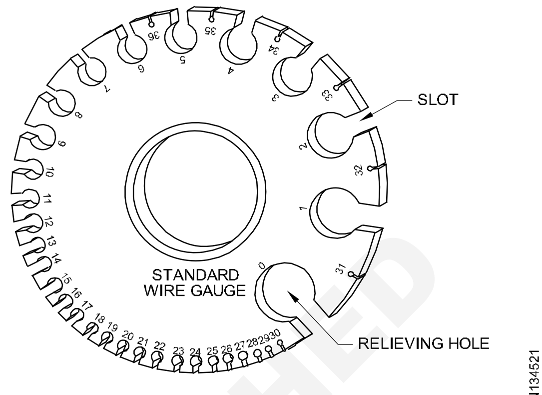
The gauge consist of a disc shape smoothened steel metal piece with numerous slots around the outside edge. These slots are of various width and correspond to certain gauge number. (Fig 1)

Gauge number is stamped on one side of each slot and on the other side, the decimal part of an inch is stamped to show the thickness of the sheet and the diameter of the wire.

Thickness of the sheet is checked by inserting the edge of the sheet in the appropriate slot of the standard wire gauge.

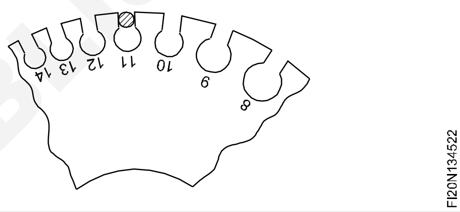
Wire diameter is checked by inserting the wire only in the slot, and not in the circle. (Fig 2)

Fig 1



STANDARD WIRE GAUGE

Fig 2



Tinman's "L" square

Objective : At the end of this lesson you shall be able to
- **state the use of the Tinman's "L" square.**

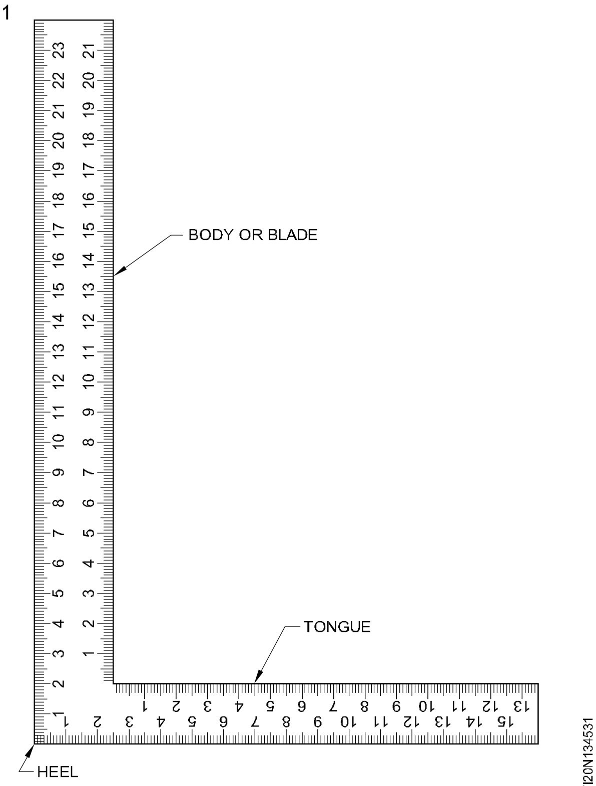
A Tinman's "L" square is an "L" shaped piece of hardened steel with graduation marks on the edges of the Tongue and Body or blade (Fig.1). It is used for marking in the perpendicular direction to any base line and to check the perpendicularity.

The short arm of the "L" square is called the tongue and the long arm is called the body or blade and the corner is called the heel. The angle between the tongue and the body of the "L" square is 90°.

The size of the "L" square is specified by the length of the body and the tongue.

It is also called as Tinman's square.

Fig 1



Straight edge

Objectives: At the end of this lesson you shall be able to
- **state the uses of straight edge**
- **list the types of straight edge.**

Straight edge: Straight edge is a flat bar of steel.

It is used to mark straight lines on a sheet metal surface.

Types (Fig 1)

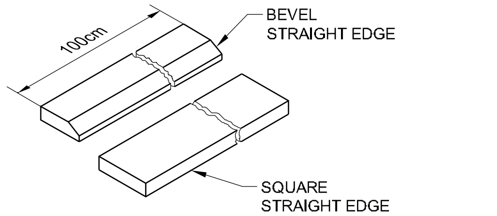
Straight edges are available in two types.

1 Square straight edges

2 Bevel straight edge.

Straight edges are available in 600 mm, 1 to 3 mtrs in length. While marking with the help of a straight edge, place the straight edge on the sheet and hold it by your left hand.

Fig 1



Scriber/Scratch awl

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

In layout work, it is necessary to scribe lines to indicate the dimensions of the workpiece to be cut or folded.

It is made out of high carbon steel about 3 to 5 mm dia. for drawing clear lines on sheet metal, working point is ground at one end angle of 10° to 20°. Scriber working point is hardened and tempered.

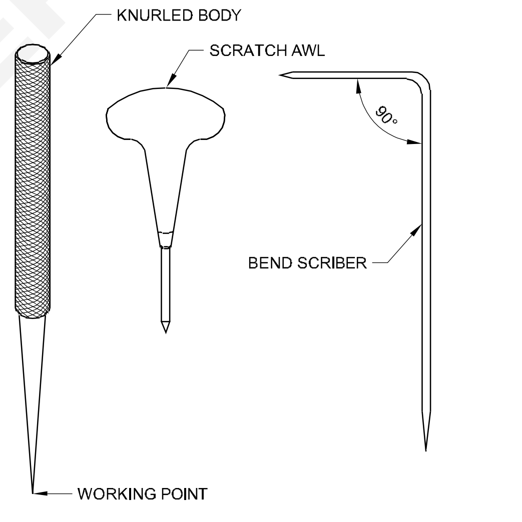
Scribers are available in different types and sizes.

Types of scribers (Fig 1)

- Straight scriber
- Bend scriber
- Scratch AWL

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.

Fig 1



Types of marking punches

Objectives: At the end of this lesson you shall be able to
- **state the different punches used in marking**
- **state the feature of each punch and its uses.**

Punches are used in order to make certain dimensional features of the layout permanent. There are three types of punches. They are

– Centre punch

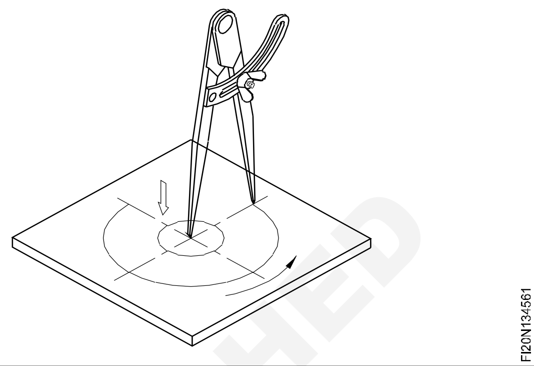
– Prick punch

– Dot punch.

Centre punch: The angle of the point is 90^0 in a centre punch. The punch mark made by this is wide and not very deep. This punch is used for locating holes. The wide punch mark gives a good seating for starting the drill. (Fig 1)

Prick punch: The angle of the prick punch is 30^0. This punch is used for making light punch marks needed to position dividers and trammels. The divider leg will get a proper seating in the punch mark. (Fig 2)

Fig 1



Dot punch: The angle of punch is 60°. It is also known as prick punch. This punch is used for witness marking.

Wing compass

Objectives: At the end of this lesson you shall be able to
- **Name the parts of a wing compass**
- **state the uses of the wing compass**
- **state the specification of the wing compass**
- **state some important hints on the wing compass**
- **state the uses of a trammel beam.**

Wing compass is used for scribing circles, arcs and for transforming and stepping off distances. (Fig 1,2 and 3)

Compasses are available with (A) Firm joints (B) Wing (C) Spring joints and (D) Beam Compass or Trammel. (Fig 4)

The measurements are set on the wing compass with a steel rule.

The sizes of a wing compass range between 50 mm to 200 mm. The distance from the point to the centre of the rivet is the size of the wing compass. (Fig 5)

For the correct location and seating of the wing compass legs, 60^0 dot punch mark is indented. (Fig 6)

The beam compass (or) Trammel is used to scribe a circle or an arc with a large diameter which cannot be scribed by a wing compass. (Fig 7)

Fig 1

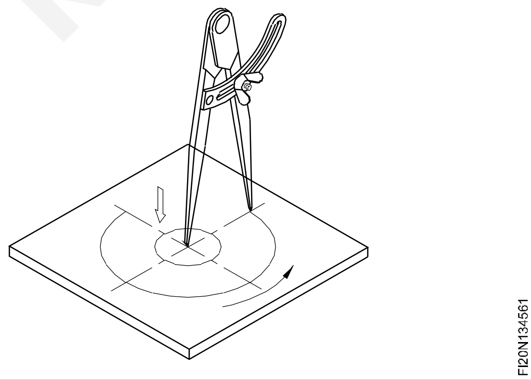


Fig 2

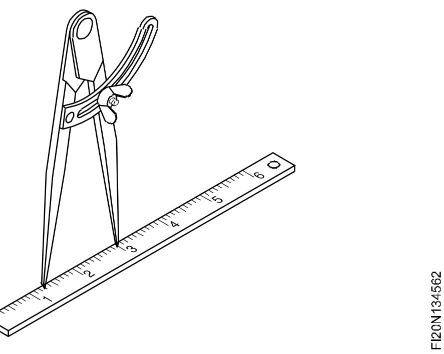
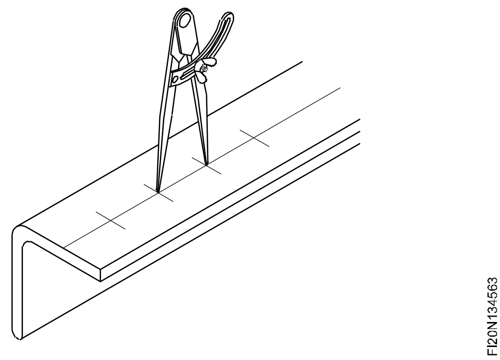


Fig 3



Parts of the wing compass are shown in Fig 8.

The two legs of the compass should always be equal in length. (Fig 9)

Compass are specified by the type of the joints and length. When using spring type wing compass the measurement once taken will not vary while marking.

The compass point should be kept sharp, in order to produce fine lines. Frequent sharpening with an oilstone is better than sharpening by grinding. (Fig 10) Sharpening by grinding will make the points soft.

Fig 4

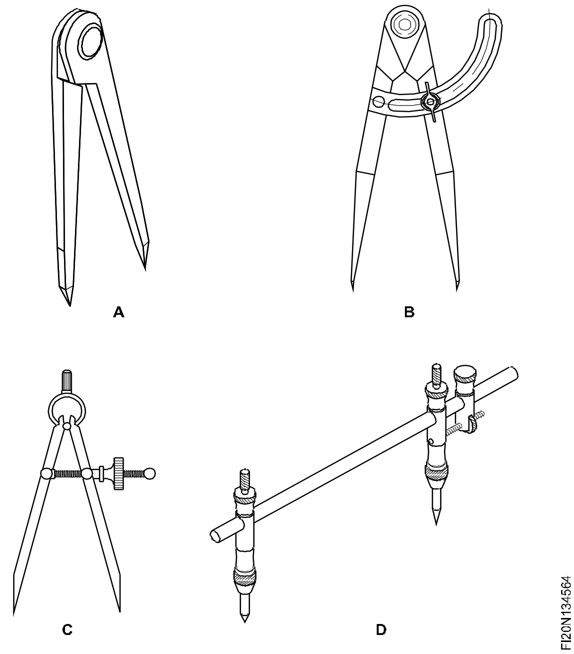


Fig 5

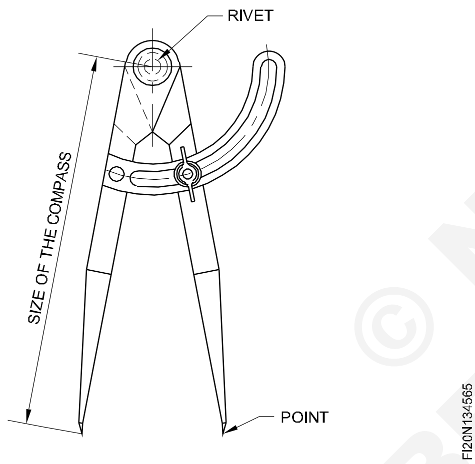


Fig 6

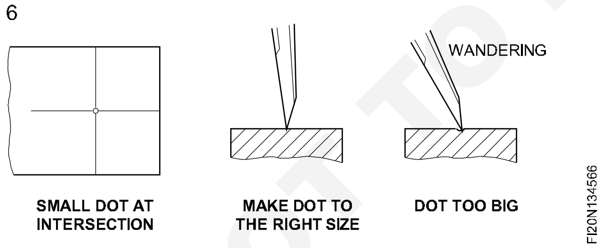


Fig 7

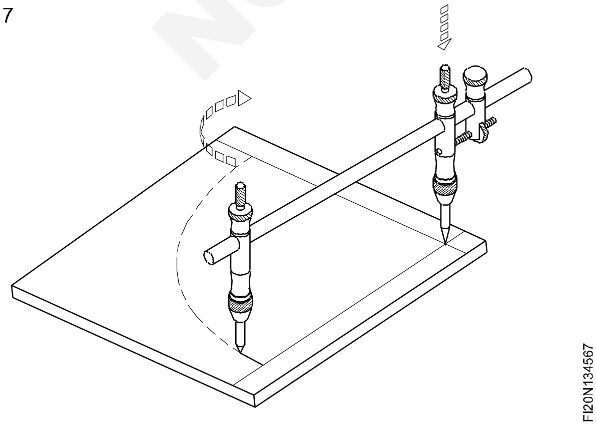


Fig 8

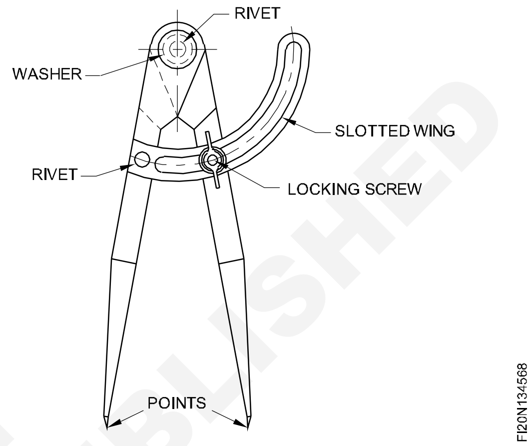


Fig 9

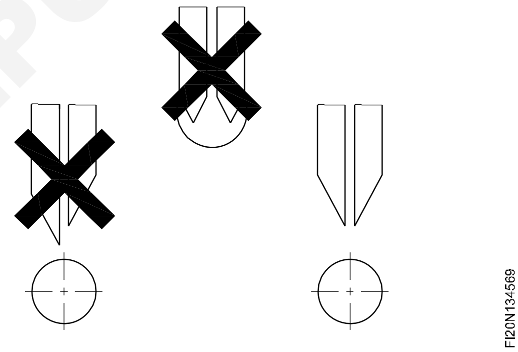
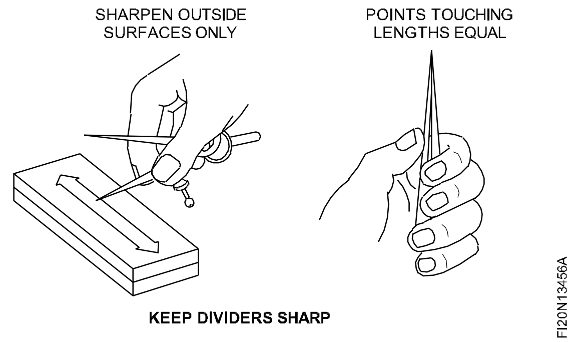


Fig 10



Straight snips

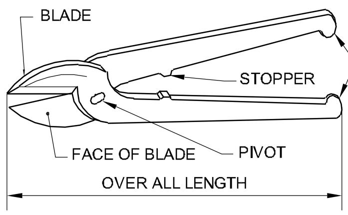
Objectives: At the end of this lesson you shall be able to
- **state the uses of straight snips**
- **state the parts of straight snips**
- **state care and maintenance.**

A snip is also called a hand shear. It is used like a pair of scissors to cut thin soft metal sheets. Snips are used to cut sheet metal upto 20 S.W.G.

Uses of straight snips: The straight snips are used to cut sheet metal along straight lines and outer sides of curves.

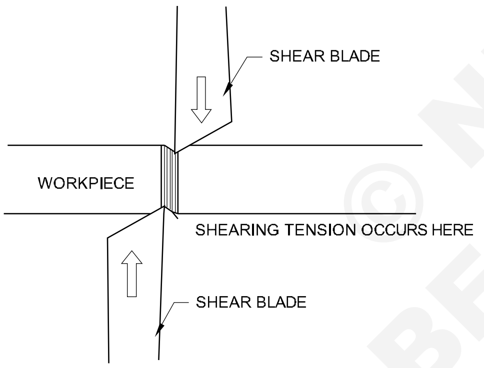
Parts of straight snips are shown in Fig 1.

Fig 1



While cutting a sheet metal, blades are pressed against the sheet, which causes shearing tension from both sides as shown in Fig 2 and the cutting action takes place.

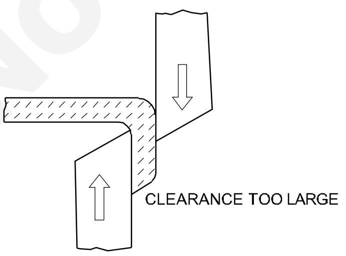
Fig 2



Cutting edge of the blade and clearance: Clearance between the blades should be free but without gap. For straight snips, cutting angle is 87°.

If the clearance is too large it cause unclean cut, chamfered and jamming of workpiece as shown in Fig 3.

Fig 3



Types: There are two types of snips

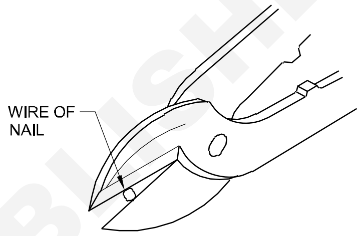
1 Straight snip

2 Bent snip

Specification: Snips are specified by its overall length and the shape of the blade. (snips are available in 150 mm, 200mm, 300 and 400 mm overall length) Ex.200 mm, straight snips.

Safety: Avoid cutting wires and nails, if so the cutting edge of the blade becomes damaged (Fig 4).

Fig 4



Avoid cutting hard sheet metal, if so the blade becomes blunt.

Due to wear and tear, the cutting edge of the blades becomes blunt. To resharpen the blade, the cutting angle alone should be ground to an angle of 87° (Fig 5) and should not grind the face of the cutting side of the blade. (Fig 6)

Fig 5

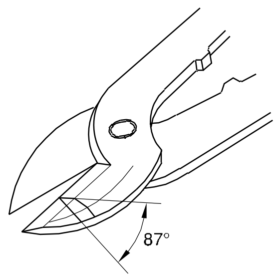
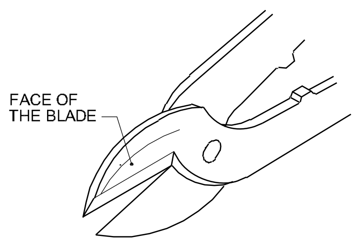


Fig 6

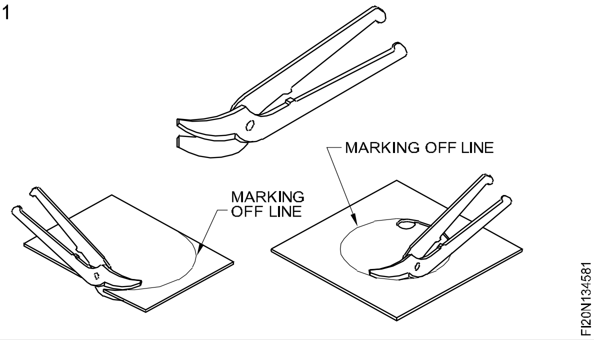


Bend snips

Objectives: At the end of this lesson you shall be able to
- **state the use of the bend snips**
- **state the parts of the bend snips**
- **state the specification of the bend snips**
- **state types of shears and their application.**

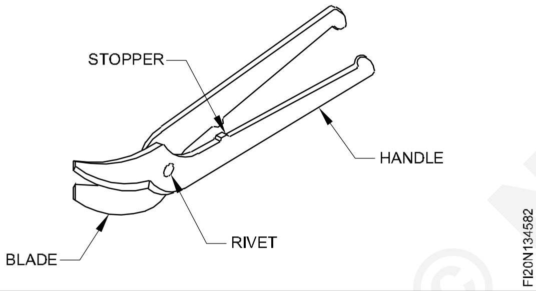
The bend snips are used to cut the inside curved lines and for trimming curved edges as shown in (Fig 1).

Fig 1



Parts of the bend snips are shown in fig 2. The blades of the bend snips are curved. (Fig 2)

Fig 2



Specification: Bend snips are specified by their overall length. Bend snips are available in 150, 200, 300 and 400 mm length.

Type of shears

1 Tinman's shears is sometimes called straight shears.

2 Universal combination shears or Gilbow shears.

3 Pipe shears

4 Scotch shears

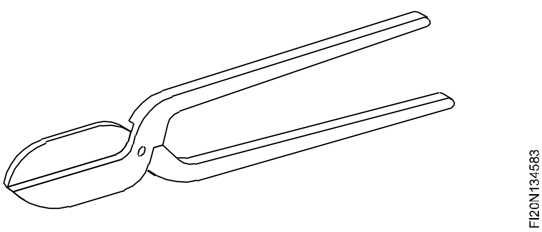
5 Block shears

6 Rhodes shears

Uses

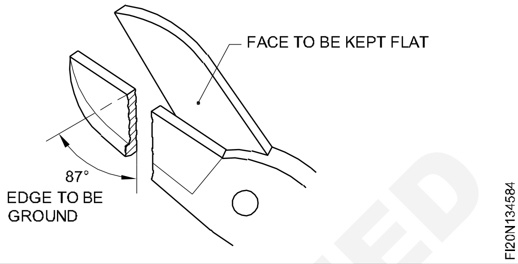
Tinman's shears (Fig.3): It is used for making straight cuts and large external curves upto the thickness of 18 SWG. Cutting angle of a shears is 87°. The cross sectional view of the cutting blades is shown in Fig 3. Never grind the face of the blade.

Fig 3



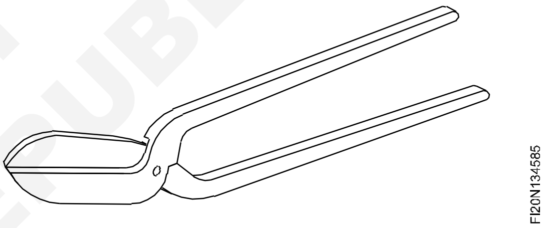
Universal combination shears or Gilbow shears (Fig 4)

Fig 4



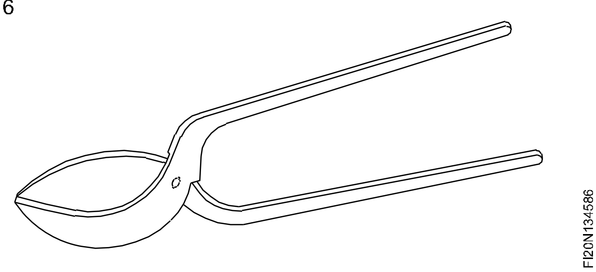
Its blades are designed for universal cutting, straight line or internal and external cutting of curves may be right hand or left hand, easily identifiable as the top blade is either on the right or the left. (Fig 5)

Fig 5



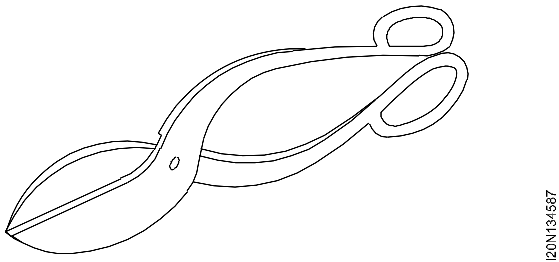
Pipe shears (Fig.6): It is applied as bend shears in all cases. Particularly it is used to time the edges of the pipes.

Fig 6



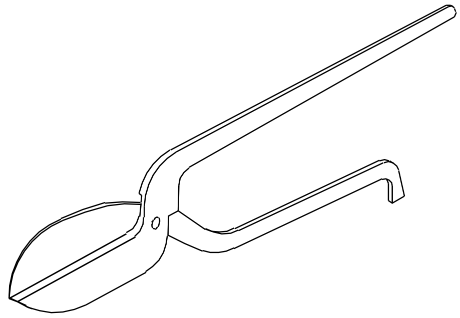
Scotch shears (Fig.7): It is a shape as shown in the fig.9 its handles are formed as eye holes to give extra grip to the hands. It is also used as Tinman's shears.

Fig 7



Block shears (Fig.8): One of the handle of the shear is bent downwards as shown in the figure. The bending portion should be fixed on the iron plates hole and the upper handle will be held by the worker. It is used in mass production purposes.

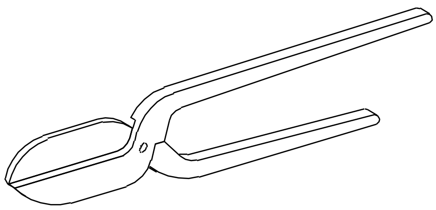
Fig 8



FI20N134588

Rohdes shears: Its one handle is shorter in length as compared with the other handle as shown in Fig.9.

Fig 9



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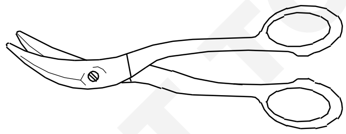
The short handle is to be pressed by the right leg of the worker and the other handle should be held by the right hand. It is used to cut lengthy sheets.

Shearing force: To produce the maximum cutting force, the hand must be kept far from the rivet and the metal being cut must be kept close to the rivet.

Hawk billed shears (Fig.10)**:** It is used for the inside cutting of an intricate work. The snips have narrow curved blades that allow you to make sharp turns without bending the metal.

Fig 10



HAWK-BILLED SHEAR

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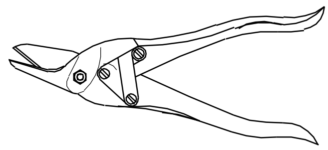
Aviation shears (Fig.11)**:** It can be used for all kinds of cutting. These are made with left, right or universal cutting blades.

Fig 11



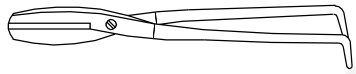
AVIATION SHEAR

FI20N13458B

Bench shears (Fig.12)**:** These are designed to have one handle held in a vice or bench plate, while the other handle is moved up and down.

They can cut 16 gauge to 18 gauge thickness sheet metal.

Fig 12

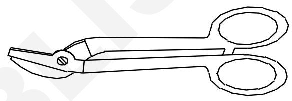


BENCH SHEAR

FI20N13458C

Double cutting shears (Fig.13)**:** These shears have three blades used to cut around cylindrical objects, such as cans and pipes. A single blade is pushed through the metal to sheet to cut.

Fig 13



DOUBLE CUTTING SHEAR

FI20N13458D

Electric portable shear (Fig.14)**:** Electric shears are used to cut corrugated metal sheets or a sheet metal of 18 gauge thickness or lighter sheet metals.

The shear point can be inserted with a light hammer blow. Successive blows will drive the shear on a scribed line for almost any shape like inner circles, zig zag, curvature line easily. A strip of metal about 3"/32 (2.5 mm) wide is removed in this shearing operations.

Fig 14

FI20N13458E

Sheet metal mallets & hammers

Objectives: At the end of this lesson you shall be able to
- **state the different types of mallets**
- **state the uses of mallets**
- **state the care and maintenance.**

Mallet is a shaping tool used for general purpose work like flattening, bending and forming to required shape of sheet metal.

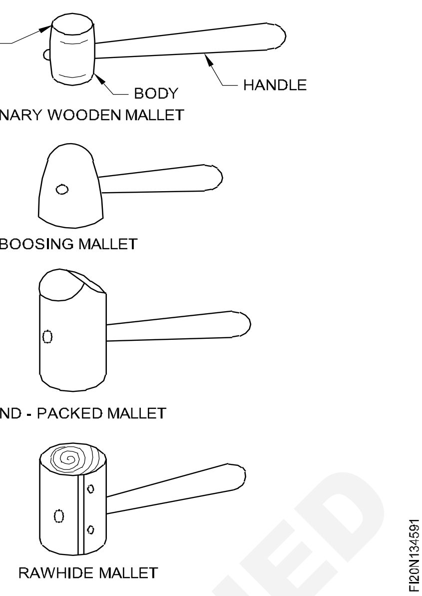
These are made of hard wood

When using any metal hammer for flattening the sheet metal, the face of the hammer may damage or leave impression on the sheet more than what is required for the job. To avoid such damage and a impression, mallets are used.

Types (Fig 1)

- Ordinary mallet
- Bossing mallet
- End-faked mallet
- Raw hide mallet.

Fig 1



Ordinary mallet: Both the faces of the mallets are provided the little convexity. If the face is not in convex shape the edges of the mallet face will get frozen while beating the job.

Mallets are specified by the dia and the shape of the face. Mallets are available in 50 mm, 75 mm and 100 mm dia.

Avoid using the mallet as hammer for doing chipping and to drive nails and work on the sharp corners.

If so the face will get damaged and the mallet is liable to break.

Sheet metal hammers

Objectives: At the end of this lesson you shall be able to
- **state the names of sheet metal hammers**
- **state the constructional features of sheet metal hammers**
- **state the uses of sheet metal hammers**
- **specify the sheet metal hammers**
- **state safety precautions while using the hammers.**

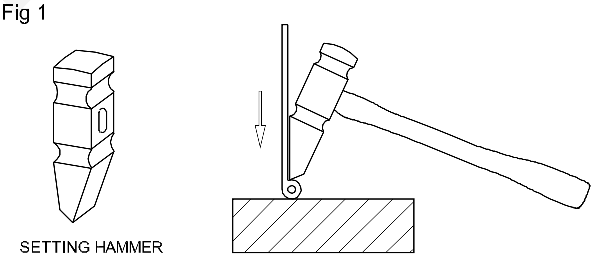
In the previous lessons, you learned about the Engineering hammers such as Ball pane hammer, cross pane hammer and straight pane hammer. Apart from these, there are some special type of hammers used in sheet metal trade, which are called sheet metal hammers.

They are

1 Setting hammer
2 Riveting hammer
3 Creasing hammer
4 Stretching hammer
5 Hollowing hammer
6 Bullet hammer
7 Plaiting hammer
8 Peening hammer

Setting hammer: Its face is either round or square in shape. Its pane is tapered from the eye hole and the other side is straight to the handle. The tip of the pane is rectangular in shape, and slightly convexed. It is used to set up the seams, flaring the edge of the cylindrical jobs and to set up the long channel also. Its face is used for general purposes. (Fig 1)

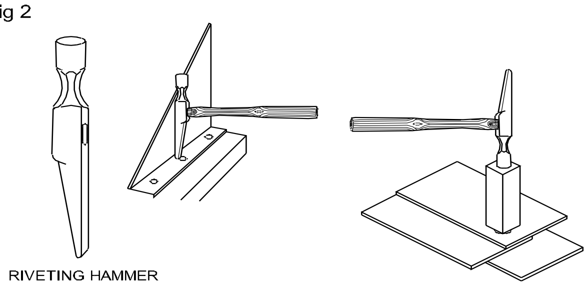
Fig 1



Riveting hammer: Riveting hammer's face is round in shape and the face is slightly convex. Its pane is long tapered and straight to the handle vertically. The tip of the pane is blended.

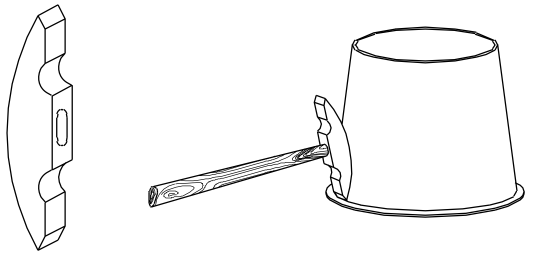
Riveting hammer is used to jump the rivet shanks and finish the rivet heads. (Fig 2)

Fig 2



Creasing hammer: Its both ends are sharpened and cross to the handle. It is used to finish the wired edges, false wiring edge and make corners of the sheet with the help of a creasing stake. (Fig 3)

Fig 3

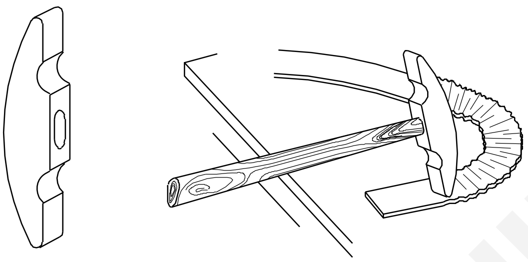


CREASING HAMMER

Stretching hammer: Its shape is like a creasing hammer but its pane ends are blended.

It is used to stretch the sheets to increase the length of the sheet. It is mostly used in raising operation. (Fig 4)

Fig 4

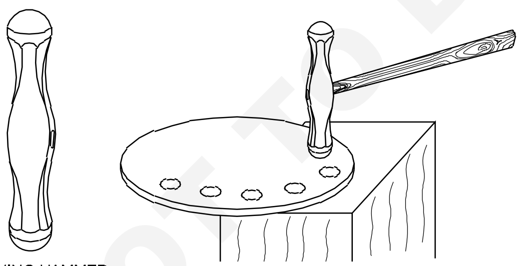


STRETCHING HAMMER

Hollowing hammer: Its both ends are shaped like ball and well polished.

It is used to make hollowing operation on the metal sheet and to remove the dents from the hollowed articles. This hammer is mostly used for panel beating work. (Fig 5)

Fig 5



HOLLOWING HAMMER

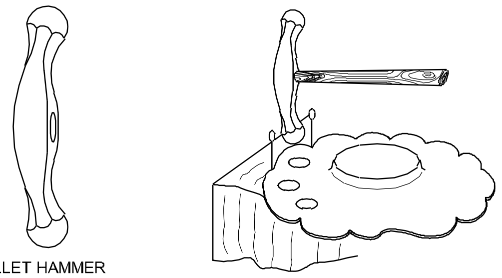
Bullet hammer: Its panes look like the hollowing hammer but the body is longer than the hollowing hammer and slightly bent. The pane ends are well polished and suitable to work on deep portion.

It is used to draw deep hollowing where the hollowing hammer cannot be used and also it is used to remove the dents from the deep hollow portion. (Fig 6)

Planishing hammer: It's one face is square and other is round in shape and well polished. Its pane is slightly convex. This hammer is heavy in weight.

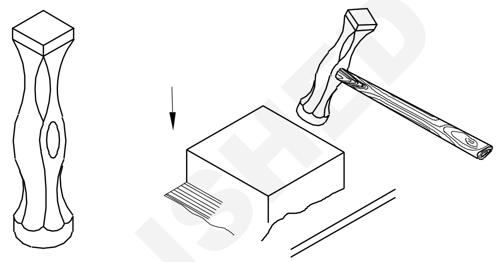
It is used to give smooth surface finish to the jobs which are hollowed and raised, and to planish the surface of the plain sheets. (Fig 7)

Fig 6



BULLET HAMMER

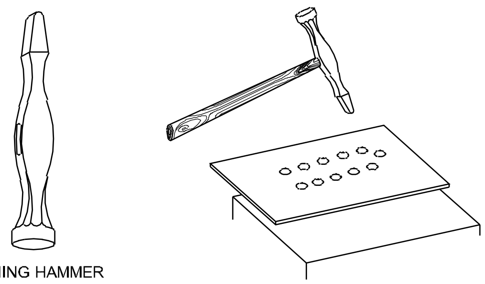
Fig 7



PLANISHING HAMMER

Peening hammer: It's face is round and slightly convex and a pane is just like stretching hammer. This hammer is used to peen polished impressions on the spinned aluminium job and hollowed copper, brass house hold vessels. (Fig 8)

Fig 8



PEENING HAMMER

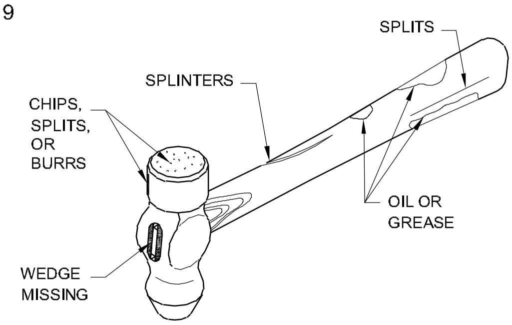
Specification: The sheet metal hammers are specified by the Type of pane and the weight of the hammer.

Example

1 Planishing hammer

Safety precautions (Fig 9)

Fig 9



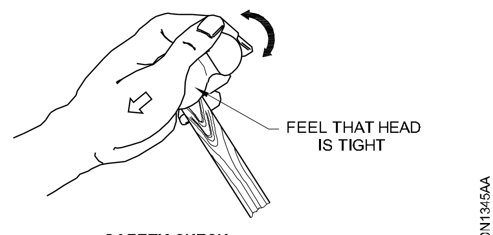
DO NOT USE HAMMERS WITH ANY OF THESE FAULTS

– Always handle and face of the hammers should be free from oil and grease.

– Face of the hammers should be free from scratches, dents, splits, burrs, chips etc.

– The handle should be securely fitted to the head. The wedge should be tight. (Fig 10)

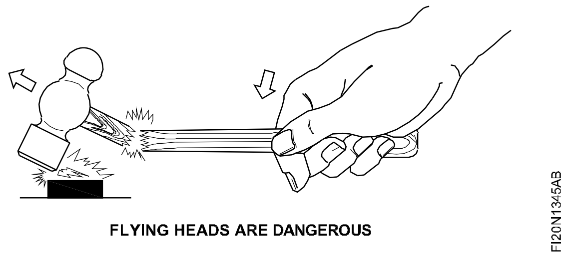
Fig 10



SAFETY CHECK

– Hammers fitted with broken, cracked, splinted handles should not be used. Replace the handles immediately. (Fig 11)

Fig 11



FLYING HEADS ARE DANGEROUS

– Heads flying from poorly fitted or broken handle can cause serious injuries.

– Always use a piece of soft metal between the hammer and the hard steel.

– Never hit two hammer faces together because the faces would split and the chips would fly dangerously.

– Select the right hammer for that particular job.

Soldering iron (soldering bit)

Objectives: At the end of this lesson you shall be able to
- **state the purpose of soldering iron**
- **describe constructional features of soldering iron**
- **state different types of copper bits and their uses.**

Soldering iron: The soldering iron is used to melt the solder and heat metal that are joined together.

Soldering irons are normally made of copper or copper alloys. So they are also called as copper bits.

Copper is the preferred material for soldering bit because

– it is a very good conductor of heat

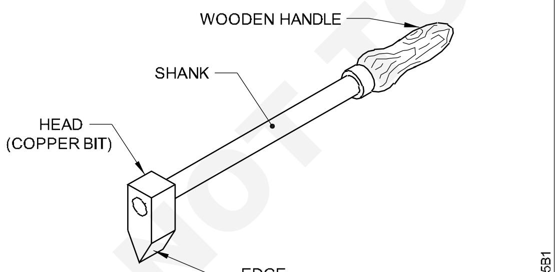
– it has affinity for tin lead alloy

– it is easy to maintain in serviceable condition

– it can be easily forged to the required shape.

A soldering iron has the following parts. (Fig 1)

Fig 1



SOLDERING IRON (HATCHET TYPE)

– Head (copper bit)

– Shank

– Wooden handle

– Edge

SOLDERING COPPER BIT

Types of soldering copper bits: There are 7 types of soldering copper bits in general use,

They are

– The pointed soldering copper bit.

– The electric soldering copper bit.

– The gas heated soldering copper bit.

– Straight soldering copper bit.

– Hatchet soldering copper bit.

– Adjustable copper bit.

– Handy soldering copper bit.

The bits of soldering irons are made in various shapes and sizes to suit the particular job. They should be large enough to carry adequate heat to avoid too frequent reheating and not too heavy to be awkward to manipulate.

Soldering bits are specified by the weight of the copper head. For general soldering process, the shape of the head is a square pyramid but for repetition, or awkward placed joints, other shapes are designated.

Point soldering copper bit: This is also called a square pointed soldering iron. The edge is shaped to an angle on four sides to form a pyramid. This is used for tacking and soldering. (Fig 2)

Electric soldering copper bit: The bit of the electric soldering iron is heated by an element. This type is preferred, if current is available because it maintains uniform heat. Electric soldering irons are available for different voltages and are usually supplied with a number of interchangeable tips. They can be made quite small and are generally used on electrical or radio assembly work. (Fig 3)

Fig 2

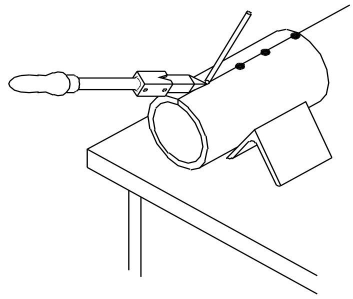
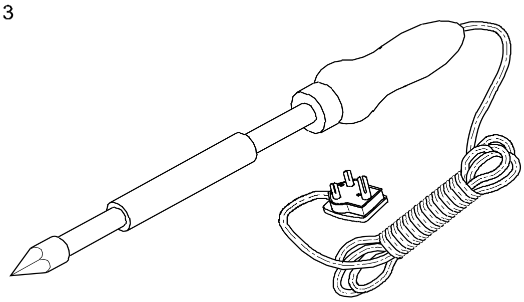


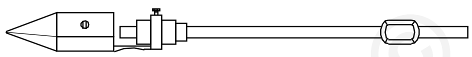
Fig 3



ELECTRIC COPPER SOLDERING

Gas heated soldering copper bit: A gas heated soldering copper bit is heated by a gas flame which impinges on the back of the head. High pressure gas is used and the bits is large enough to have a good heat storage capacity. Liquified petroleum gas (LPG) flame is used extensively for this purpose. Soldering kit normally includes many sizes and shapes of bits which can be used to make most kinds of soldering connections. (Fig 4)

Fig 4

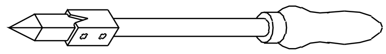


GAS HEATED SOLDERING COPPER BIT

Straight soldering copper bit: This type of soldering iron is suitable for soldering the inside bottom of a round job. (Fig 5)

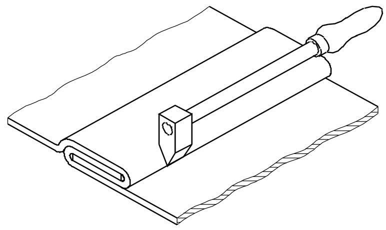
Hatchet soldering copper bit: This type of soldering iron is very much suitable for soldering on flat position lap or grooved joint outside round or square bottom. (Fig 6)

Fig 5



STRAIGHT SOLDERING COPPER WITH HANDLE

Fig 6



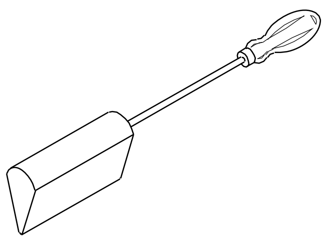
Adjustable soldering copper bit: This type of soldering iron is used for soldering where straight or hatchet bit cannot be used for soldering. Adjustable soldering bit can be adjusted in any position for soldering. (Fig 7)

Fig 7

ADJUSTABLE SOLDERING BIT

Handy soldering copper bit: It is like a hatchet type but bigger in size than the hatchet. It is used for soldering heavy gauge of metal. It should not be used for soldering on light gauges of metal because additional heat will cause the metal to buckle. (Fig 8)

Fig 8



HANDY SOLDERING COPPER BIT

Trammels

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

Beam Trammels and taper measures: Trammel set is used for striking lines at 90° to each other, and also for measuring the distances accurately. It is a usual practice for the craftsman to use a pair of trammel heads or 'trams' and any convenient beam such as a length of wooden batten. The arrangement of the trammel for fine adjustment for accurate marking out is shown in Fig 1.

The 90^0 angle lines i.e lines square with each other, may be set out, with the aid of the beam trammel set or steel tape as shown in Fig 2.

Fig 1

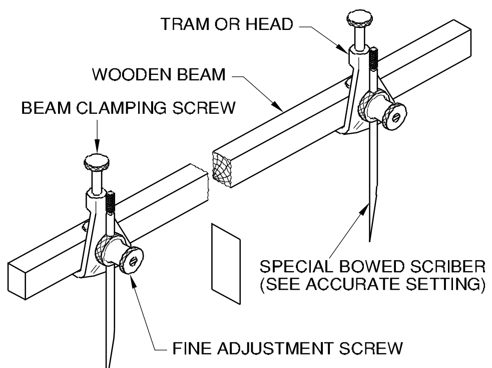
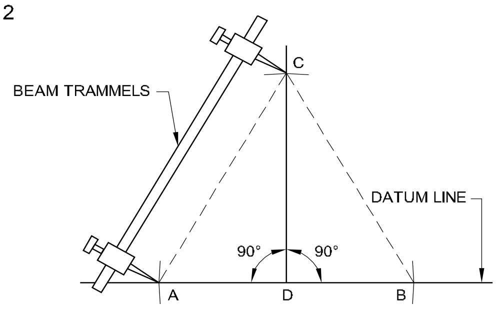


Fig 2



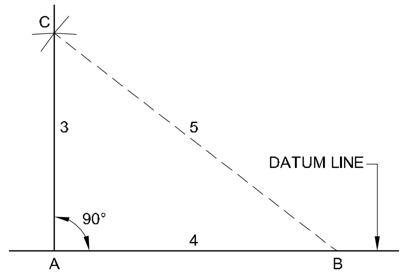
(AD = DB AND AC = CB)

USE OF TRAMMELS TO CONSTRUCT A RIGHT ANGLE

FI20N1345C2

The normal accuracy obtainable when marking out with the dividers, and the trammels is within 0.15 mm of the true dimension. Fig 3 show how the properties of a right angled triangle can be used to set out a perpendicular line by using trammel set.

Fig 3



USE OF TRAMMELS AND STEEL TAPE TO CONSTRUCT A RIGHT ANGLE.

APPLICATIONS OF BEAM TRAMMELS AND STEEL TAPE (MAKING OUT)

FI20N1345C3

Groovers

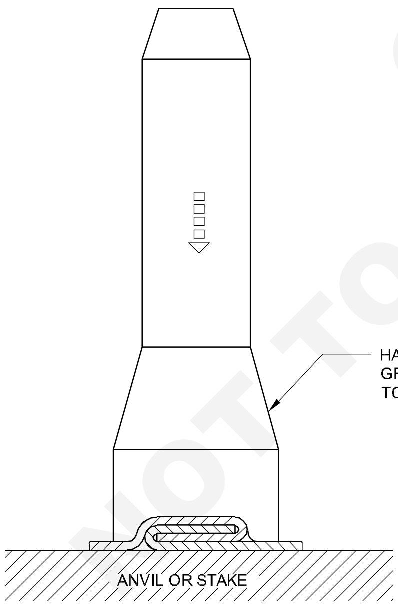
Objectives: At the end of this exercise you shall be able to
- **state what is groover**
- **state the size of the groovers**
- **state the uses and applications of groovers.**

Any seam in sheetmetal should be locked or closed property for effective functioning. Otherwise the joint will be a failure.

What is a groover?

A groover is hand tool used for closing and locking of seams in sheetmetal work. (Fig 1)

Fig 1



FI20N1345D1

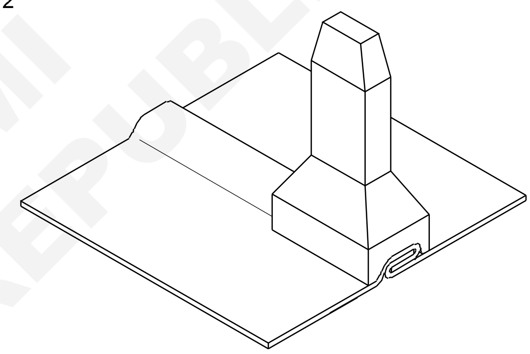
The end of the tool is recessed to fit over the lock making the grooved seams. (Fig 2)

Sizes

Groovers are available in various sizes viz. 3mm, 4mm, 5mm etc.

Generally a groover 1.5mm wider than the width of the fold is used.

Fig 2



FI20N1345D2

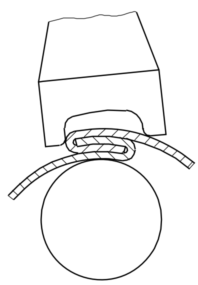
For thicker materials, a groover 3mm larger than the width of the fold is used.

The width of the groove is stamped on the tool body.

Closing and locking

First the joint is held in position and then it is closed with a mallet. (Fig 3)

Fig 3

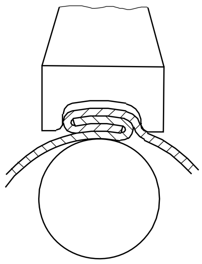


FI20N1345D3

Then the groover is placed over the closed end of the joint. The groover is positioned at a very slight angle. The edge of the joint acts as a guide to position the groover.

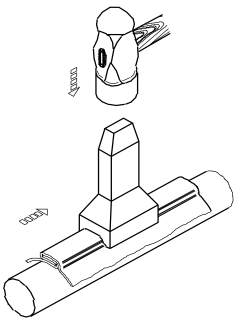
The grooving operations are repeated for the other end of the joint. (Fig 4 and 5).

Fig 4



FI20N1345D4

Fig 5



FI20N1345D5

The joint is locked working along the joint in stages.

The seam is tighter using a mallet or a light planishing hammer.

Failure to lock the joints in stages with the end of the groover will result in bite marks along the joint.

Using too small a groover will mark the metal and prevent locking.

Stakes and their uses

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

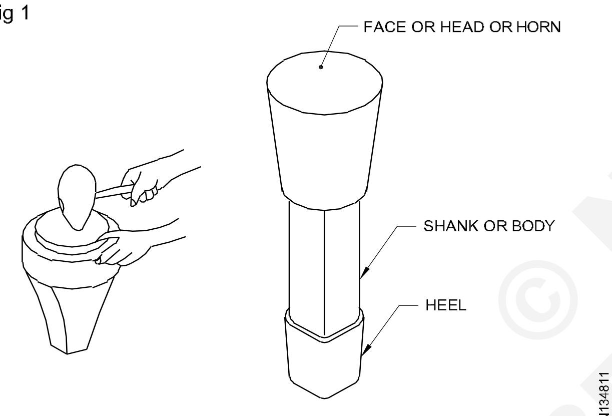
Stakes are the sheet metal workers anvils used for bending, seaming or forming. They actually work as supporting tools as well as forming tools.

Stakes are made in different shapes and sizes to suit the types of operations for which machines are not readily available or readily adaptable.

Some stakes are made of forged mild steel, faced with cast steel. The better class stakes are made either of forged steel or of cast steel.

A stake used in sheet metal working consists of a head (or) a horn. (shank or body and heel) The shanks are designed to fit into a tapered bench socket. (Fig 1)

Fig 1

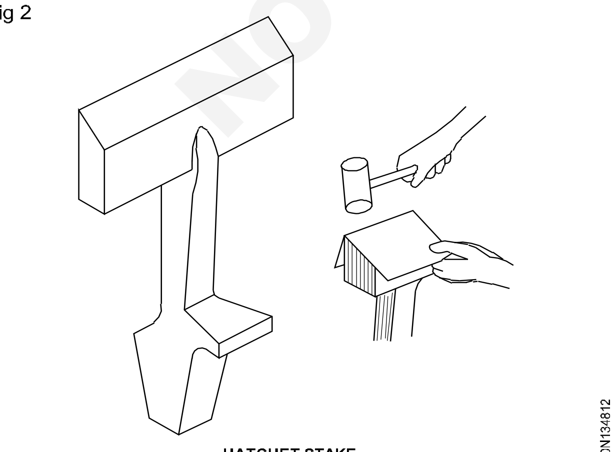


ROUND BOTTOM STAKE

Round bottom stake (Fig 1): It has a round and a concave face head. It is used for hollowing the sheet.

Hatchet stake (Fig 2): The hatchet stake has a sharp, straight edge, beveled along one side. It is very useful for making sharp bends, folding the edges of sheet metal, forming boxes and pans by hand.

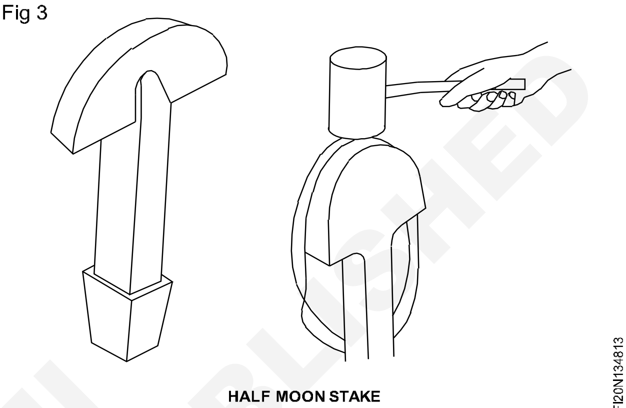
Fig 2



HATCHET STAKE

Half moon stake (Fig 3): This stake has a sharp head in the form of an arc of a circle, beveled along one side. It is used for turning up flanges on metal discs.

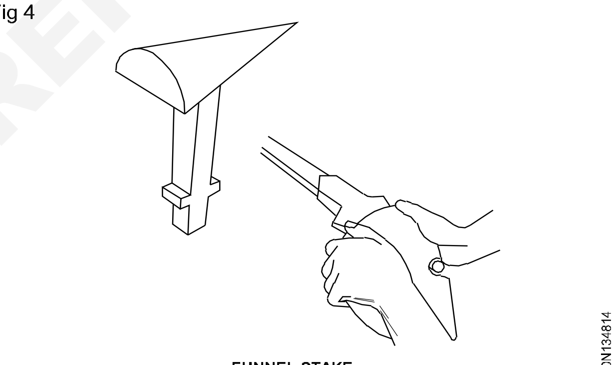
Fig 3



HALF MOON STAKE

Funnel stake (Fig 4): This stake is used when shaping and seaming funnels and tapered articles.

Fig 4



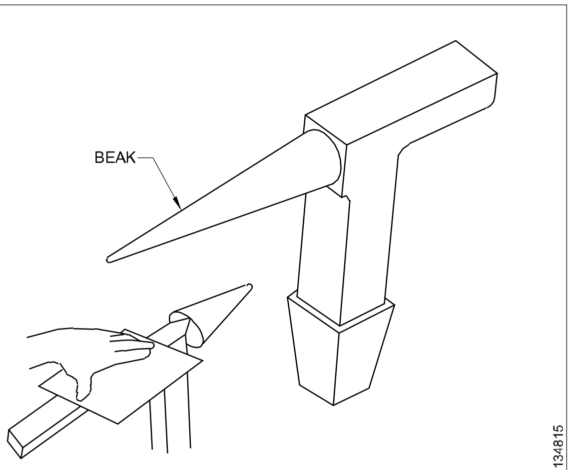
FUNNEL STAKE

Beak or Bick Iron stake (Fig 5): This stake has two horns, one of which is tapered the other is a rectangular shaped anvil. The thick tapered horn or beak is used when making spouts and sharp tapered articles. The anvil may be used for squaring corners, seaming and light riveting.

Creasing Iron (Fig 6): This stake has two rectangular shaped horns, one of which is plain. The other horn contains a series of grooving slots of various sizes. The grooves are used when 'Sinking' a bead on a straight edge of a flat sheet. This is also used when making small diameter tubes with thin gauge metal.

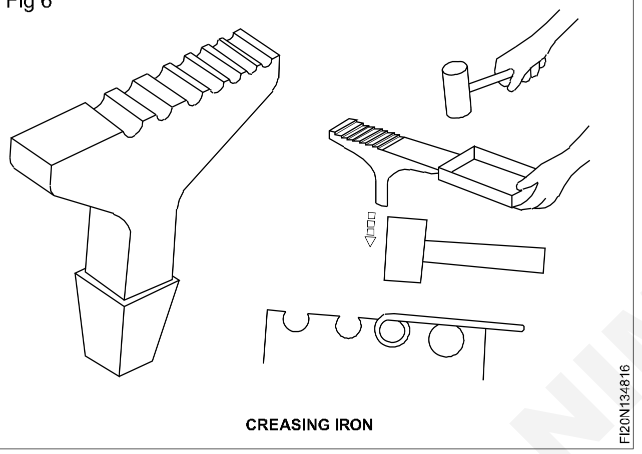
Pipe stake or Square edge stake (Fig 7): This stake has the horn and the shank. The horn is available in two types. one is with flat face as shown in (Fig 7A). Other one is with curved face as shown in (Fig 7B) Flat face horn stake is used to fold the edges, and to turn up straight edges. The

Fig 5



BEAK OR BICKIRON

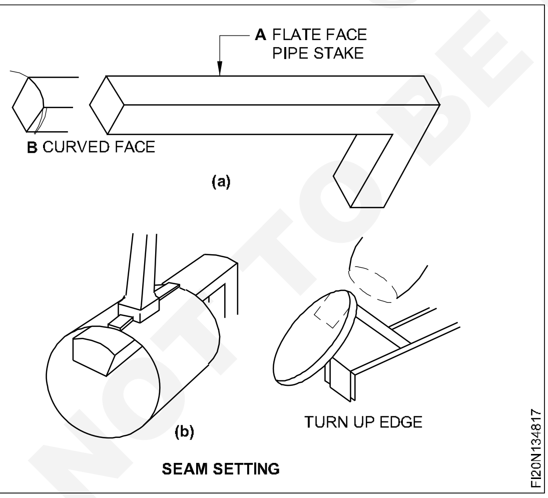
Fig 6



CREASING IRON

curved face horn stake is used to turn circular disc or curved edges and to make knocked up joints.

Fig 7

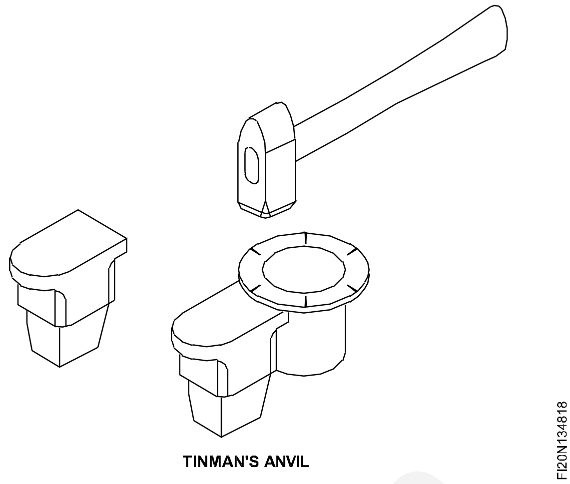


SEAM SETTING

Tinman's Anvil (Fig 8): It is used for planishing all types of flat shaped works. It is highly polished on its working surface.

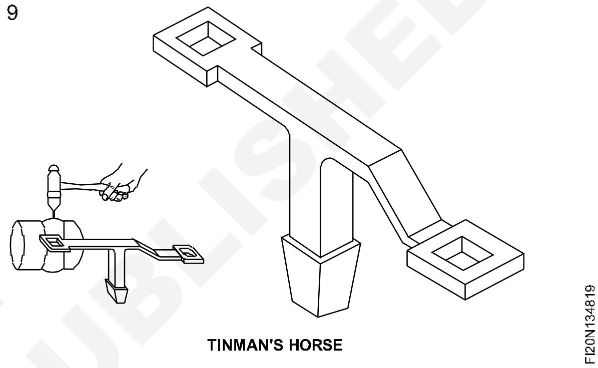
Tinman's Horse (Fig 9): This stake has two arms at its both ends, one of which is usually cranked downwards for clearance purpose. There is a square hole for the reception of a wide variety of heads. (Fig 10)

Fig 8



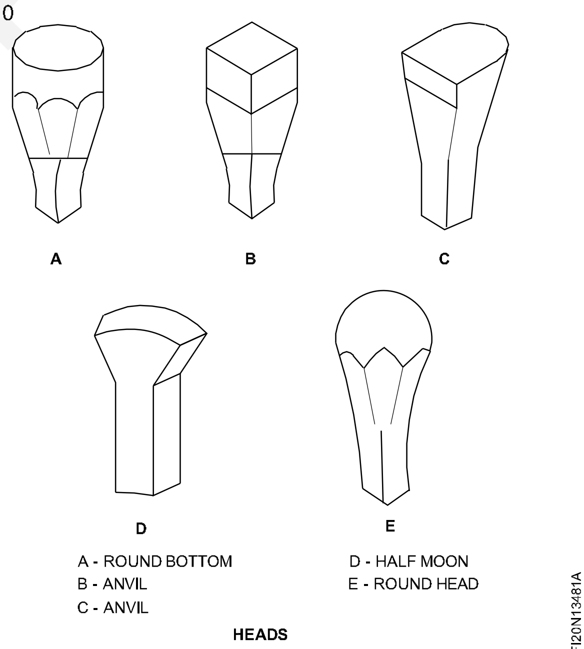
TINMAN'S ANVIL

Fig 9



TINMAN'S HORSE

Fig 10



HEADS

The surface of the stake is important for the workmanship of the finished article. Therefore, care must be taken to avoid any damage to the surface of the stake when centre punching or cutting with a cold chisel.

Apart from these stakes, special types of stakes are also available to suit different types of jobs.

Copper smith stake

Objectives: At the end of this lesson you shall be able to
- **identify a copper smith stake**
- **state the constructional features of a copper smith stake**
- **state the uses of a copper smith stake**
- **state safety, care and maintenance while using a copper smith stake.**

It is not economical to have too many stakes for simple operations in a sheet metal shop.

Hence, an economical way of tooling is adopted and designed by combining two edges of different cross sections on a common head as in Fig 1. This stake is called a copper smith stake or tinman's anvil. It is a very useful stake used in sheet metal work, due to its constructional features.

This stake is used for flattening the surfaces of the sheet metal, bending, flanging, finishing wired edges on both straight and curved edges.

These stakes are made of medium carbon steel and case hardened.

Safety care and maintenance

1 Fix the stake firmly in the bench plate or stake holder to avoid slipping and causing accidents.

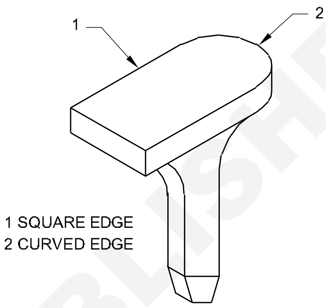
2 Do not use it for heavy work.

3 Do not spoil the surface of the stake by chiseling and punching.

4 Do not spoil the edges by cutting wire or nails on the edges of the stake.

5 Remove and keep it in its place after use.

Fig 1



Bottom round stake

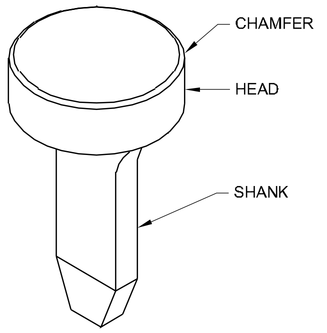
Objectives: At the end of this lesson you shall be able to
- **identify the Round Bottom Stake**
- **state the constructional features of this stake**
- **state the uses of this stake.**

Bottom round stake: This is a very common stake used in a sheet metal shop. This stake is round in shape with a flat face, slightly chamfered to avoid the cracking or tearing of sheets while using it.

It is used for turning edge on circular discs, seaming and fixing bottom to cylindrical parts, making a paned down joint at the bottom of the cylindrical parts. The tail is designed to fit in the square slot made in the work bench or stake holder.

Do not cut wires or nails on the edge of the stake. This will spoil the edge and the same impression will be formed on the sheet or the part formed on it.

Fig 1



Stake holders

Objectives: At the end of this lesson you shall be able to
- **name the different types of stake holders**
- **state the constructional features of stake holders**
- **state the uses of stake holders**
- **state safety, care and maintenance when using stake holders.**

There are three types of stake holders

1 Bench plate

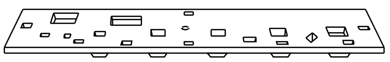
2 Revolving bench plate

3 Universal stake holder

Bench plate: Stakes are held in position while using them by means of a plate which is fastened to the work bench with bolts and nuts. These plates are called bench plates or stake holders.

These bench plates are made of cast iron and are rectangular in shape as in Fig 1. The tapered holes are conveniently arranged so that the shanks of the stakes may be fixed and used in any convenient position. The smaller holes are used to support the bench shears.

Fig 1



BENCH PLATE

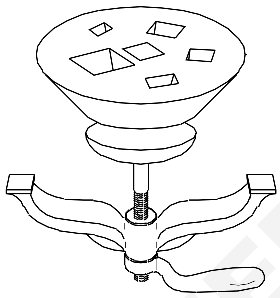
Revolving bench plate: Revolving bench plate consists of a revolving plate with tapered holes to support the shanks of the stakes while using them.

This revolving bench plate can be held in any convenient position by clamping it on to the work bench, with the clamping provision provided on it as in Fig 2.

Universal stake holder: Universal stake holder can be clamped to any desired position on the work bench. So it is preferred by most of the mechanics.

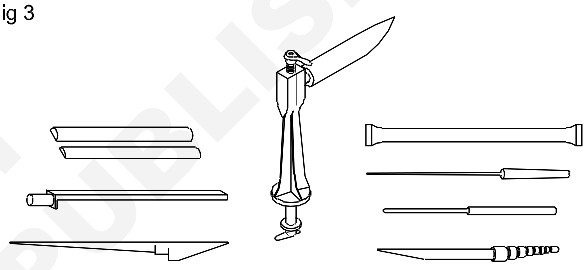
This stake holder is designed with a set of stakes which can be easily fixed on to the stake holder and hence it is termed as universal stake holder set as shown in Fig 3. One stake may be replaced by another very quickly by simply turning the swivel handle and replacing the stake.

Fig 2



REVOLVING BENCH PLATE

Fig 3



UNIVERSAL STAKE HOLDER

When placing an order to purchase this type of stake holder set, we should specify clearly the type of stakes to be supplied along with the stake holder.

Safety, care and maintenance:

– Fix the stake holder firmly on to the work bench.

– Do not use it for very heavy work.

– Do not overtighten the locking arrangements which may spoil the threads on the device.

– Do not place the unnecessary accessories on the work table. Place only the required ones.

– Avoid chiseling or punching on this stake holder.

– Remove and keep it in its place after use.

Sheet metal seams

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

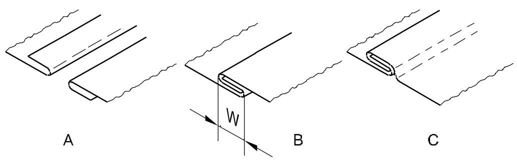
Introduction

In Sheet metal construction, mechanical seams are employed when joining light and medium gauge metal sheets. While fabricating sheet metal articles, the sheet metal worker should be able to select the type of seam that is best suited for the specific job.

Types of seams

1 **Grooved seam :** Grooved seam is most commonly used for joining sheet metal. This seam consists of two folded edges called locks as shown in Fig 1. The edges are hooked together and locked with a hand groover or a grooving machine.

Fig 1

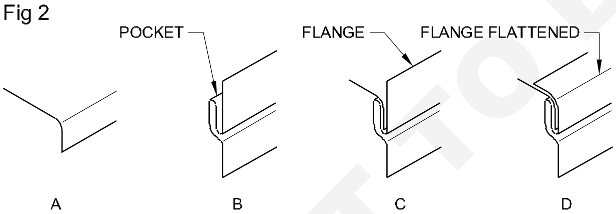


STEPS IN FORMING A GROOVED SEAM.

FI20N134911

2 **Pittsburgh seam:** This seam is also called hammer lock or hobo lock. This seam is used as a longitudinal corner seam for various types of pipes such as duct work. The single lock is placed in a pocket lock and then the flange is hammered over, step by step as shown in Fig 2.

Fig 2



STEPS IN FORMING THE PITTSBURGH SEAM.

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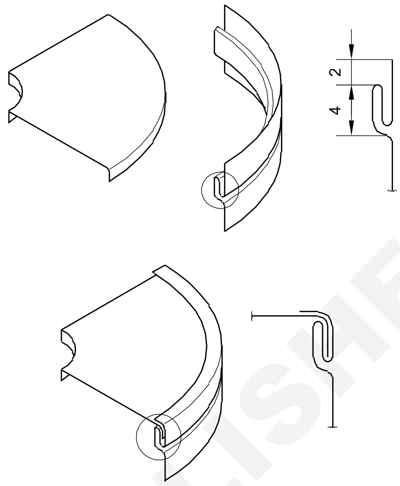
The advantage of the Pittsburgh seam is that the single lock can be turned on a curve and the pocket lock can be formed on a flat sheet and rolled to fit the curve as shown in Fig 3. If roll forming machine is not available in shop, Pittsburgh seam is formed on the brake.

3 **Dovetail seam :** This seam is an easy and convenient method of joining flanges to collars. There are three types of dovetail seams - plain dovetail, beaded dovetail and the flange dovetail as shown in Fig 4.

Dovetail seams are used mainly on round or elliptical pipe and rarely on rectangular ducts.

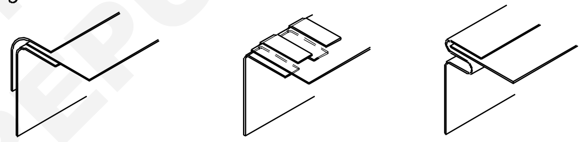
Fig 3



PITTSBURGH SEAMS CAN BE FORMED ON CURVES.

FI20N134913

Fig 4

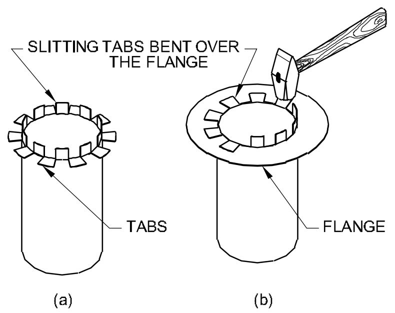


FLANGE DOVETAIL SEAM | PLAIN DOVETAIL SEAM | BEADED DOVETAIL SEAM

FI20N134914

(A) Plain dovetail seam : It is used when joining a collar to a flange without the use of solder, screws or rivet. It is made by slitting the end of the collar and bending every other tab as shown in Fig 5

Fig 5



PLAIN DOVETAIL SEAM.

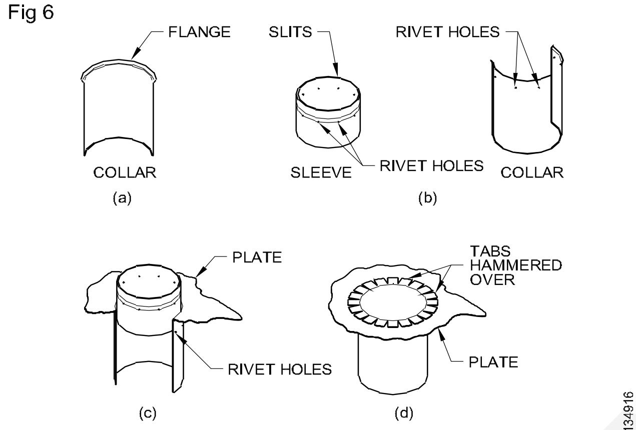
FI20N134915

The straight tabs are bent over the part to be joined and the bent tabs act as stops. This seam may be made water tight by soldering around the joint.

(B) Flange dovetail seam

This seam is used where neat appearance and strength are important. The seam shown in Fig 6 is the assembly of a flange type dovetail seam for a cylindrical pipe. It is commonly used where pipes intersect with a metal plate such as furnace flues, ceilings etc. Steps in forming a flange dovetail seam are shown in Fig 6. First, a flange is turned on the collar, next, slits are cut at regular interval sat the end of the sleeve and matching rivet holes are drilled in the sleeve and the collar. The rivet holes are aligned and the rivets are installed and finally the tabs are hammered over to complete the seam.

Fig 6



STEPS IN FORMING A FLANGE DOVETAIL SEAM.

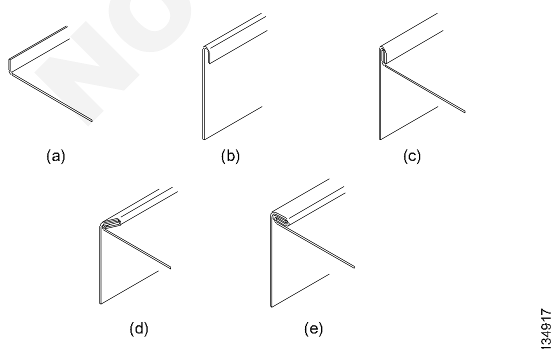
(C) Beaded dovetail seam

This is similar to the plain dovetail seam, except a bead is formed around one end of the cylinder by a beading machine. This bead acts as the stop for the flange to rest upon and the tabs are bent over to hold the flange in the desired place.

4 Double seam

There are two types of double seams. One type is used for making irregular fittings such as square elbows, boxes, offsets, etc. This seam is used on corners and can also be used as a longitudinal seam on small square and rectangular ducts. A double edge is formed and placed over the single edge and the seam is completed step by step as shown in Fig 7.

Fig 7

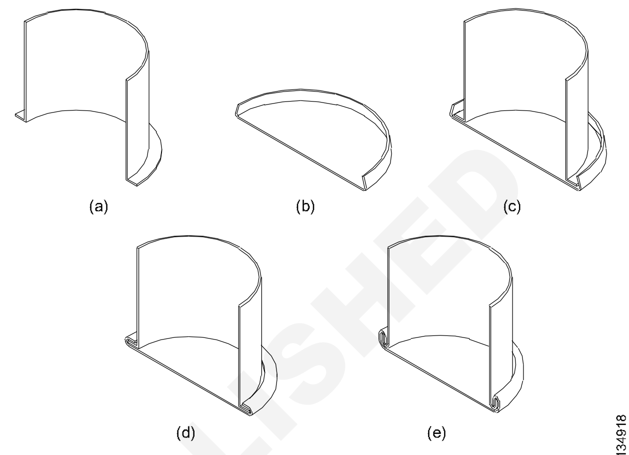


MAKING A DOUBLE SEAM.

The other type is used to fasten bottoms to cylindrically shaped jobs such as pails, tanks etc.

The steps in making this type of double seam is shown in Fig 8, where A is turned on the machine. B is burred on the burring machine. The bottom is snapped on the body as in C and is peened down as in D. Finally the seam is completed by using a mallet as in E. This seam is called Bottom double seam or Knocked up seam.

Fig 8



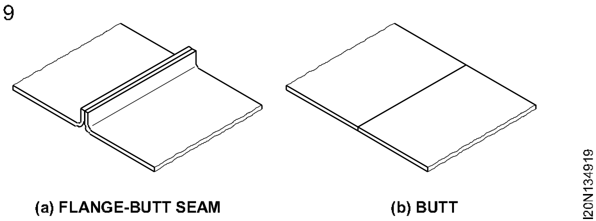
STEPS IN MAKING A BOTTOM DOUBLE SEAM.

If the seam is not turned up, as in D, the seam is called paned down seam.

5 Butt seam

This seam has two pieces butt together and soldered as shown in Fig 9. Figure shows two types of butt seams. One is flanged butt seam and the other one is butt seam.

Fig 9



(a) FLANGE-BUTT SEAM (b) BUTT

6 Lap seam

The lap seam is made by lapping the edge of one piece over the other piece and soldered as shown in Fig 10. Figure shows plain lap, sunk lap, inside lap and outside lap seams.

7 Slip joint seam

This seam is used for a longitudinal corner seam as shown in Fig 11.

The assembly of the seam consists of a single lock A and a double lock B. The single lock is slipped into the double lock C to complete the seam.

Fig 10

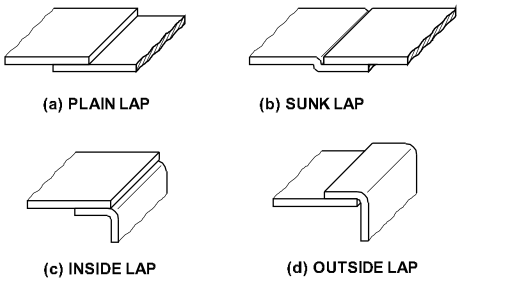
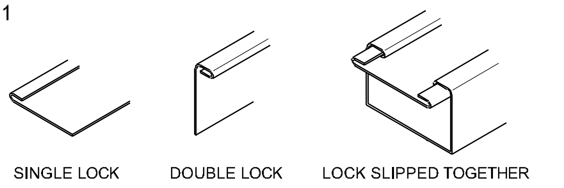


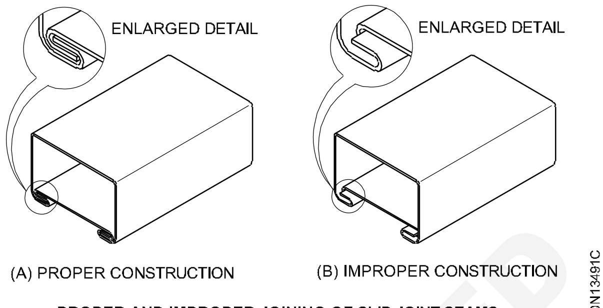
Fig 11



SLIP JOINT SEAM.

For making pipes with a slip joint seam, proper care should be taken to see that the corners of the metal are squared and the edges are trimmed. The proper slip joint is shown as A and improper as B in Fig 12. If the edges are not trimmed, it will twist the pipe out of shape and may cause the edges of the pipe to be uneven.

Fig 12



PROPER AND IMPROPER JOINING OF SLIP JOINT SEAMS.

Locked grooved joint

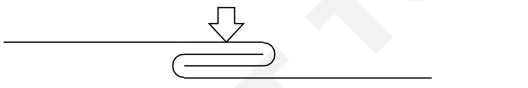
Objectives: At the end of this lesson you shall be able to
- **state the purpose of a joint**
- **state the use of the groover**
- **determine the allowance for the locked grooved joint**

Locked grooved joint: Many methods are employed to join and strengthen the pieces of a sheet metal. One of the common joint is called locked grooved joint.

This is usually done on straight lines. The workpieces to be joined are made in the form of a hook, inserted and locked using a groover.

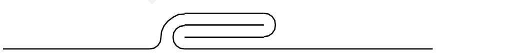
When they are interlocked and tightened only then it is called a "grooved joint" (Fig 1).

Fig 1



When the grooved joint is clinched down, making one side plane using a groover is called a "Locked grooved joint". (Fig 2)

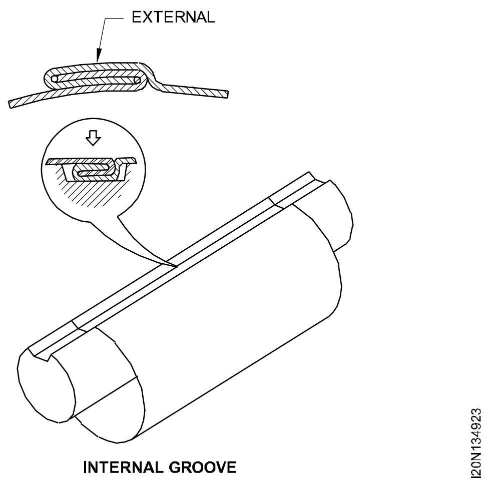
Fig 2



External and internal locked grooved joints: This joint is used to join the two ends of a sheet metal to form a circular shape in longitudinal direction. When the seam is formed outside as shown in Fig 3 then it is called 'external locked grooved joint'.

If the seam is formed using grooved mandrel then it is called 'Internal locked grooved joint' (Fig 3)

Fig 3

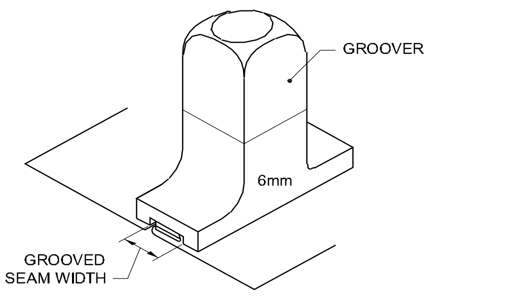


Hand Groover: The hand groover is made up of cast steel and is used to make external locked grooved joint.

A groove is made at the bottom of this tool to the required width and depth.

This has a handle in square or hexagonal shape like chisel to hold. This whole part is hardened and tempered. (Fig 4)

Fig 4



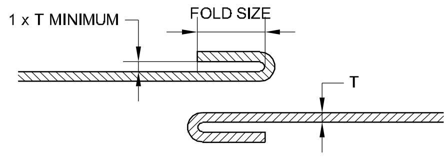
SIZE OF GROOVE & SEAM

The hand groover is specified according to the size of the groove of the groover.

Locked grooved joint allowance: To arrive the size (width) of the fold to suit a particular groover, subtract the thickness by 3 times from the width of the groove. (Fig 5)

For example, the width of the groover is 6 mm and the sheet thickness is 0.5 mm,

Fig 5



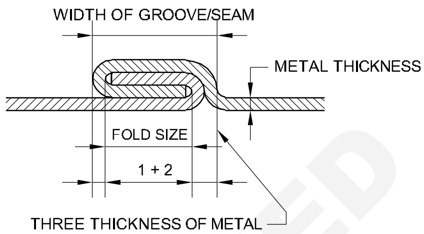
EDGE FOLDS

Then the width of the fold

= 6 - (3 x 0.5)

= 4.5 mm (See Fig 6).

Fig 6



Stake joint

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

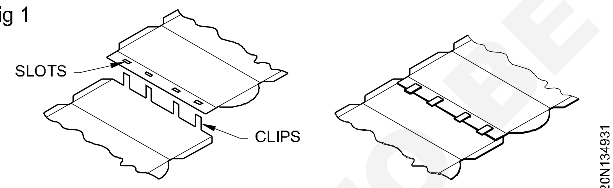
- **state the applications of stake joint**
- **state the types of stake joints.**

Stake joint

It is one of the folded joint and is used in light articles such as toys. It is also called as joint.

In this type of joint, clips are cut on one pieces to be jointed. Clips are inserted in slots and folded flat either in one direction or alternate clips are folded in opposite direction. (Fig 1)

Fig 1



Types of stake joint

i Straight stake joint

ii Zigzag stake joint

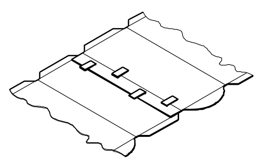
Straight stake joint

In this joint, clips and slots are in a line an the clips are inserted directly, into the slots, folded and smashed in opposite direction. (Fig 1)

Zigzag stake joint

In this joint, clips are inserted in the slots and alternate clips are folded in opposite direction. (Fig 2)

Fig 2



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**
- **calculate the allowances for grooved joints**
- **calculate the allowances for dovetail joints**
- **calculate the allowances for paned down and knocked up joints.**

When making self secured joints or seams, it is necessary to provide material for the preparation of the edges and seams, the extra material is called an allowance.

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

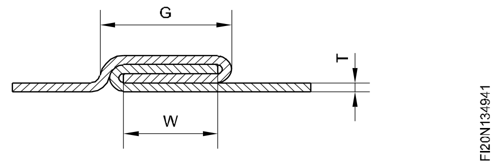
Allowance is also necessary for avoiding cracking or warping, and for obtaining the required finish.

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

You may neglect the thickness of the metal for thinner sheet 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 seen that the final width of the groove will have a minimum value of W+ 3T, where T represents the metal thickness.

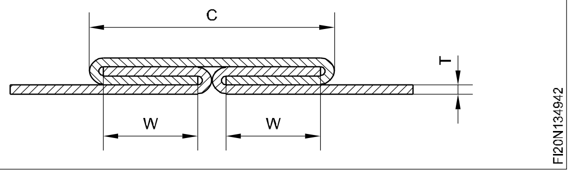
Fig 1



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

Allowance for double grooved seam/joint: It will be seen from Fig.2 that the width of the capping strip is equivalent of two times the width of the folded edge plus four times the thickness of the metal size.

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.

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 (Fig 3) and 'K' represents the size of the knocked-up joint. (Fig 4)

Allowance for P = 2W + 2T

Allowance for K = 2W + 3T

Fig 3

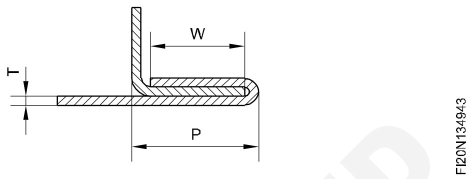
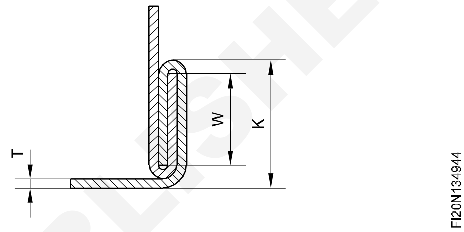


Fig 4



Edge stiffening by wiring

Objective: At the end of this lesson you shall be able to
- **state what is edge stiffening**
- **state what is the purpose of edge stiffening**
- **state methods of edge stiffening by wiring.**

Edge stiffening: Edge stiffening is the process by which edges of the sheets are made stronger and rigid.

Edge stiffening is done by

1 Wiring
2 Hemming
3 Flanging
4 Curling
5 Beading
6 Gutting
7 Ribbing

Purpose of edge stiffening

1 To give extra strength and rigidity to edges, to prevent it from bending/buckling, damage during handling etc.

2 To avoid sharp edges for safe handling.

3 In addition, this adds to decorative appearance of the sheet metal articles.

Methods of edge stiffening by wiring

1 Solid wiring

2 False wiring

In solid wiring, sheet metal edges are wrapped around the wire and wires are kept permanent in place. This is generally called simple "Wiring".

In false wiring, sheet metal edges are wrapped around the wire, after forming final shape, the wire is removed from the edge to retain it hollow.

If the edge of the sheet metal is straight, the edge formed is called "straight wired edge".

If the edge of the sheet metal is curved, the edge formed is called "curved wired edge".

False wiring cannot be done on curved edges

Wiring allowance

Objectives: At the end of this lesson you shall be able to
- **state what is wiring allowance**
- **determine the wiring allowance.**

Wiring allowance is nothing but the amount of additional length provided on sheet metal to wrap around the wire to make a wired edge.

Wiring allowance is determined by the following formula.

Wiring allowance = 2.5 x d+t

where

d=dia of wire

t=thickness of sheet metal

If wiring allowance provided is more, then the correct shape of the wire is not formed. If wiring allowance provided is less, the gap is found at the inner side of the edge and the wire can be seen.

Generally, the length of the wire provided is slightly more than the length of the edge. This is required to hold the wire at ends, while forming the edge of the sheet metal around the wire.

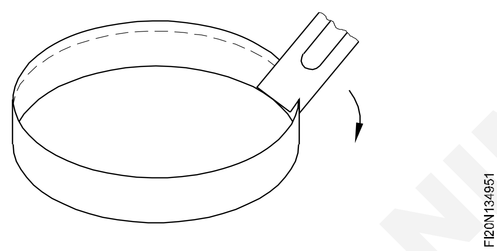
Surplus wire is cut after the wired edge is finished.

Making wired edge along a curved surface by hand process

Objectives: This shall help you to
- **mark the wiring allowance at the curved edge**
- **make a wired edge along a curved surface by hand process**

Mark the wiring allowance at the curved edge to be wired using a gauge with sheet metal as shown in Fig 1.

Fig 1



Flange the edge to be wired using a hatchet stake and a setting hammer, step by step upto 90°. (Fig 2) Then upset the flange to its half the width and make curve on the flange for wiring. (Fig 3)

Make a round ring from the given G.I.wire to the required dia. (Fig 3)

The joint of the wire should be opposite to the locked grooved joint.

Place the G.I. Wire ring on the flange. (Fig 4)

Fig 2

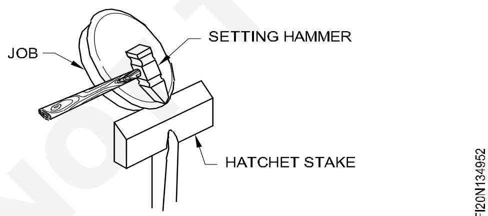


Fig 3

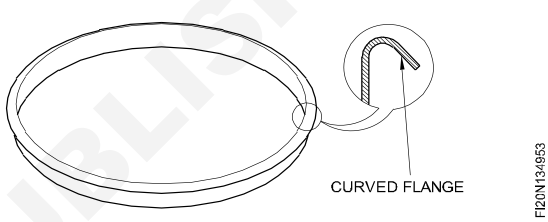
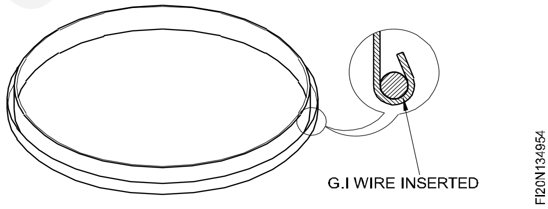
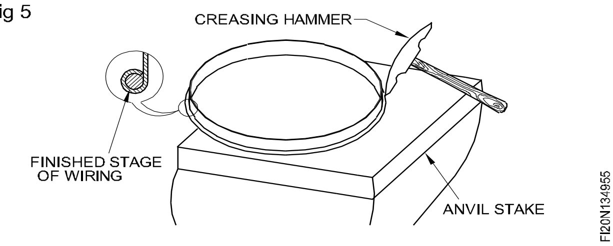


Fig 4



Complete the wiring using a creasing hammer. (Fig 5)

Fig 5



Dress the wiring by using a half moon stake and a mallet.

Redress the trueness of the cylindrical shape by a round mandrel and a mallet.

False wiring

Objectives: At the end of this lesson you shall be able to
- **state what is false wiring**
- **state advantages of false wiring**

False wiring is one of the methods of edge stiffening in which wired edge is formed and fially wire is removed from the edge, to make the edge hollow.

Advantages of false wiring: In addition to advantages by wiring, false wiring gives following advantages.

1 Cost of the article is reduced.

2 Weight of the article is also reduced.

In sheet metal articles like trunks, boxes etc,. wiring is done only at the corners of the adjacent sides and the remaining portion of the wired edge is kept hollow.

This helps to maintain the sides in position.

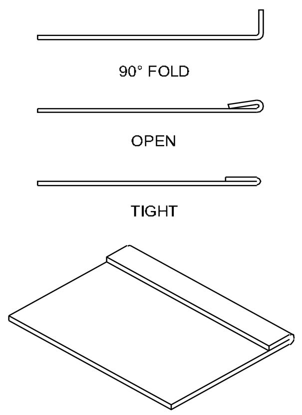
Hemming

Objectives : At the end of this lesson you shall be able to
- **state the importance of hemming**
- **determine the hemming allowance.**

The sheet metal edges being thin are very unsafe while we handle. They are like knife edge and can cause injuries. Therefore the edges should be made blunt by way of making the edge folded to 180°. Also since the sheet metal is very thin the edges will deflect due to low strength without stiffness.

For the above reasons the edges are hemmed (Fig 1) which will ensure safety, retaining of shape, owning to the stiffness and also enhance good appearance.

Fig 1



SINGLE HEM

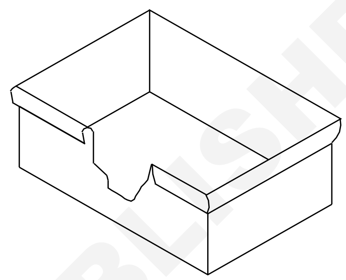
The folded edge will be more strong if it is not completely flattened and a hollow channel is made.

Usually the hemming allowance will be 3 to 4 times the thickness of the sheet to be hemmed, subject to a minimum of 4 M M.

If the hemming width is more, wrinkles are formed at the hemmed edges.

A hemmed box is shown in Fig 2 gives good appearance, safe and strong edge.

Fig 2



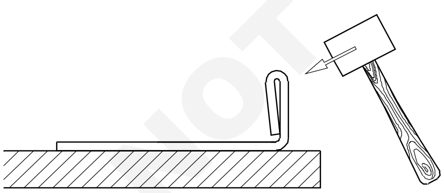
BOX WITH HEMMED EDGE

Double hemming by Hand Process

Objectives : At the end of this lesson you shall be able to
- **state the purpose of double hemming**
- **give the hemming allowance for the first and second folds.**

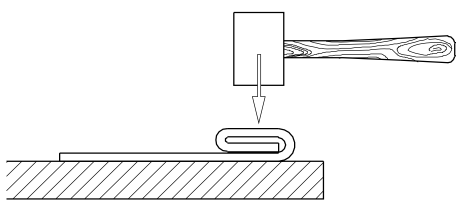
Double hemming is done by folding twice. This give more strength, when compared to single hemming. This is done on various sheet metal articles which in square, rectangular objects like trays. (Fig1 & Fig 2)

Fig 1



While doing double hemming, care must be taken making second fold. Angle of folding should be grade increased throughout the length of the fold.

Fig 2



Edge Stiffening

Objective : At the end of this lesson you shall be able to
- **make a single hemming on a curved edge using anvil stake and setting hammer.**

Mark the hemming allowance on the formed body using a marking template.

Fix the anvil stake on to the vice or bench plate.

Hold the workpiece such that the marked line coincides with the edge of the stake approximately inclined an angle of 10° as shown in Fig 1.

Strike and rotate the workpiece gradually along the marked line to form a small flange using a setting hammer. (Fig 2)

Fig 1

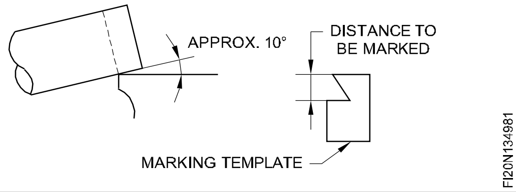
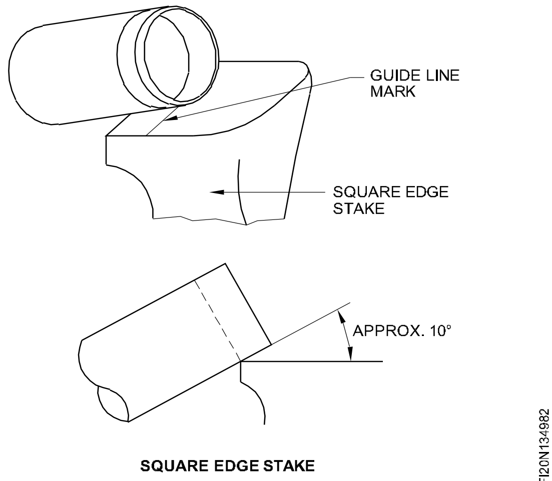


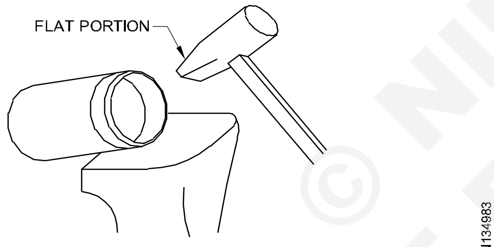
Fig 2



SQUARE EDGE STAKE

Gradually increase the angle of inclination while forming range as shown in Fig 3.

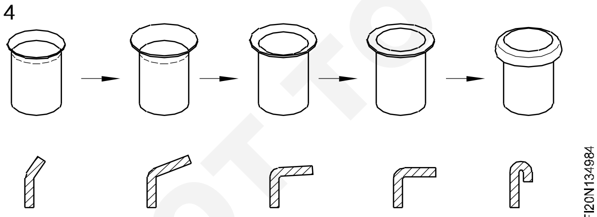
Fig 3



SETTING HAMMER

Finish the hemmed edge on a round mandrel stake by a let (Fig 4)

Fig 4



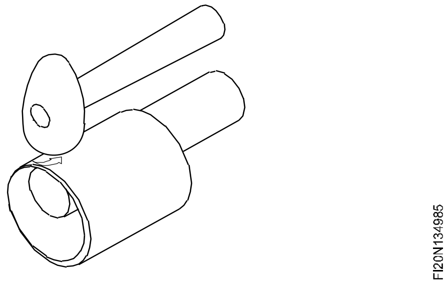
Press the disturbed body of the cyclinder to a round shape using round mandrel stake and a mallet

Check the cylindrical body for roundness and the marketing allowance for flanging.

Fix the copper smith stake in the benchvice or bench plate firmly.

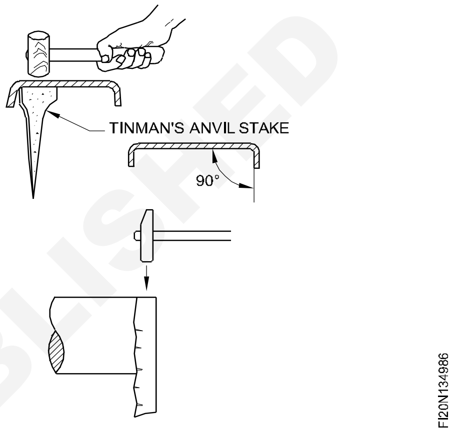
Mark the flanging allowance as guideline on the stake as in Fig 5

Fig 5



Hold the cylinder such that the marked line on the cylinder for flanging, coincides with the straight edge of the stake. (Fig 6)

Fig 6

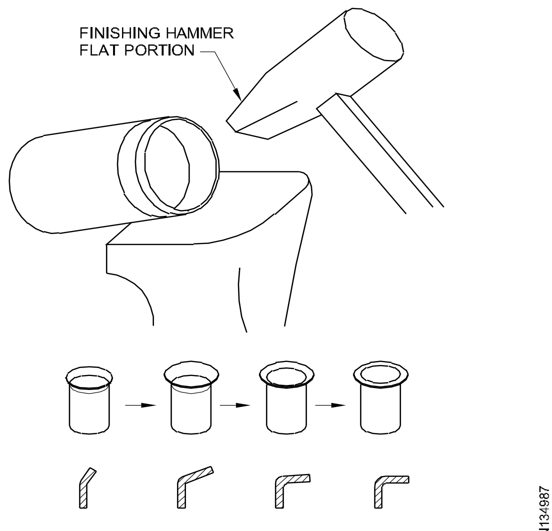


Position the cylinder as in Figure 1 and strike the metal using the flat face of the finishing hammer.

Rotate the body of the cylinder by one hand.

Strike with finishing hammer to increase the angle of bending gradually as in (Fig 7) till the flange is bent to 90°

Fig 7



FLANGING

Solders

Objectives: At the end of this lesson you shall be able to
- **define a solder**
- **state the types of solders**
- **state the constituents of soft and hard solders.**

Solder is a bonding filler metal used in soldering process.

Pure metals or alloys are used as solders. Solders are applied in the form of wires, sticks ingots, rods, threads, tapes, formed sections, powder, pastes etc.

Types of solders

There are two types of solders.

– Soft solder

– Hard solder

Soft solders: Soft solders are alloys of tin and lead in varying proportions. They are called soft solders because of their comparatively low melting point. One distinguishes between soft solder whose melting points are 450°C and hard solders whose melting points lie above 450°C. These are alloys of the materials tin, lead, antimony, copper, cadmium and zinc and are used for soldering heavy (thick) and light metals. Table shows different compositions of solder and their application.

In the composition of soft solder, tin is always stated first.

WARNING

For cooking utensils, do not use solder containing lead. This could cause poisoning. Use pure tin only.

Hard solders: These are alloys of copper, tin, silver, zinc, cadmium and phosphorus and are used for soldering heavy metals.

Table 1

Sl.No.	Types of solder	Tin	Lead	Application
1	Common solder	50	50	General sheet metal applications
2	Fine solder	60	40	Because of quick setting properties and higher strength,
3	Fine solder	70	30	they are used for copper water tanks, heaters and general electrical work.
4	Coarse solder	40	60	Used on galvanised iron sheets
5	Extra fine solder	66	34	Soldering brass, copper and jewellery
6	Eutectic alloy	63	37	Similar to fine solder

Soldering flux

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

All metal rust to some extent, when exposed to the atmosphere because of oxidation. The layer of the rust must be removed before soldering. For this, a chemical compound applied to the joint is called flux.

Functions of the fluxes

1 Flues removes oxides from the soldering surface it prevents corrosion

2 It forms a liquid cover over the workpiece and prevents further oxidation.

3 It helps molten solder to flow easily in the required place by lowering the surface tension of the molten solder.

Selection of flux: The following criteria's are important for selecting a flux.

- Working temperature of the solder
- Soldering process
- Material to be joined

Different types of fluxes: Flux can be classified as (1) Inorganic or Corrosive (Active) & (2) Organic or non-corrosive (Passive).

Inorganic fluxes are acidic and chemically active and remove oxides by chemically dissolving them. They are applied by brush directly on to the surface to be soldered and should be washed immediately after the soldering operation is completed.

Organic fluxes are chemically inactive. These fluxes coat the surface of the metals to be joined and exclude the air from the surface, to avoid further oxidation. They are applied only to the metal surfaces which have been previously cleaned, by mechanical abrasion. They are in the form of lump, powder, paste or liquid.

Different types of fluxes

(A) Inorganic fluxes

1 **Hydrochloric acid:** Concentrated hydrochloric acid is a liquid which fumes when it comes into contact with air. After mixing with water 2 or 3 times the quantity of the acid, it is used as dilute hydrochloric acid. Hydrochloric acid combines with zinc forming zinc chloride and acts as a flux. So it cannot be used as a flux for sheet metals other than zinc iron or galvanised sheets. This is also known as muriatic acid.

2 **Zinc chloride:** Zinc chloride is produced by adding small pieces of clean zinc to hydrochloric acid. It gives off hydrogen gas and heat after a vigorous bubbling action, thus producing zinc chloride. The zinc chloride is prepared in heat resisting glass beakers in small quantities. (Fig 1)

Zinc chlorides are known as killed spirits. It is mainly used for soldering copper, brass and tin sheets.

3 **Ammonium chloride or Sal-Ammoniac:** It is a solid white crystalline substance used when soldering copper, brass, iron and steel. It is used in the form of powder or mixed with water. It is also used as a cleaning agent in dipping solution.

4 **Phosphoric acid:** It is mainly used as flux for stainless steel. It is extremely reactive. It is stored in plastic containers because it attacks glass.

(B) Organic fluxes

1 **Resin:** It is an amber coloured substance extracted from pine tree sap. It is available in paste or powder form.

Resin is used for soldering copper, brass, bronze, tin plate, cadmium, nickel, silver and some alloys of these metals. This is used extensively for electrical soldering work.

2 **Tallow:** It is a form of animal fat. It is used when soldering lead, brass and pewter.

Table 1

The following Table shows the nature and type of flux used in soldering.

Metal to be soldered	Inorganic flux	Organic flux	Remarks
Aluminium Aluminium-bronze			Commercially prepared flux and solder required
Brass	Killed spirits Sal-ammoniac	Resin Tallow	Commercial flux available
Cadmium	Killed spirits	Resin	Commercial flux available
Copper	Killed spirits Sal-ammoniac	Resin	Commercial flux available
Gold		Resin	
Lead	Killed spirits	Tallow Resin	

Monel			Commercial flux required
Nickel	Killed spirits	Resin	Commercial flux available
Silver		Resin	
Stainless steel	Phosphoric acid		Commercial flux available
Steel	Killed spirits		
Tin	Killed spirits		Commercial flux available
Tin-bronze	Killed spirits	Resin	
Tin-lead			
Tin-zinc	Killed spirits	Resin	
Zinc	Muriatic acid		

Soft soldering

Objectives: At the end of this lesson you shall be able to
- **explain soft soldering process**
- **state the melting characteristics of soft solders**
- **state the essential features of the soldering technique**
- **explain the importance of the attitude of the bit**
- **state the importance of movement of the bit in soldering**
- **state the characteristics of the soldered seams to be observed while inspection.**

Soft soldering involves the process

– preparing the workpiece.

– select the correct soft solder.

– preparing the soldering iron.

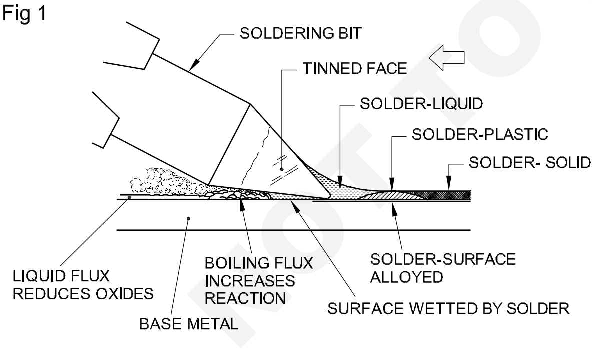
– select and apply suitable flux.

– heat the soldering iron bit and the workpiece to the correct temperature.

– manipulating the soldering iron on the workpiece skillfully as shown in Fig 1.

– complete the job to a satisfactory standard.

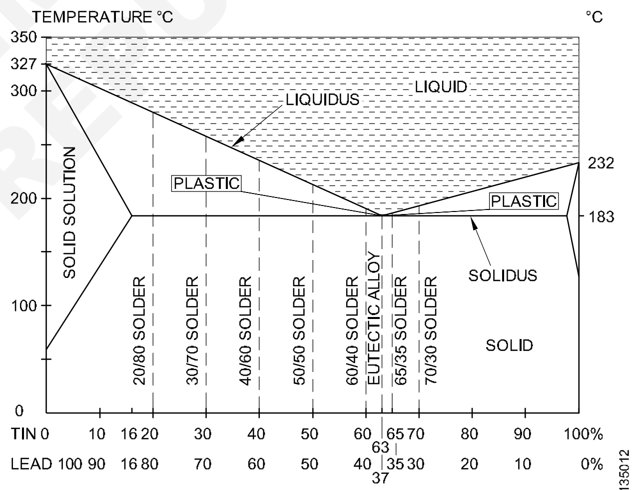
Fig 1



THE SOFT SOLDERING PROCESS

Melting characteristics of soft solders: The eutectic alloy of tin lead solder is a mixture of 63% tin and 37% lead. 63/37 solder melts at 183^{0}C and is the lowest melting point of all combinations in the alloy series as shown in Fig 2.

Fig 2



MELTING CHARACTERISTICS OF TIN-LEAD SOLDER

Soldering Techniques: The following features are essential to do soldering.

– Correct joint design

– Preparation of the joint

– Selection of the solder

– Selection and preparation of the soldering iron.

– Copper bit heating

– Soldering bit manipulation

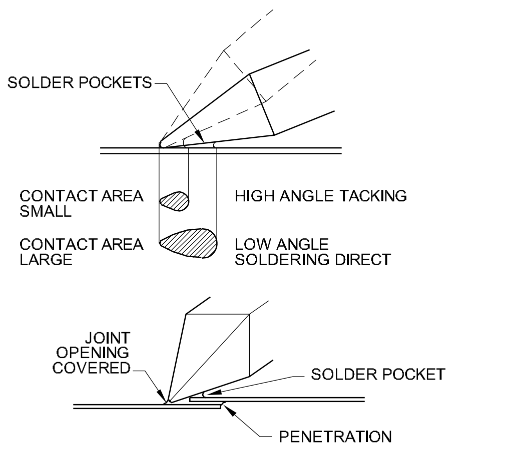
– Cleaning after soldering

– Inspection of the seam.

Attitude of the bit: The soldering iron bit should be placed in a position that enables sufficient heat and solder to flow into the joint.

The angle between a working face of the bit and the joint surface should be filled with a pocket of solder.(Fig 3)

Fig 3



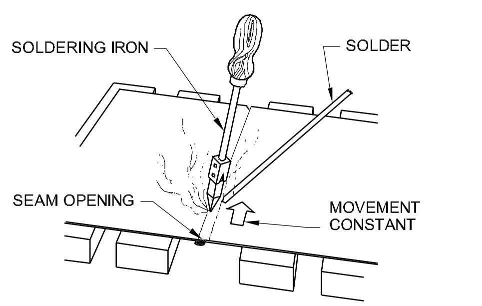
ATTITUDE OF BIT

Any variation of this angle will control the amount of heat and solder which is transferred onto the lapped surfaces.

Contact between the molten solder and the joint opening is essential for the penetration of the solder into the joint as shown in figure.

The pattern of the bit movement ensures successful heating of the solder deposited, when the point of the bit covering the joint opening penetrate through the lap as shown in Fig 4

Fig 4



MOVEMENT OF BIT

Flux residues and stains should be removed from the seam, to keep clean dry surfaces for paint finishes.

Inspection of the seam: A soldered seam should have the following characteristics.

- The solder has penetrated the lapped surfaces.
- The joint gap is sealed with a neat smooth fillet of the solder.
- The upper surfaces of the seam must be smooth, thin coating of solder, with tidy solder margins with uniform width.

Visual inspection is good to rectify the faults of the solder. However, physical testing for air or water tight seams is specified often. Leaks, detected by the tests are corrected by re-cleaning, re-fluxing and re-soldering of the faulty area in the soldered seam.

Process of soft soldering and hard soldering

Objectives: At the end of this exercise you shall be able to
- **define 'soldering'**
- **state the different types of soldering processes**
- **state the different types of solder and their applications**
- **state the different types of soldering bits and their uses.**

Soldering method: 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 should not be done on joints subjected to heat and vibrations and where more strength is required.

Soldering can be classed as soft soldering and hard soldering.

The process of joining metals using tin lead solders which melt below 420°C is known as soft soldering.

The process of joining metals using hard solders consisting of copper, zinc, cadmium and silver which melt above 600° is known as hard soldering

Brazing is a hard soldering process used to join copper brass and most ferrous metals.

The bonding filler metal usually consists of copper and zinc alloys. Silver brazing or silver soldering is a process used to join steel, copper, bronze and brass and precious metals like gold and silver.

The bonding filler metal consists of silver, copper and zinc tin alloys.

Factors considered while soldering

Objectives: At the end of this exercise you shall be able to
- **follow the conditions for proper define 'soldering'**
- **state the different types of soldering processes.**

Soldering is joining two metal parts with a solder, i.e. a third metal that has a lower melting point.

Before soldering the following conditions must be met.

1 The metal must be clean

2 The correct soldering device must be used and it must be in good condition

3 The correct solder and flux or soldering agent must be chosen.

4 Proper amount of heat must be applied. If you folds these conditions, you could get a good solder joint.

Cleanliness: Solder will never stick to a dirty, oil or exide coated surface. Begineers often ignore this simple point the metal is dirty. Clean it with a liquid cleaner. If it is a annealed sheet remove the oxide with an abrasive and clean it until the surface is bright.

A bright metal, such as copper, can be coated with even though you cannot see it. This oxide can be removed with any fine abrasive.

Successful soldering

Objective : At the end of this lesson you shall be able to
- **follow the hints for successful soldering.**

Hints for successful soldering

You should always wear safety glasses to avoid possible injury to the eyes.

Sheet metal must be cleaned with a file, wire brush, steel wool strip, or emery cloth.

Be sure that the pieces to be soldered fit closely together, for a strong joint.

Soldering flux must be applied by a swab or brush only to the surfaces on which molten solder is to be applied.

Hold the pieces to be soldered firmly to prevent their movement.

Hold the soldering iron in one hand, placing its widest tinned face flat against the surface to be soldered.

When soldering iron is held incorrectly, the point of the soldering iron touches only a portion of the area to be soldered, this is referred to as "skimming" the joint and results in a weak joint.

Apply the wire solder beneath the edge of the iron and nearest to the work. Move the soldering iron slowly along the work making sure that the solder melts, spreads and penetrates properly.

Solder as much surfaces as possible without re-heating the soldering iron or changing to another iron.

A temperature capable of merely melting the solder is not sufficient enough, heat must be transmitted by the soldering iron to the workpiece to quickly raise the temperature of the metals to the solder melting temperature.

It is this step in soldering that beginners often fail to understand and remember.

A soldering iron that is too small, often causes difficulty.

Do not breathe any smoke from the sal ammoniac block as it is a toxic gas and is dangerous.

Sweating of sweat soldering

Objective : At the end of this lesson you shall be able to
- **explain the process of sweating.**

Sweating or Sweat soldering is a process, in which two or more surfaces are soldered one on the top of the other without allowing the solder to be seen after assembly.

In sweating, metal surfaces to be joined are tinned first, then placed on above the other and heated together. While heating, the solder melts and flows to join the overlapped surfaces.

Sweating process is applied in body repairing works in which the damaged surface is sweat soldered with a piece of metal called patch. This process is also applied in rectifying leakages of water tanks and fuel tanks.

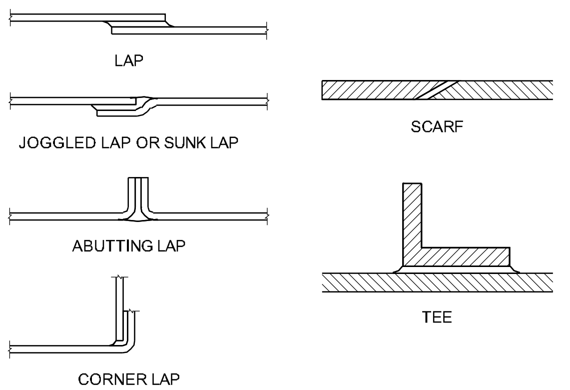
Soldered Joint

Objectives: At the end of this lesson you shall be able to
- **state the types of the soldered joints**
- **state the points to be considered for correct joint design.**

Types of soldered joints: Sheet metal components are joined together by soldered joints. In many cases, the edges are joined by sheet metal mechanical joints and then soldered to make the joint stronger and leak proof.

Fig 1 shows soldered lap joints.

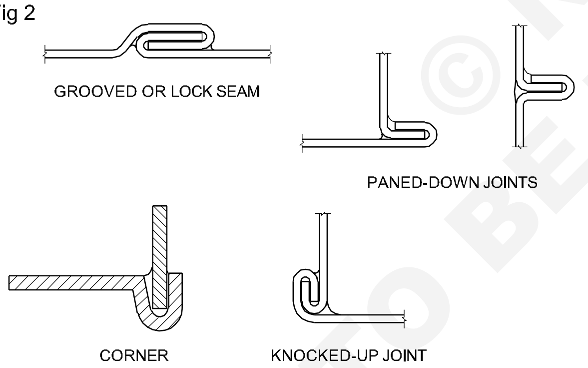
Fig 1



SOLDERED LAPPED SEAMS

Fig 2 shows soldered seams.

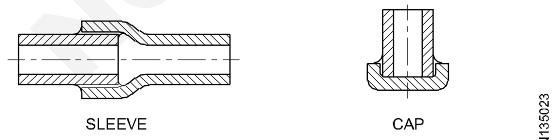
Fig 2



SOLDERED FOLDED SEAMS

Fig 3 shows soldered joint on round shaped parts.

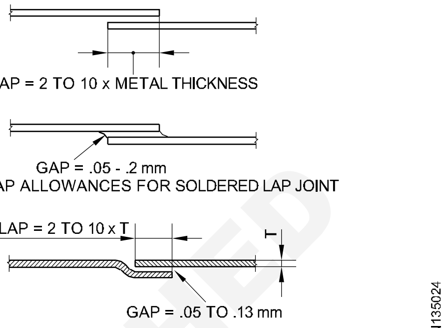
Fig 3



SOLDERED JOINTS ON ROUND SHAPED PARTS

Sheet metal joints both lapped and folded, are suitable for silver soldering application as shown in Fig.4

Fig 4



LAP AND GAP ALLOWANCES FOR SOLDERED SUNK LAP JOINT

Silver solder effects the union of lapped joints and seals the beam openings of the interlocking folded joints.

Correct joint design: Sheet metal joints with overlapping surfaces are ideal for joining or sealing with solder. Close fitting of lapped surfaces are essential for the flow of molten solder into the joint by capillary action.

Joint design suitable for silver brazing or soldering mainly depends on the type of assembly and its intended use.

Maximum strength can be achieved by observing the following conditions.

– A suitable filler alloy must be used.

  Component metal is of major consideration.

– Joint clearances should be minimum.

  Close fitting surfaces helps capillary flow and gaps between 0.05 and 0.13 mm should be used.

– The solder must contact lapped surface sufficiently.

  Lap width is commonly made 2 to 10 times the component metal thickness. In case of unequal thickness, the lap size is based on the thinner materials.

– Workpieces must be firmly supported.

  It is essential to prevent the movement for the control of the solder application, alignment and accuracy of the component assembly.

Dipping solution

Objectives: At the end of this lesson you shall be able to
- **state the use of the dipping solution**
- **state the constituents of the dipping solution.**

It is used to dissolve oxides from solder coated faces of the copper bit before applying it to the workpiece.

It is made of

1 Dissolving sal-ammoniac powder in water.

2 Dilute zinc-chloride with water.

3 Adding commercial flux with zinc chloride or ammonium chloride as active ingredients to water.

A mixture of approximately one part of active component and four parts of water is satisfactory as the acidity of the solution should not be strong.

Safety precautions in soldering

Objective : At the end of this lesson you shall be able to
- **follow safety precautions in soldering to avoid injuries/accidents.**

Safety precautions followed while soldering

1 Wear safety glasses to protect your eyes from solder splattering and flux.

2 Be careful while storing hot soldering irons after use to avoid burns.

3 Wash your hands thoroughly after using soft solder because it is poisonous.

4 Tin the soldering iron in a well ventilated area to exhaust fumes coming out while soldering.

5 Wear safety goggles when using acids for cleaning.

6 When making acid solution, always pour acid into water slowly.

7 Never pour water into the acid.

8 All inorganic fluxes are poisonous.

9 Wear goggles and gloves while handling corrosive flux.

Fluxes types and description

Objectives : At the end of this lesson you shall be able to
- **explain flux and its function**
- **describe the types of fluxes and their storage.**

Flux is a fusible (easily melted) chemical compound to be applied before and during welding to prevent unwanted chemical action during welding and thus making the welding operation easier.

The functions of fluxes : To dissolve oxides and to prevent impurities and other inclusions that could affect the weld quality.

Fluxes help the flow of filler metal into very small gap between the metals being joined.

Fluxes act as cleaning agents to dissolve and remove and clean the metal for welding from dirt and other impurities.

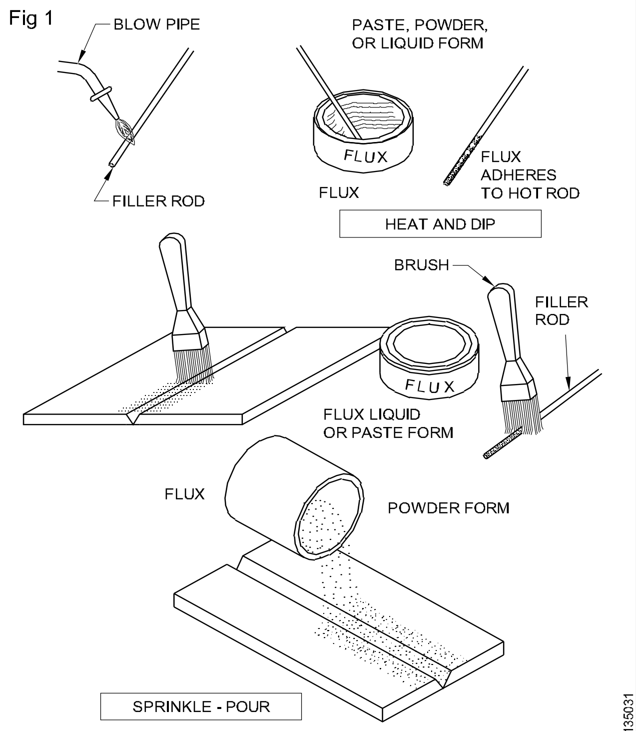
Fluxes are available in the form of paste, powder and liquid.

The method of application of flux is shown in Fig. 1

Storing of fluxes; where the flux is in the form of a coating on the filler rod, protect carefully at all times against damage and dampness. Fig 2.

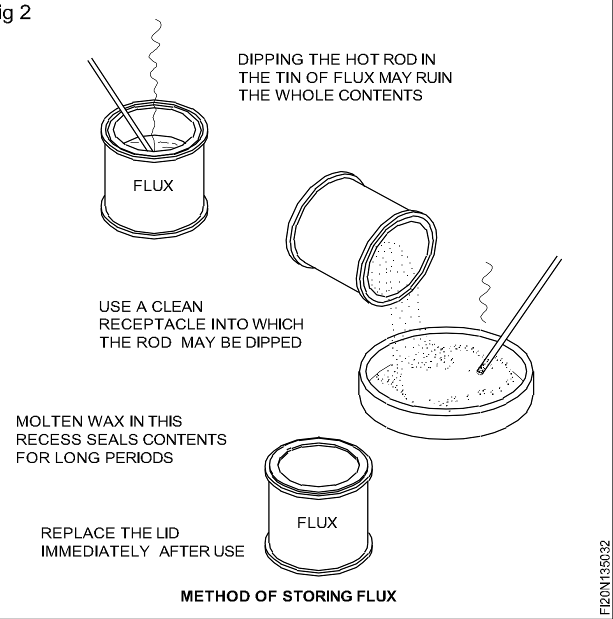
Seal flux tin lids when storing especially for long periods (Fig 2)

Fig 1



METHOD OF APPLICATION

Fig 2



METHOD OF STORING FLUX

Though the inner reducing envelope of an oxy-acetylene flame offers protection to the weld metal, it is necessary to use a flux in most cases.Fluxes used during welding not protect the weldment from oxidation but also from a slag which floats up and allows clean weld metal, to be deposited. After the completion of welding, flux residues should be cleaned.

Removal of flux residues: After welding or brazing is over, it is essential to remove the flux residues. Fluxes in general are chemically active. Therefore, flux residues, if not properly removed, may lead to corrosion of parent metal and weld deposit.

Some hints for removal of flux residues are given below:

- **Aluminium and aluminium alloys**- As soon as possible after welding, wash the joints in warm water and brush vigorously. when conditions allow, follow up by a rapid dip in a 5 percent solution of nitric acid; wash again,using hot water to assist drying.
- When containers, such as fuel tanks, have been welded and parts are inaccessible for the hot water scrubbing method, use a solution of nitric and hydrofluoric acids.To each 5.0 litres of water add 400 ml of nitric acid (specific gravity 1.42) followed by 33ml of hydrofluoric acid (40 percent strength).The solution used at room temperature will generally completely remove the flux residue in 10 minutes, producing a clean uniformly etched surface, free from stains. Following this treatment the parts should be rinsed with cold water and finished with a hot water rinse. The time of immersion in hot water should not exceed three minutes, otherwise staining may result; after this washing with hot water the parts should be dried. It is essential when using this treatment that rubber gloves be worn by the operator and the acid solution should preferably be contained in an aluminium vessel.
- **Magnesium alloys**-Wash in water followed quickly by standard chromating. Acid chromate bath is recommended.
- **Copper and brass**- Wash in boiling water followed by brushing.Where possible, a 2 percent solution of nitric or sulphuric acid is preferred to help in removing the glassy slag, followed by a hot water wash.
- **Stainless steel**- Treat in boiling 5 percent caustic soda soultion, followed by washing in hot water. Alternatively, use a de-scaling solution of equal volume of hydrochloric acid and water to which is added 5 percent of the total volume of nitric acid with 0.2 percent of total volume of a suitable restrainer.
- **Cast iron**- Residues may be removed easily by a chipping hammer or wire brush.
- **Silver brazing** -The flux residue can be easily removed by soaking brazed components in hot water, followed by wire brushing. In difficult cases the work piece should be immersed in 5 to 10 percent sulphuric acid solution for a period of 2 to 5 minutes, followed by hot water rinsing and wire brushing.

Types of spelters and fluxes used in brazing

Objectives: At the end of this lesson you shall be able to
- **state the types of spelter and flux used in brazing**
- **state the composition of spelter and its melting point.**

Brazing is essentially similar to soldering but it gives a much stronger joint than soldering. The principal differences is the use of a harder filler material, commercially known as spelter which fuses at temperature above red heat, but below the melting temperature of the parts to be joined. Filler materials used in this process may be divided into two classes. Copper base alloys and silver base alloys. There are a number of different alloys in each class, but brass (Copper and Zinc) sometimes with upto 20% tin are mostly used mainly for brazing the ferrous metals. Silver alloys (Silver and Copper or Silver and Copper and Zinc) having a melting point range of 600 to 850^0C are suitable for brazing any metals capable of being brazed. They are giving a clean finish and a strong ductile joint. Spelters are commonly made according to the thickness of sheets.

After brazing, the joint must be hammered to check the leakages and to remove flux. Mostly and commonly used flux is "Borax" for ferrous and non-ferrous metals. It removes rust and prevents atmospheric effect, when brazing operation is going on.

COMPOSITION OF SPELTER AND MELTING POINTS

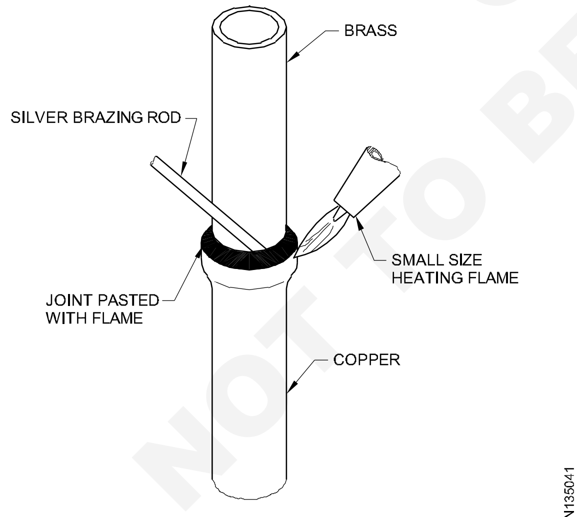
Sl. No.	Types of spelters	Common metals	Copper %	Zinc %	Silver %	Melting temperatures	Uses
1	Copper + Zinc Base spelter	Common	60	40	NIL	850^0C	Hard brazing on copper sheets and non-ferrous
2	-do-	Ferrous metals	80	20	NIL	600^0C	Brass sheet thick
3	-do-	brass	30	70	NIL	400^0C	Brass sheet thin
4	Silver solder	Gold	10	10	80%	350^0C	It is used for gold ornaments brazing

Silver brazing of copper pipes by gas

Objectives: At the end of this lesson you shall be able to
- **explain the term silver brazing**
- **state the various applications of silver brazing.**

Silver brazing (Fig 1)

Fig 1



SILVER BRAZING METHOD

A low temperature brazing method.

Also called by other names such as:- Silver soldering, Hard soldering.

Its temperature range is 600°C to 850°C.

Silver-brazing filler rods are composed of copper and silver with a small percentage of Zinc, Cadmium and Nickel.

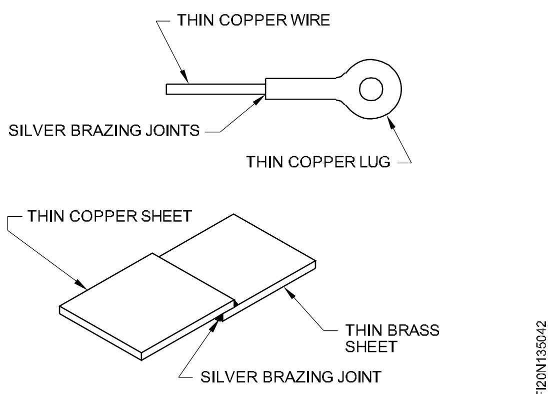
Silver content may vary from 40 to 60%.

Applications

This low temperature brazing alloy is suitable for the following.

Joining electrical parts requiring high electrical conductivity. (Fig 2)

Fig 2



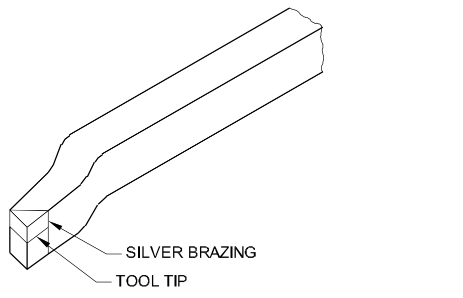
Food handling and processing equipment. (Stainless steel).

Economy in brazing operation requiring a low temperature, thin layer, quick and complete penetration.

Joining of thin sheets and close fitted joints in steel, copper, brass, bronze, nickel alloys and nickel-silver alloys.

Brazing tungsten carbide tips to ROCK DRILLS, MILLING CUTTERS, CUTTING and SHAPING TOOLS. (Fig 3)

Fig 3



Joining dissimilar metals and jewellery making works.

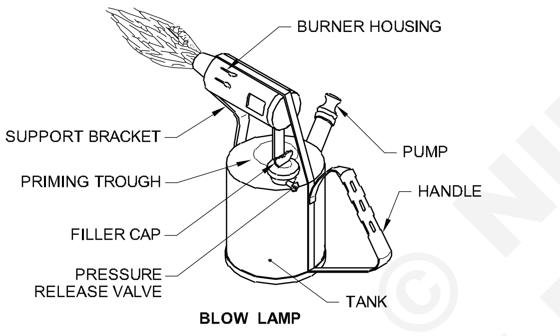
There is economy in the brazing operation as it requires only low temperature and a thin layer of deposition. There is quick and complete penetration in this method of joining.

Blow lamp

Objectives: At the end of this lesson you shall be able to
- **state the constructional feature of blow lamp**
- **identify the parts of blow lamp**
- **describe the operation of blow lamp.**

In 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 methylated spirit for lighting the blow lamp. Set of nozzle is provided to direct the kerosene vapour 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.

Portable hand forge with blower

Objectives: At the end of this lesson you shall be able to
- **state the purpsoe of hand forge**
- **describe the constructional feature of hand forge**
- **state the fuel used in hand forge.**

Hand forge: It is used for heating the soldering bit.

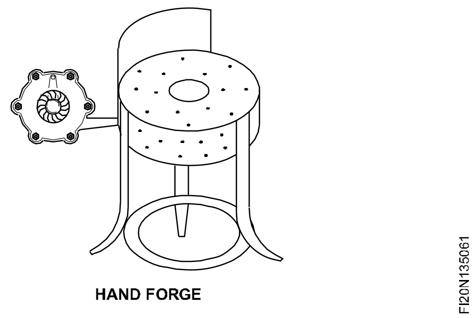
It is made of mild steel plates and angles. It is generally round in shape. the hand blower is attached to it for air supply.

A pefforated plate is fixed at the bottom to remove burnt residuals.

The fuel zone is built up with fire bricks and coated with the mixture of clay and sand, providing space at the centre for fuel. (Fig 1)

The fuel used for firing is mainly charcoal. The charcoal is prepared from hard wood.

Fig 1



HAND FORGE

Rivet and riveting

Objectives: At the end of this lesson you shall be able to
- **state what is rivet and riveting**
- **list the part of rivet**
- **explain the type of rivet.**

Rivet

A rivet is a permanent mechanical fastener consisting of a head at one end and a cylindrical stem at the other end (called the tail) which has the appearance of a metal pin.

Rivets are used to in structures, bridges, sheet metal operations, ships, and in many industries.

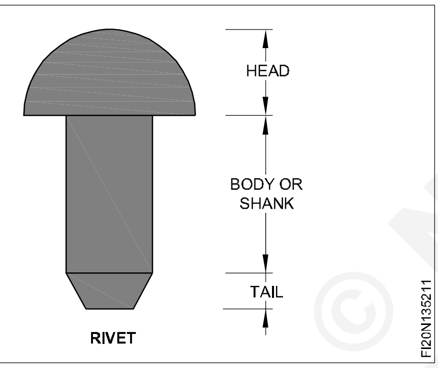
Riveting

Riveting is one of the methods of making permanent joint

Parts of a Rivet

Following are the parts of a Rivet (Fig 1)

Fig 1



1 Head 2 Shank or Body 3 Tail

Head : The upper-most part of rivet is called "head". These are made of different type according to different jobs.

Shank or Body: The part below rivet is called shank or body. This is round in shape.

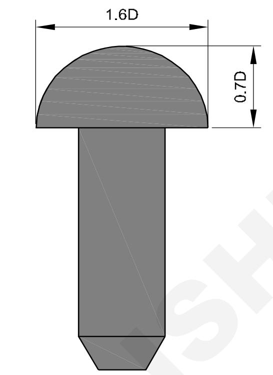
Tail: Part below its centre is called tail. It is somewhat tapered. It is inserted into holes of two plates and head is made by beating their tail. The length of tail is ¼ D. A rivet is known by its roundness, length and shape of head.

Type of rivet

1 Snap head or cup head rivets
2 Pan head rivets
3 Conical head rivets
4 Countersunk head rivets
5 Flat head rivets
6 Bifurcated head rivet
7 Hollow head rivets.
8 Tinman's rivet
9 Flush rivet

Snap head or cup head rivets (Fig 2)

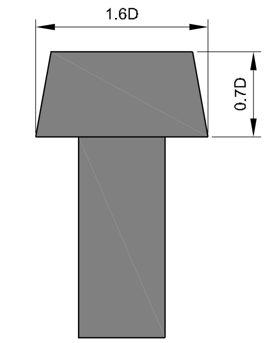
Fig 2



The head is of a semi-circle in shape.. The joints of this rivet are very strong. It is widely used in bridges made of iron material.

Pan head rivets (Fig 3)

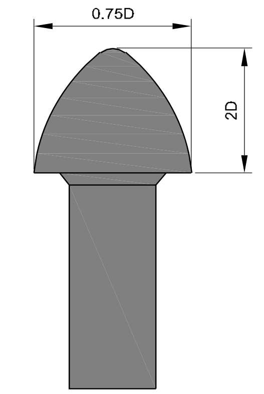
Fig 3



The upper portion of the rivet head is flat and taper. Small diameter of the head is equal to the diameter of the rivet. In heavy engineering, pan head rivets are used.

Conical Head Rivet (Fig 4)

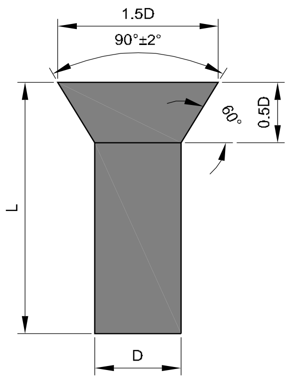
Fig 4



The conical shape is given is used for light jobs. A conical shape is given to the head by a hammer.

Counter Sunk Head Rivet (Fig 5)

Fig 5

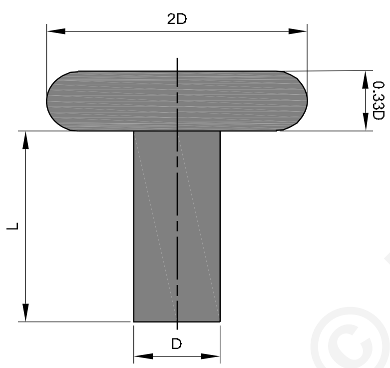


COUNTER SUNK HEAD RIVET

At places where it is necessary to keep the surface plane even after fixing a rivet, this type of rivets is used.

Flat Head Rivet (Fig 6)

Fig 6

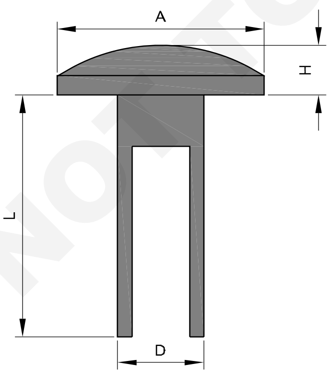


FLAT HEAD RIVET

For small and light jobs of sheet metal, flat head rivets are used. These are generally used in non-ferrous metals and thin sheets. Its head is flat.

Bifurcated rivet (Fig 7)

Fig 7

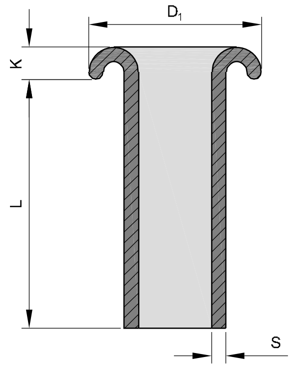


BIFURCATED RIVET

These types of rivets are different from other rivets. These are used for joining chains etc. in place of pins.

Hollow Rivet (Fig 8)

Fig 8

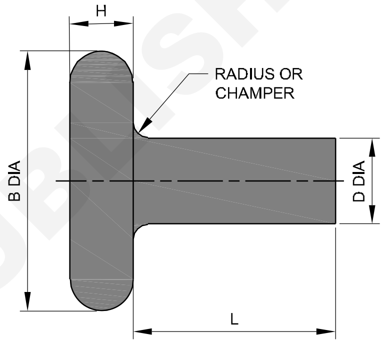


HOLLOW RIVET

Hollow rivets used where a part of the machine moves and it is also necessary to keep this part attached to the machine.

Tinman's Rivets (Fig 9)

Fig 9



TINMAN'S RIVET

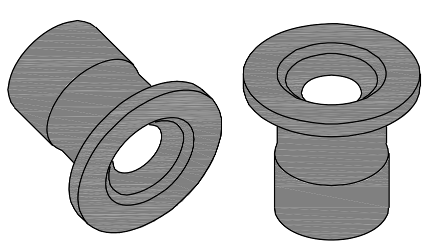
They are small flat headed rivets with relatively short lengths. The size number of tin man's rivets are determined

by the approximate weight per thousand rivets. Each weight of rivet has a definite diameter and length. (Table 1)

Tinmen's rivets are commonly used in light sheet metal work, such as the manufacture of buckets, steel trunks and fabrication of air-conditioning ducts.

Flush rivet (Fig 10)

Fig 10



TINMAN'S RIVET

Flush riveting is a method of connecting two pieces of sheet metal together, using rivets whose heads do not protrude above the surface of the metal. In aircraft construction, a flush rivet reduces drag, thus increasing aircraft performance

A flush rivet takes advantage of a countersink hole; they are also commonly referred to as countersunk rivets

Table 1 Dimensions of tinmen's riverts (Clause 4.1 and Fig 1)						
Rivet	Lencth	Shank	Head Dia		Head Thickness	
Size	(L)	Dia	(B)		(H)	
Designating Number			max	min	max	min
(1)	(2) mm	(3) mm	(4) mm	(5) mm	(6) mm	(7) mm
2	4-0	2-1	4-2	4-0	0-6	0-5
4	4-8	2-4	4-8	4-6	0-6	0-5
6	5-2	2-7	5-6	5-3	0-8	0-6
8	6-0	3-1	6-4	6-0	0-9	0-7
10	6-8	3-8	7-8	7-4	1-1	0-9
12	8-3	4-2	8-5	8-1	1-1	0-9
14	9-1	5-2	10-7	10-2	1-4	1-1
16	11-5	5-6	11-4	10-8	1-5	1-2
18	12-7	6-4	13-0	12-3	1-7	1-4
20	14-3	7-0	14-3	13-6	1-9	1-6

Types of riveted joints

Objectives: At the end of this lesson you shall be able to
- **brief the different types of riveted joints**
- **state the sizes of rivets, lapping allowance pitch and length of rivets**
- **layout the spacing of rivets in chain and zig zag riveting**
- **determine the pitch of the riveting**
- **compare hot and cold riveting.**

In construction and fabrication work different types of riveted joints are made. The commonly used joints are:

– single riveted lap joint

– double riveted lap joint

– single strap butt joint

– double strap butt joint

Single riveted lap joint: This is the simplest and most commonly used type of joint. This joint is useful for joining both thick and thin plates. In this, the plates to be joined are overlapped at the ends and single row of rivets is placed in the middle of the lap.(Fig 1)

Double riveted lap joint: This type of joint will have two rows of rivets. The overlap is large enough to accommodate two rows of rivets.(Fig 2)

Double riveted (Zigzag) lap joint: This provides a stronger joint than a single lap joint. The rivets are placed either in a square formation or in a triangular formation. The square formation of rivet placement is called CHAIN riveting. The triangular formation of rivet placement is called zigzag riveting.(Fig 3)

Single strap butt joint: This method is used in situations where the edges of the components are to be joined by riveting.(Fig 4)

Fig 1

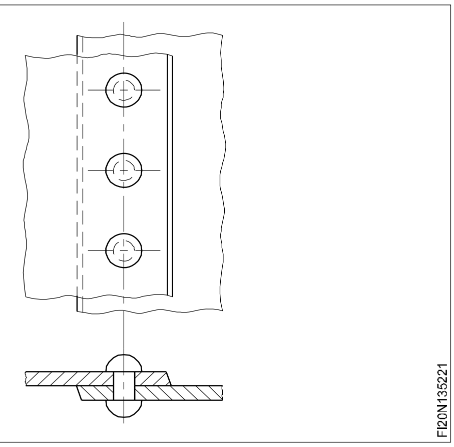


Fig 2

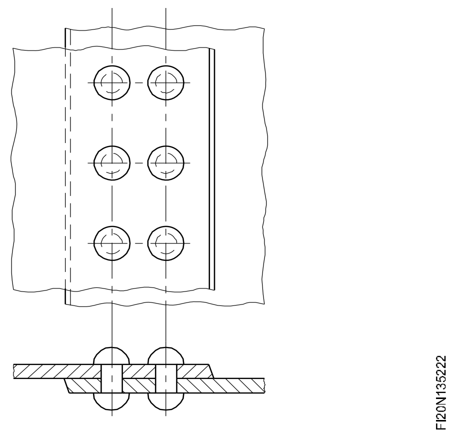


Fig 3

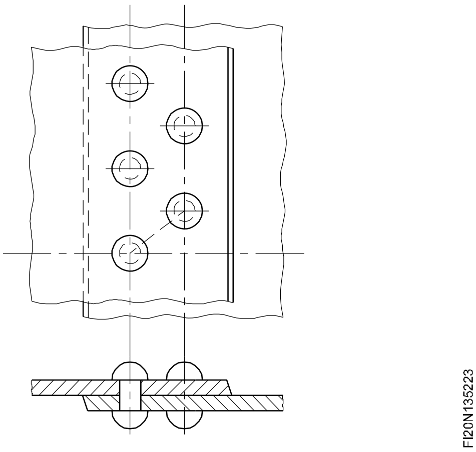
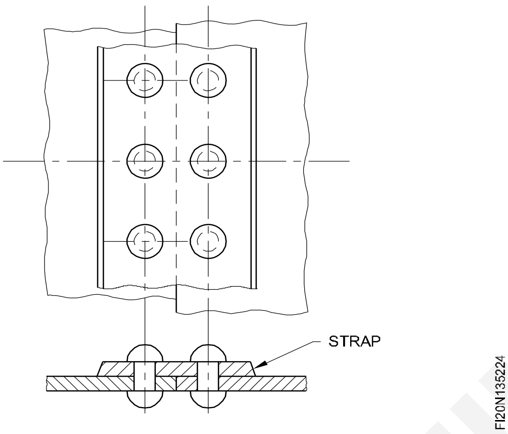


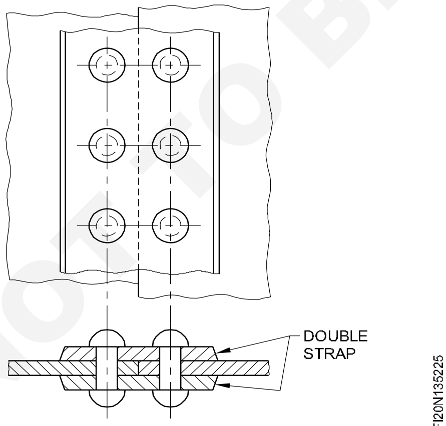
Fig 4



A separate piece of metal called STRAP is used to hold the edges of the components together.

This joint is also used for joining the edges of components together. This is stronger than the single strap butt joint. This joint has two cover plates placed on either side of the components to be assembled.(Fig 5)

Fig 5



When single or double straps are used for riveted butt joints, the arrangement of rivets may be:

- Single riveted i.e one row on either side of the butt.
- double or triple riveted with chain or zigzag formation. (Fig 6)

Layout the spacing of rivet holes in chain riveting

Fig 7 shows the layout of the spacing of rivets holes in chain riveting

Fig 6

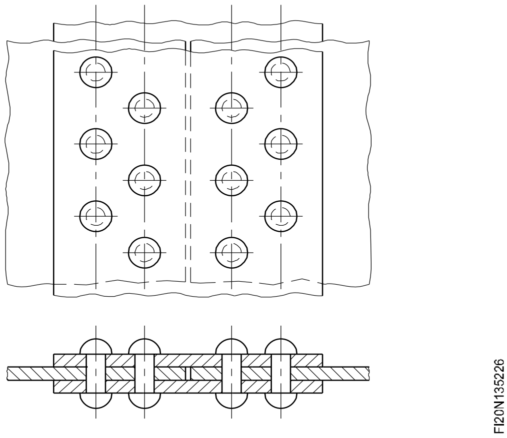
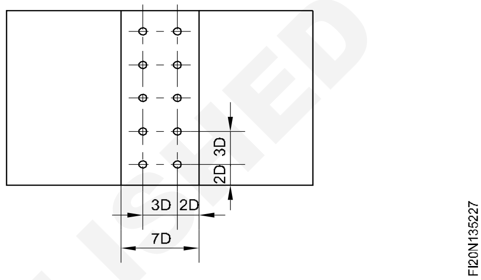


Fig 7



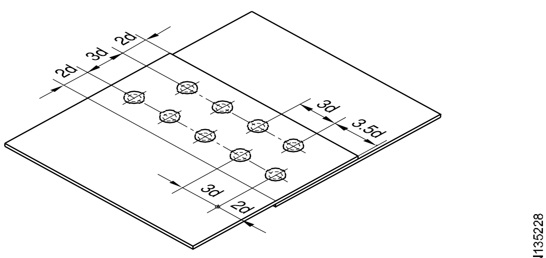
In chain riveting, square formation of rivets is formed in placement of rivets.

Zig Zag Riveting: Zig zag riveting is one type of layout of rivet spacing in veted joint

Zig zag riveting, triangular formation of rivets is formed in placement of rivets.

Layout of spacing for zigzag riveting is shown in Fig 8.

Fig 8

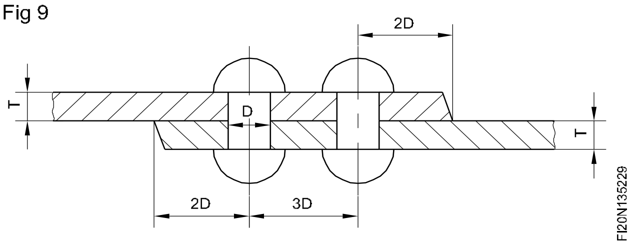


ZIGZAG RIVETING

Spacing of rivets in joints: The spacing of the rivet holes depends upon the job. Given below is a general approach in determining this.

Distance from the edge to the centre of the rivet. (Fig 9)

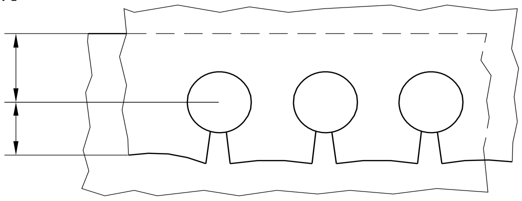
Fig 9



The space or distance from the edge of the metal to the centre of any rivet should be atleast twice the diameter of the rivet.

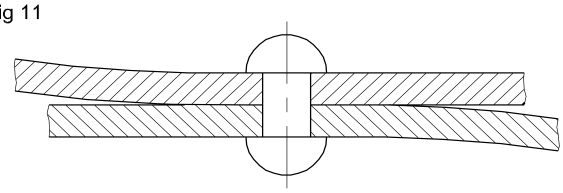
The purpose of this is to prevent the splitting of the edges. The maximum distance from the edge should not be more than ten times the thickness of the plate.(Fig 10)

Fig 10



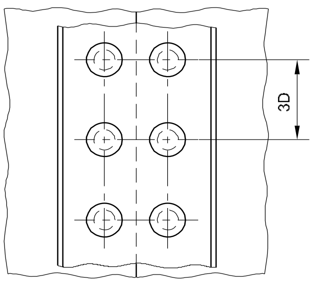
Too much distance from the edge will lead to GAPING. (Fig 11)

Fig 11



Pitch of rivet: The minimum distance between rivets should be three times the diameter of the rivet. (3D) (Fig 12)

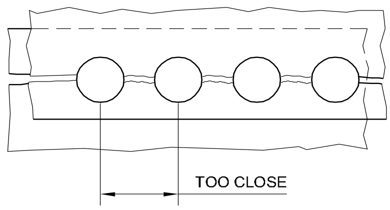
Fig 12



The distance will help to drive the rivets without interference.(Fig 13)

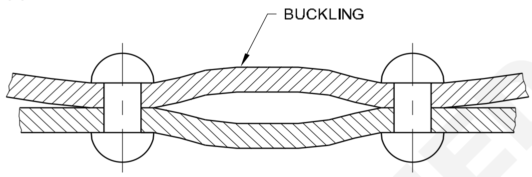
Too closely spaced rivets will tear the metal along the centre line of the rivets.

Fig 13



The maximum distance between the rivets should exceed twenty four times the thickness of the metal.(Fig 14)

Fig 14



Too far a pitch will allow the sheet/plate to buckle between the rivets.

Each rivet consists of a heated cylindrical body.

Sizes of rivets: Sizes of rivets are determined by the diameter and length of the sizes.

Selection of rivet size: The meter of the rivet is calculated by using the formula (2 1/2 to 3) x T where T is total thickness.

Lapping allowance: Normally sheet metal trade we will use the following formula it is three times of the dia of rivet +2 times the sheet thickness on thin sheets.

Pitch allowance: Three of fourness the diameter of rivet +sheet thickness 1 time.

The shank length is given by

Length: L=T=D where T is sheet thickness and D is the diameter of the rivet.

Comparison of hot and cold riveting

Hot Riveting	Cold Rivetting
End of the rivet shank is heated to an elevated temperature prior to up setting	No such heating is carried out up setting is performed at room temperature
Lower pressure is required to apply on die	More pressure is required to apply on the die
External heat source is required	No such heat source is required
Since heating process requires time, so hot riveting is a time consuming process	Cold riveting is time efficient as no heating is carried out
It is suitable when rivet material is ferrous and rivet diameter is about 10mm	For small diameter non-ferrous rivet (like aluminium, brass) cold riveting is suitable

Hand-riveting tools

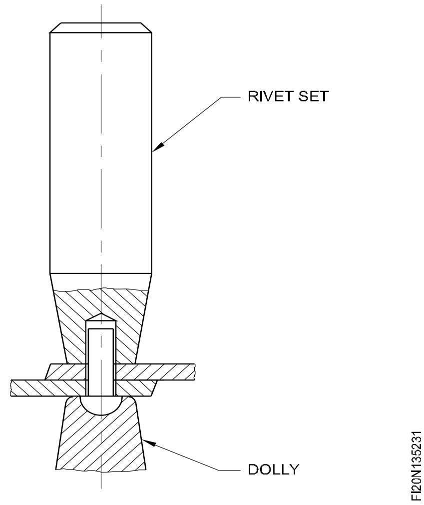
Objectives: At the end of this exercise you shall be able to
- **name the different hand-riveting tools**
- **state the uses of different hand -riveting tools**

Rivet set: It is used for bringing the sheet metal closely together after inserting the rivet in the hole

This is required while riveting thin plates or sheet with small rivets (Fig 1)

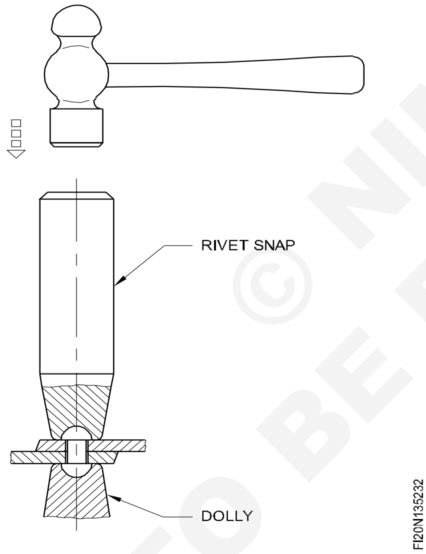
Dolly: It is used to support the head of the rivet which is already formed and also to prevent damage to the shape of the rivet head (Fig 1)

Fig 1



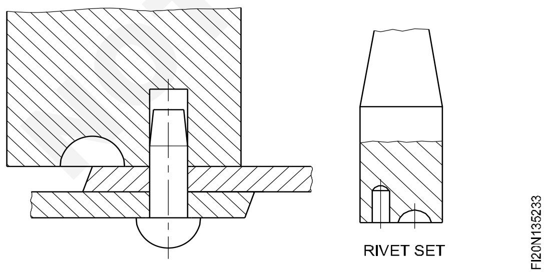
Rivet snap: It is used to form the final shape of the rivet during riveting. Rivet snaps are available to match the different shapes of rivet heads (Fig 2)

Fig 2



Combined rivet set: This is a tool which can be used for setting and forming the head (Fig 3)

Fig 3



Hand riveter: 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: 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)

Fig 4

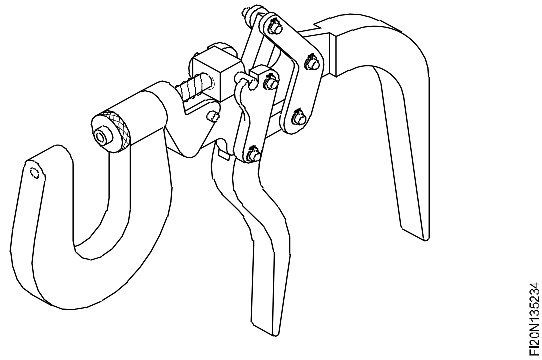
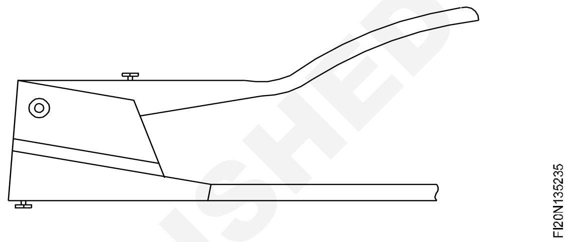
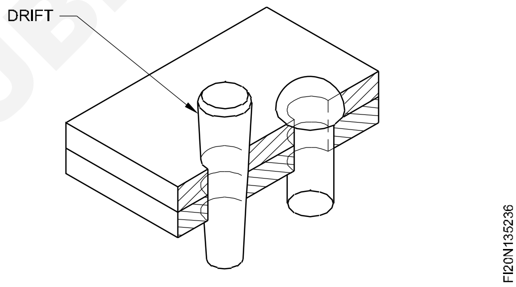


Fig 5



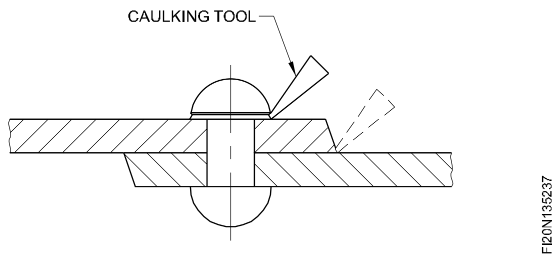
Drift: It is used to align the holes to be riveted. (Fig 6)

Fig 6



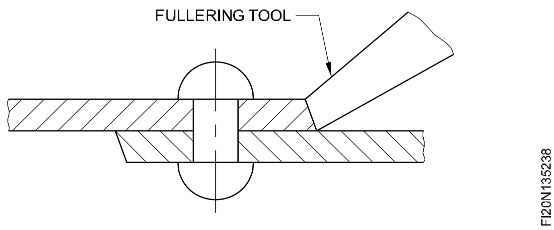
Caulking tool: It is used for closing down the edges of the plates and heads of the rivets to form a metal-to-metal joint (Fig 7)

Fig 7



Fullering tool: It is used for pressing the surface of the edge of the plate (Fig 8) Fullering helps to make fluid-tight joints.

Fig 8



Safety

Objectives: At the end of this lesson you shall be able to
- **state the importance of safety in welding shop**
- **list the general safety precautions to be observed in welding shop.**

Safety

Welding can be dangerous and unhealthy if the proper precautions are not taken. However, using new technology and proper protection greatly reduces risks of injury and death associated with welding. Since many common welding procedures involve an open electric arc or flame, the risk of burns and fire is significant, that is why it is classified as a hot work process.

To prevent injury, welders wear personal protective equipment in the form of heavy leather gloves and protective long-sleeve jackets to avoid exposure to extreme heat and flames. Additionally, the brightness of the weld area leads to a condition called arc eye or flash burns in which ultraviolet light causes inflammation of the cornea and can burn the retinas of the eyes. Goggles and welding helmets with dark UV-filtering face plates are worn to prevent this exposure.

Since the 2000s, some helmets have included a face plate which instantly darkens upon exposure to the intense UV light. To protect bystanders, the welding area is often surrounded with translucent welding curtains. These curtains, made of a polyvinyl chloride plastic film, shield people outside the welding area from the UV light of the electric arc, but can not replace the filter glass used in helmets.

Welders are often exposed to dangerous gases and particulate matter. Processes like flux-cored arc welding and shielded metal arc welding produce smoke containing particles of various types of oxides. The size of the particles in question tends to influence the toxicity of the fumes, with smaller particles presenting a greater danger. This is because smaller particles have the ability to cross the blood brain barrier. Fumes and gases, such as carbon-di-oxide, ozone, and fumes containing heavy metals, can be dangerous to welders lacking proper ventilation and training. Exposure to manganese welding fumes, for example, even at low levels (<0.2 mg/m^3) may lead to neurological problems or to damage to the lungs, liver, kidneys, or central nervous system. Nano particles can become trapped in the alveolar macrophages of the lungs and induce pulmonary fibrosis. The use of compressed gases and flames in many welding processes possess an explosion and fire risk. Some common precautions include limiting the amount of oxygen in the air, and keeping combustible materials away from the workplace.

General safety

- To prevent injury to personnel, extreme caution should be exercised when using any types of welding equipment. Injury can result from fire, explosions, electric shock, or harmful agents. Both the general and specific safety precautions listed below must be strictly observed by workers who weld or cut metals.
- Do not permit unauthorized persons to use welding or cutting equipment.
- Do not weld in a building with wooden floors, unless the floors are protected from hot metal by means of fire resistant fabric, sand, or other fireproof material. Be sure that hot sparks or hot metal will not fall on the operator or on any welding equipment components.
- Remove all flammable material, such as cotton, oil, gasoline, etc., from the vicinity of welding.
- Before welding or cutting, warm those in close proximity who are not protected to wear proper clothing or goggles.
- Remove any assembled parts from the component being welded that may become warped or otherwise damaged by the welding process.
- Do not leave hot rejected electrode stubs, steel scrap, or tools on the floor or around the welding equipment. Accidents and/or fires may occur.
- Keep a suitable fire extinguisher nearby at all times. Ensure the fire extinguisher is in operable condition.
- Mark all hot metal after welding operations are completed. Soapstone is commonly used for this purpose.

Safety precautions in handling gas welding plant

Objectives : At the end of this lesson you shall be able to
- **state the general safety precautions in oxy-acetylene plants.**
- **state the safety rules for handling gas cylinders**
- **state the safety practices for handling gas regulators and hose-pipes.**
- **state the safety precautions related to blowpipe operations.**

To be accident-free, one must know the safety rules first and then practise them as well. As we know can 'accident starts when safety ends'.

Ignorance of rules is no excuse!

In gas welding, the welder must follow the safety precautions in handling gas welding plants and flame-setting to keep himself and others safe.

Safety precautions are always based on good common sense.

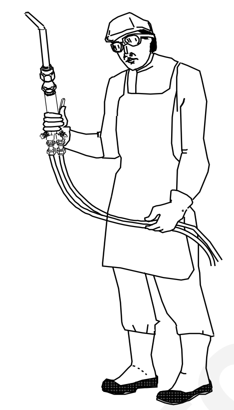
The following precautions are to be observed, to keep a gas welder accident-free.

General safety

Do not use lubricants (oil or grease) in any part or assembly of a gas welding plant. It may cause explosion.

Keep all flammable material away from the welding area. Always wear goggles with filter lens during gas welding. (Fig 1)

Fig 1



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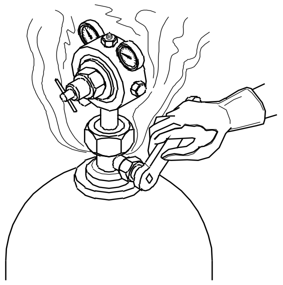
Always wear fire resistant clothes, asbestos gloves and apron.

> **Never wear nylon, greasy and torn clothes while welding.**

Whenever a leakage is noticed rectify it immediately to avoid fire hazards. (Fig 2)

Fig 2



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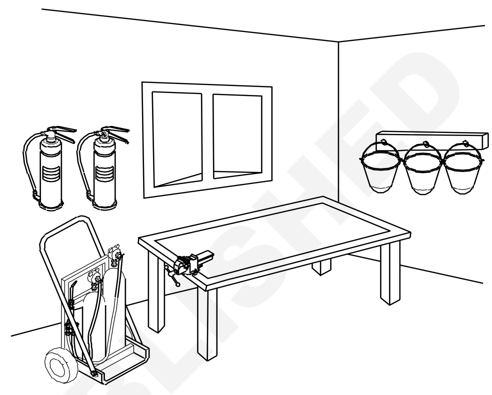
Even a small leakage can cause serious accidents.

Always keep fire-fighting equipment handy and in working order to put out fires. (Fig 3)

Keep the work area free from any form of fire.

Fig 3



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Safety precautions before gas welding

Safety for cylinders.

Do not roll gas cylinders or use them as rollers.

Use a trolley to carry the cylinders.

Close the cylinder valves when not in use or empty.

Keep full and empty cylinders separately.

Always open the cylinder valves slowly, not more than one and a half turn.

Use the correct cylinder keys to open the cylinders.

Do not remove the cylinder keys from the cylinders while welding. It will help to close the cylinders QUICKLY in the case of a back-fire or flash-back.

Always use the cylinders in an upright position for easy handling and safety.

Always crack the cylinder valves to clean the valve sockets before attaching regulators. (Fig 4)

Fig 4

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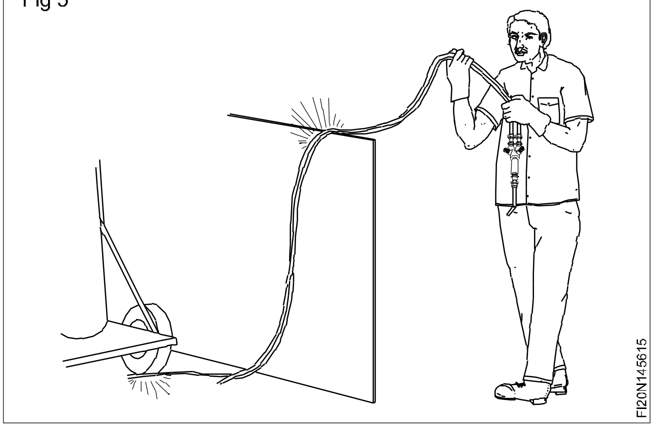
Safety for rubber hose pipes (Fig 5)

Fig 5



Inspect the rubber hose pipes periodically and replace the damaged ones.

Do not use odd bits of hose pipes / tubes.

Do not replace the hose pipes for acetylene with the ones used for oxygen.

Always use a black hose pipes for oxygen and maroon hosepipes for acetylene.

Safety for regulators

Prevent hammer blows to the gas cylinders and ensure that water, dust and oil do not settle on the cylinders.

One right hand threaded connection for oxygen and left hand threaded connection for acetylene.

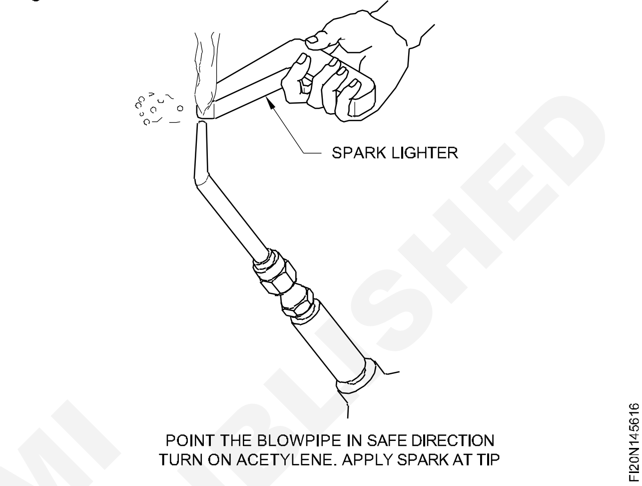
Safety for blowpipes

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

When flame snaps out and backfires, quickly shut both the blowpipe valves (oxygen first) and dip in water.

While igniting the flame, point the blowpipe nozzle in a safe direction. (Fig 6)

Fig 6



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

Safety precautions before, during, after arc welding

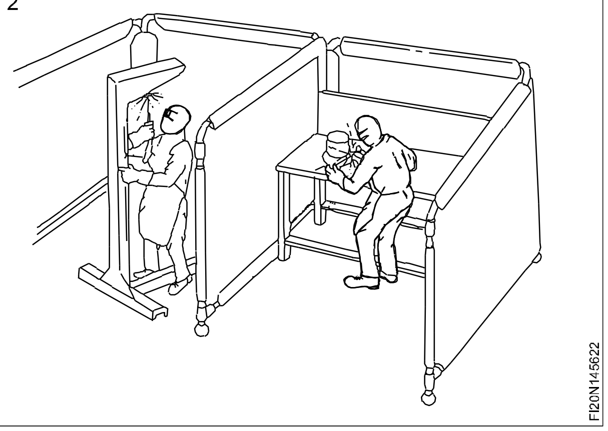
Objective : At the end of this lesson you shall be able to
- **state the precautions necessary in arc-welding.**

Safety precautions

- Never stand on a damp or wet place while arc-welding.
- Always wear all the safety apparels (gloves, apron, sleeves, shoes). (Fig 1)
- Use welding and a chipping screen during welding and chipping respectively, for the protection of the eyes and the face.
- Switch off the machine when not in use.
- Keep the clothes free from oil and grease.
- Use tongs while handling hot metals.
- Do not carry matches or petrol lighters in your pocket during arc-welding.
- Protect the outsiders from radiation and reflection of rays, by using portable screens or welding booths. (Fig 2)
- Keep the welding area free from moisture and flammable material.
- Do not try to rectify electrical faults yourself; call an electrician.

Fig 1

Fig 2



- Do not throw the electrode stubs on the floor. Put them in a container. (Fig 3)
- Use exhaust fans to remove the arc-welding smoke and fumes. (Fig 4)
- Safety precautions after gas and electric welding after working gas welding and gas cutting bleed the lines to take pressure off regulators, neatly coil the hoses and replace equipment.
- Store hoses, torches, blow pipes regulators safety in proper place.
- Store away the gas cylinders from in flammable and combustible materials.
- After electric welding operations are completed the welder will mark the hot metal or provide some other means of warning other workers.

Fig 3

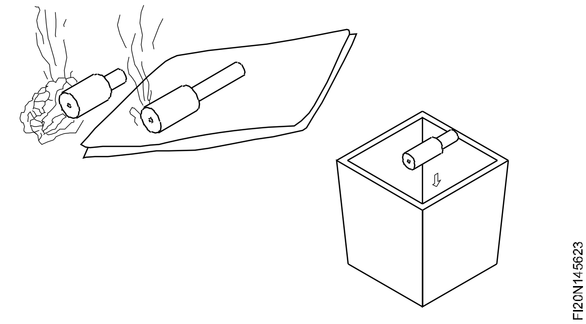
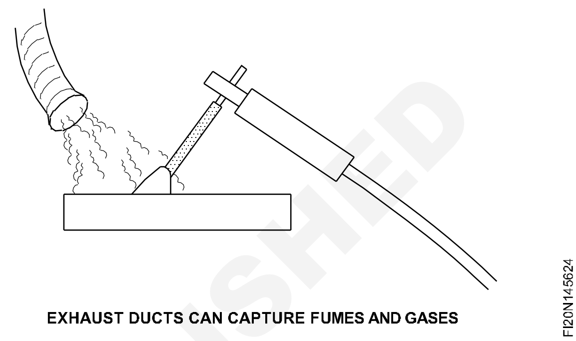


Fig 4



EXHAUST DUCTS CAN CAPTURE FUMES AND GASES

- Welding machines will be disconnected from the power source.
- Disconnect the welding cables from welding equipment.
- Neatly coil the cable and kept in place safety.
- Place and store electrode holder and other hand tools safely.

Safety equipment and their uses in welding

Objectives : At the end of this lesson you shall be able to
- **Name the safety apparels and accessories used in arc welding**
- **Select the safety apparels and accessories to protect from burns and injuries**
- **learn how to protect yourself and others from the effect of harmful arc rays and toxic fumes**
- **select the shielding glass for eye and face protection.**

Non-fusion welding: This is a method of welding in which similar or dissimilar metals are joined together without melting the edges of the base metal by using a low melting point filler rod but without the application of pressure.

Example: Soldering, Brazing and Bronze welding.

During arc welding the welder is exposed to hazards such injury due to harmful rays (ultra violet and infra red rays)of the arc, burns due to excessive heat from the arc and contact with hot jobs, electric shock, toxic fumes, flying hot spatters and slag particles and objects falling on the feet.

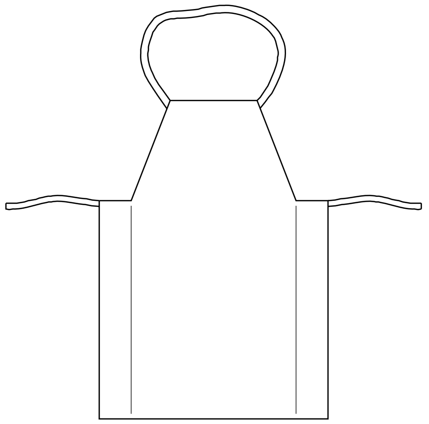
The following safety apparels and accessories are used to protect the welder and other persons working near the welding area from the above mentioned hazards.

1 Safety apparels
   a Leather apron
   b Leather gloves
   c Leather cape with sleeves
   d Industrial safety shoes
2 a Hand screen
   b Adjustable helmet
   C Portable fire proof canvas screens
3 Chipping/grinding goggles
4 Respirator and exhaust ducting

The leather apron, glooves, cape with sleeves and leg guard Fig 1,2,3 and 4 are used to protect the body, hands, arms, neck and chest of the welder from the heat radiation and hot spatters from the arc and also from the hot slag particles flying from the weld joint during chipping off the solidified slag.

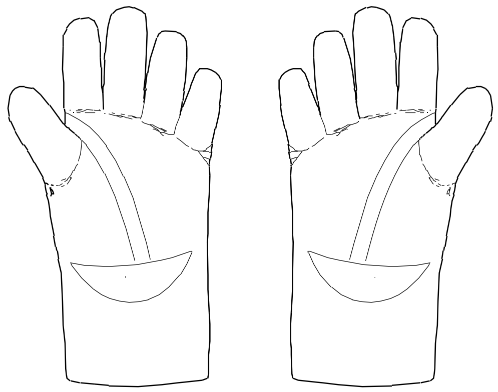
All the above safety apparels should not be loose while wearing them and suitable size has to be selected by the welder.

Fig 1



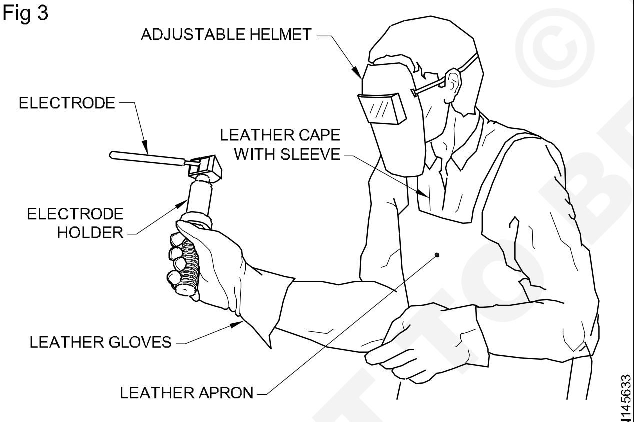
APRON

Fig 2



GLOVES

Fig 3



CAPE WITH SLEEVES

The industrial safety boot (Fig5)is used to avoid slipping. injury to the toes and ankle of the foot. It also protects the welder from the electric shock as the sole of the shoe is specially made of shock resistant material.

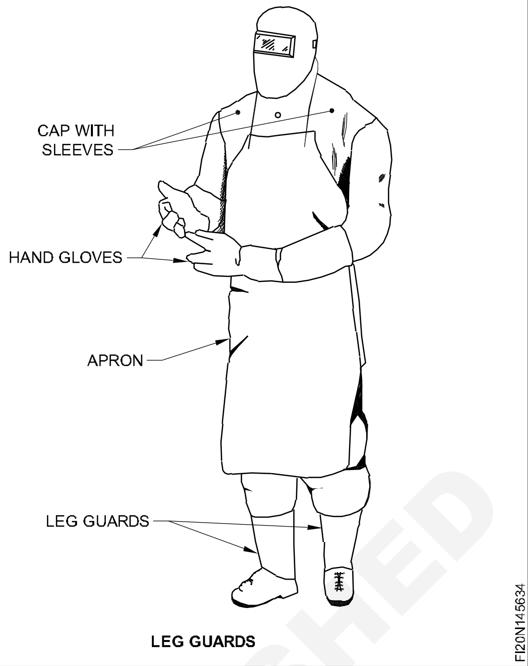
Welding hand screens and helmet: These are used to protect the eyes and face of a welder from arc radiation and sparks during arc welding.

A hand screen is designed to hold in hand (Fig 6)

A helmet screen is designed to wear on the head.(Fig 7)

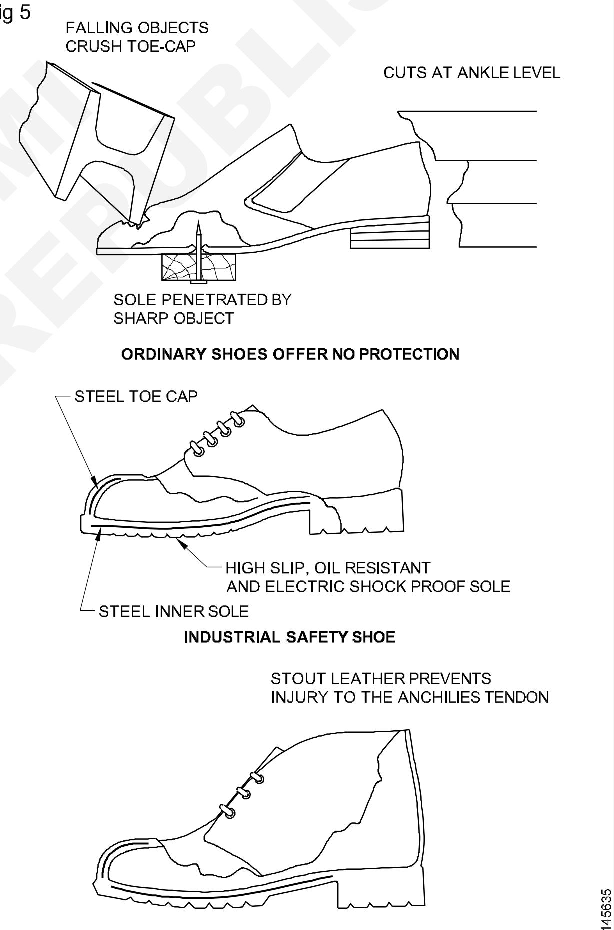
Clear glasses are fitted on each side of the coloured glass to protect it from weld spatters. (Fig 8)

Fig 4



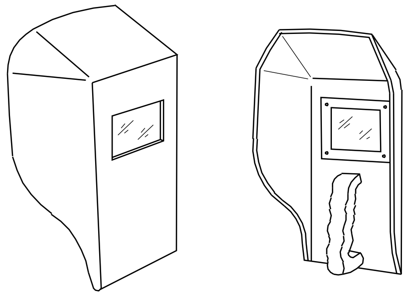
LEG GUARDS

Fig 5



INDUSTRIAL SAFETY BOOT

Fig 6



HAND SCREEN

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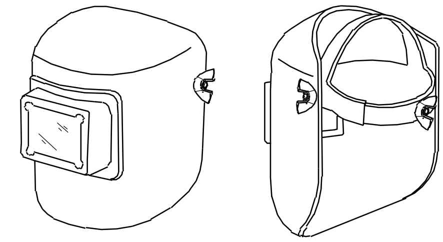
Fig 7



WELDING HELMET

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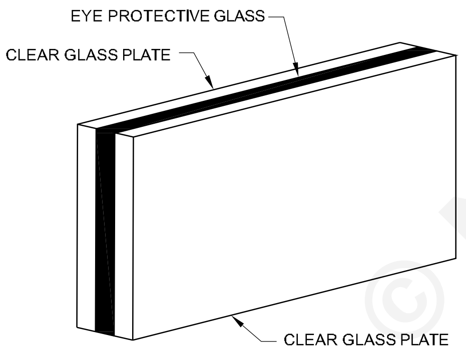
Fig 8



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The helmet screen provides better protection and allows the welder to use his both hands freely.

Coloured (filter) glasses are made in various shades depending on the welding current ranges used. (Table 1)

Table 1

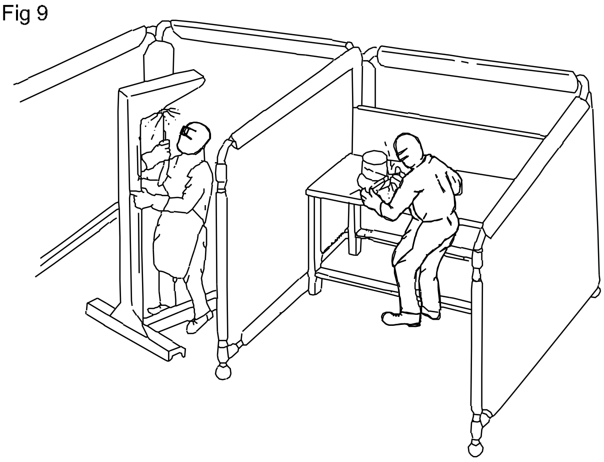
Recommendations of filter glasses for manual metal arc welding

Shade No of coloured glass	Range of welding current current in amperes
8-9	Up to 100
10-11	100 to 300
12-14	Above 300

Portable fire proof canvas screens. Fig 9 are used to protect the persons who work near the welding area from arc flashes

Plain goggles are used to protect the eyes while chipping the slag or grinding the job. Fig 10

Fig 9



PORTABLE FIREPROOF CANVAS SCREENING

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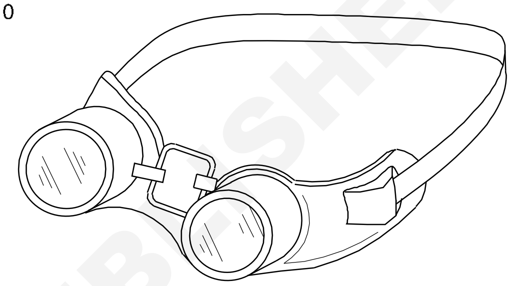
Fig 10



SAFETY GOGGLES

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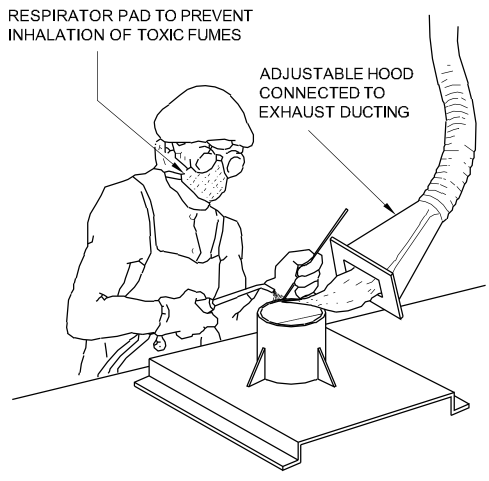
It is made of Bakelite frame fitted with clear glasses and an elastic band to hold it securely on the operator's head.

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

Sometimes toxic fumes and heavy smoke may be liberated (given out) from the weld while welding non-ferrous alloys like brass etc. Use a respirator and use exhaust ducts and fans near the weld area to avoid inhaling the toxic fumes and smoke. Fig 11.

Fig 11



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Inhaling toxic fumes will make the welder to become unconscious and fall on the hot welded job/ on the floor. This causes burns or injury.

Gas welding equipment and accessories

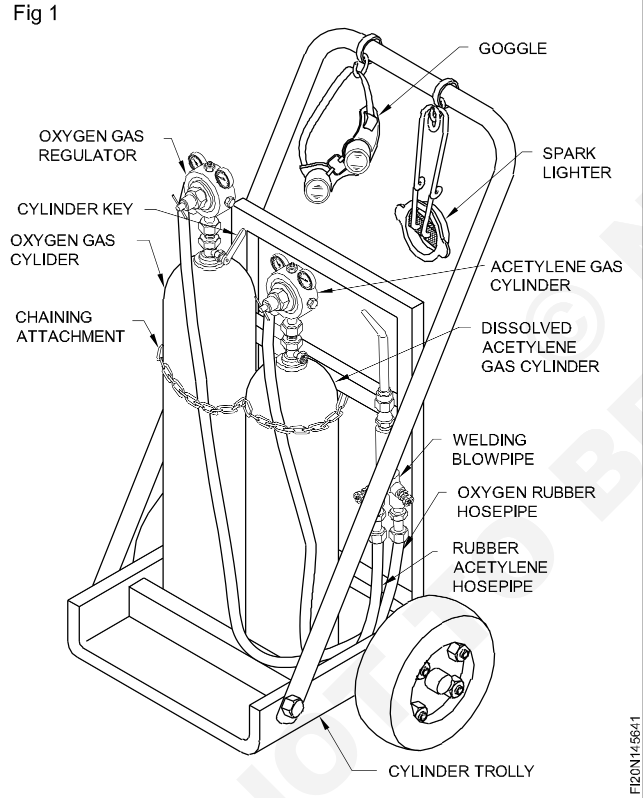
Objectives : At the end of this lesson you shall be able to
- **brief the process of gas welding**
- **list the equipment used in gas welding**
- **state the functions of each equipment used in gas welding.**

Oxy-acetylene welding, popularly known as gas welding is simple, cheap and easy to operate. The heat input can be closely controlled to weld even thin, tiny components. In oxy-acetylene welding process, the metal is heated by an intense flame (3300ºC) produced by burning proper quantity of oxygen and acetylene at the tip of welding torch. The flame is directed towards the weld location to melt the metal to be joined and are fused together thus producing weld.

Gas welding equipment

The principle function of the oxy-acetylene welding equipment is to supply the oxy-acetylene gas mixture in the correct ratio to the welding tip at the correct rate of flow and velocity. (Fig 1)

Fig 1

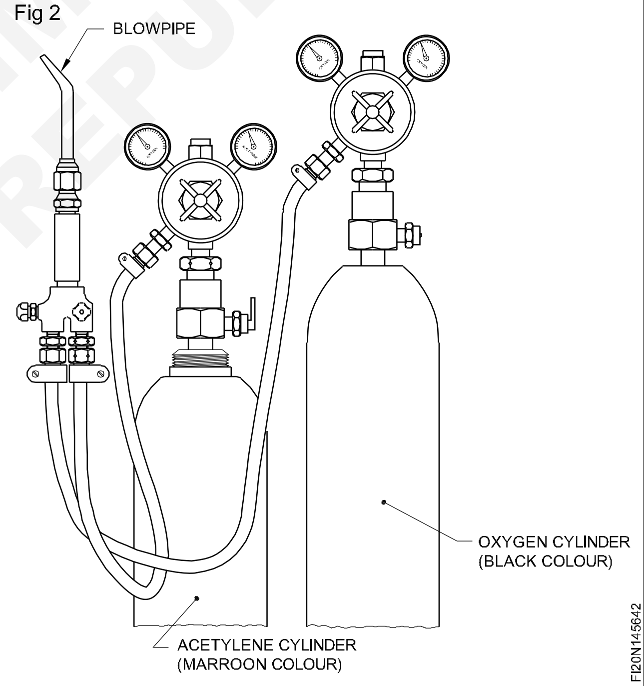


The basic equipment used to carry out gas welding are

- Oxygen gas cylinder
- Acetylene gas cylinder
- Oxygen pressure regular
- Oxygen gas hose (black/green)
- Acetylene gas hose (Maroon)
- Welding torch or blow pipe with a set of nozzles and gas lighter.
- Trolleys for transportation of oxygen and acetylene cylinder.
- A set of keys and spanners
- Filler rod and fluxes
- Protective clothing for welder (Leather apron, gloves, goggles, etc)

Oxygen gas cylinders: The oxygen gas required for gas welding is stored in bottle-shaped cylinders. These cylinders are painted in black colour. (Fig 2) Oxygen cylinders can store gas to a capacity of $7m^3$ with the pressure ranging between 120 to 150 kg/cm^2. Oxygen gas cylinder valves are right hand threaded.

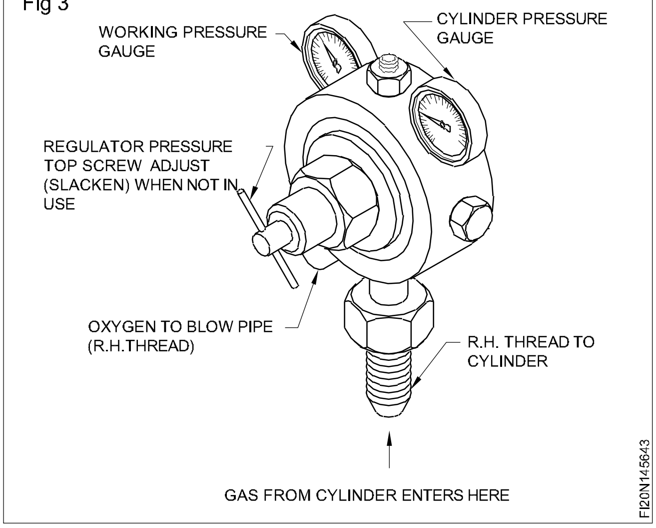
Fig 2



Dissolved acetylene cylinders: The acetylene gas used in gas welding is stored in steel bottles (cylinders) painted in maroon colour. The normal storing capacity of storing acetylene in dissolved state is $6m^3$ with the pressure ranging between 15-16 kg/cm^2.

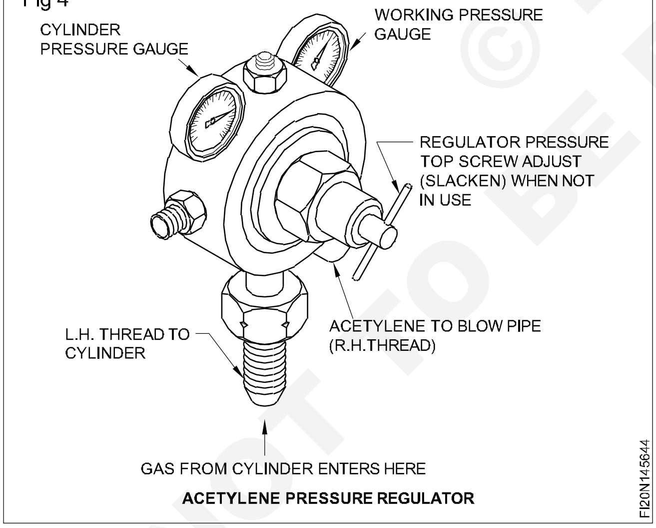
Oxygen pressure regulator: This is used to reduce the oxygen cylinder gas pressure according to the required working pressure and to control the flow of oxygen at a constant rate to the blowpipe. The threaded connections are right hand threaded. (Fig 3)

Fig 3



Acetylene regulator: As with the case of oxygen regulator this also is used to reduce the cylinder gas pressure to the required working pressure and to control the flow of acetylene gas at a constant rate to the blowpipe. The threaded connections are left handed. For quickly identifying the acetylene regulator, a groove is cut at the corners of the nut.(Fig 4)

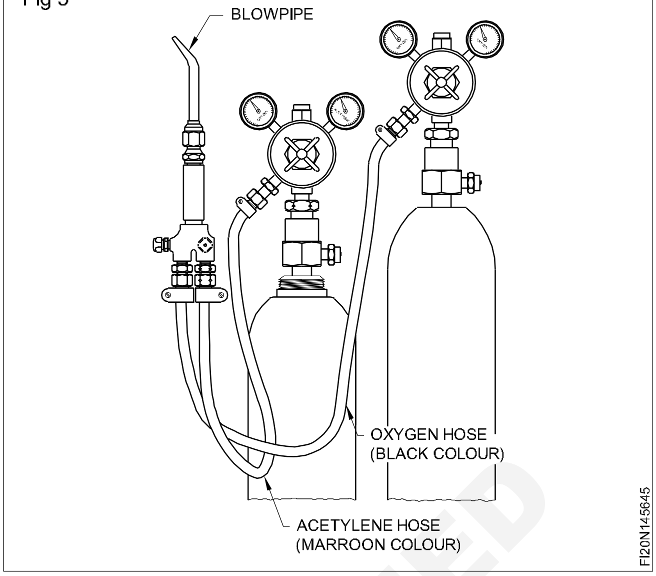
Fig 4



ACETYLENE PRESSURE REGULATOR

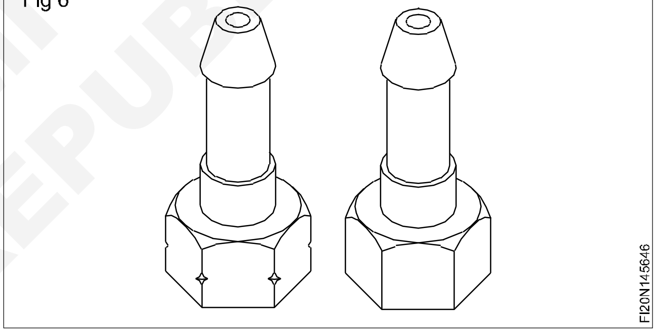
Rubber hose-pipes and connections: These are used to carry gas from the regulator to the blowpipe. These are made of strong canvas rubber having good flexibility. Hose-pipes which carry oxygen are black in colour and the acetylene hoses are of maroon colour. (Fig 5)

Fig 5



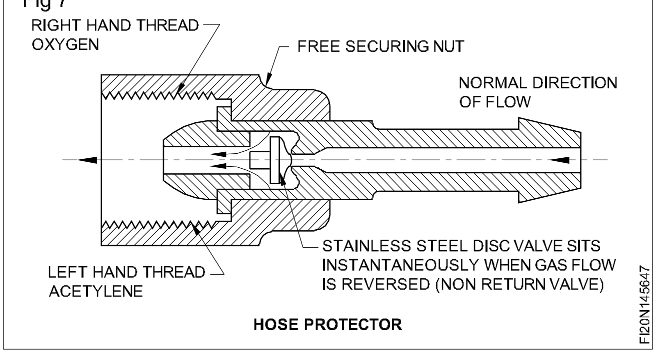
Rubber hoses are connected to regulators with the help of unions. These unions are right hand threaded for oxygen and left hand threaded for acetylene. Acetylene hose unions have a groove cut on the corners. (Fig 6)

Fig 6



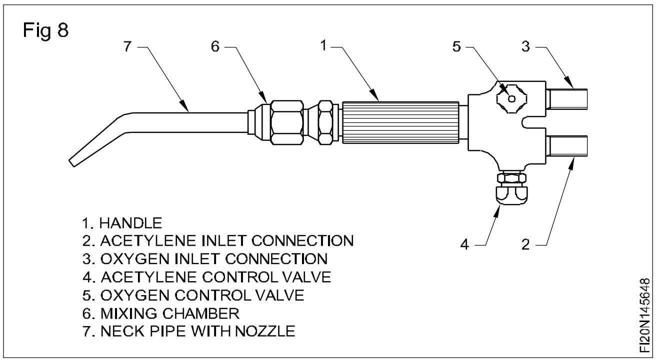
At the blowpipe end of the rubber hoses hose-protectors are fitted. The hose protectors are in the shape of a connecting union and have a non-return disc fitted inside to protect from flashback and backfire during welding. (Fig 7)

Fig 7

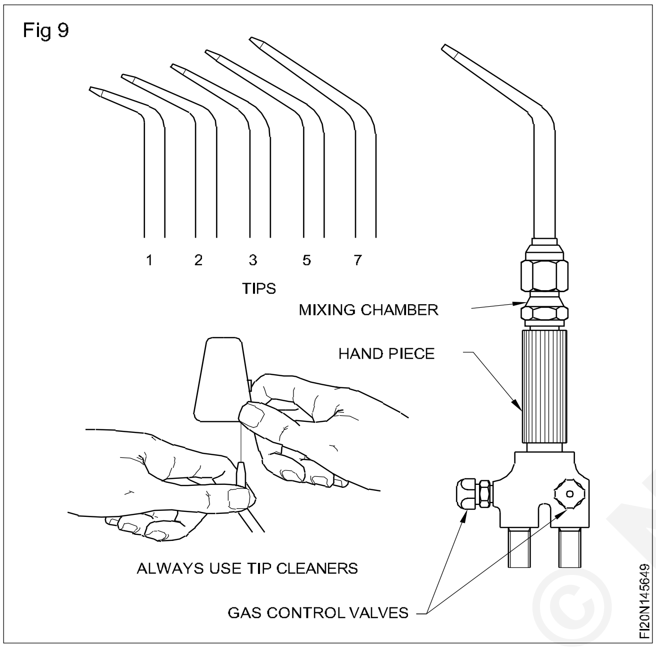


HOSE PROTECTOR

Blowpipe and nozzle: Blowpipes are used to control and mix the oxygen and acetylene gases to the required proportion. (Fig 8)



A set of interchangeable nozzles/tips of different sizes is available to produce smaller or bigger flames. (Fig 9)



The size of the nozzle varies according to the thickness of the plates to be welded. (Table 1)

TABLE 1

Plate thickness (mm)	Nozzle size (Number)
0.8	1
1.2	2
1.6	3
2.4	5
3.0	7
4.0	10
5.0	13
6.0	18
8.0	25
10.0	35
12.0	45
19.0	55
25.0	70
Over 25.0	90

Arc welding machines and accessories

Objectives : At the end of this lesson you shall be able to
- **state the function of arc-welding machines**
- **name the different types of arc-welding machines.**

In the arc-welding process, the source of heat is electricity (high ampere low voltage). This heat is supplied by the arc-welding machine which is the power source.

Function (Fig 1)

The equipment is used to

– provide A.C. or D.C. supply for arc welding

– change the high voltage of main supply (A.C.) to low voltage, heavy current (A.C. or D.C.) suitable for arc welding

– control and adjust the required supply of current during arc welding

Types (Fig 2)

Basically the power sources are

– alternating current (A.C.) welding machine

– direct current (D.C.) welding machine.

Fig 1

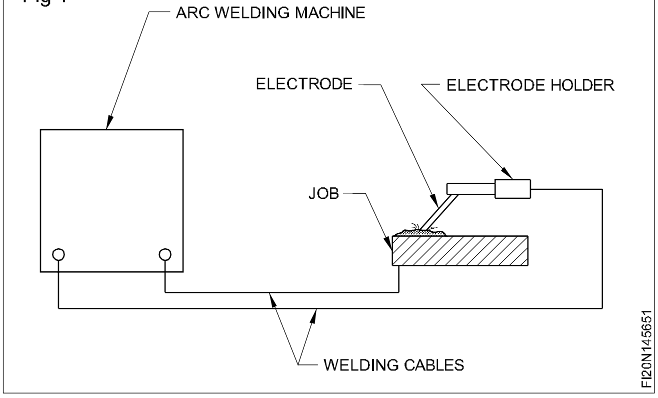
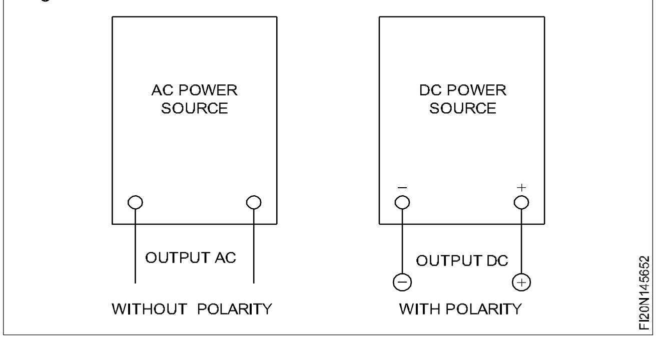


Fig 2



These may be further classified as

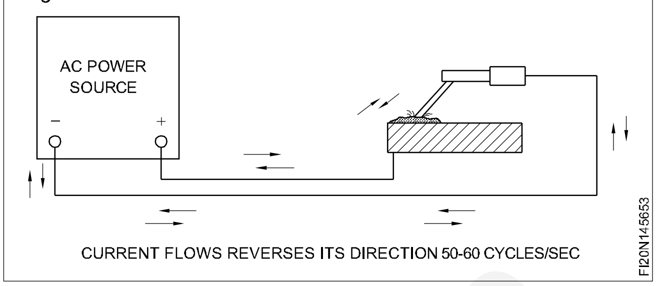
- D.C.Machines
- motor generator set
- engine generator set
- rectifier sets.

A.C. Machines

- Transformer sets

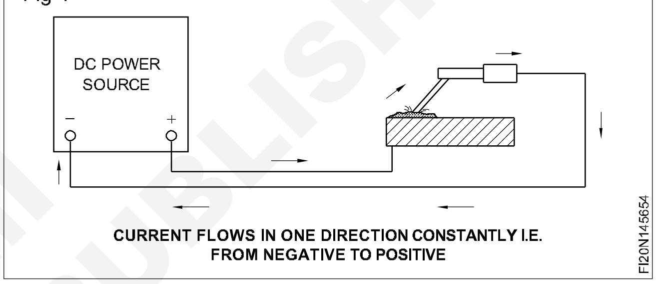
A.C. means Alternating Current. It changes or reverses its direction of flow 50-60 cycles per second. (Fig 3)

Fig 3



D.C. means Direct Current. It flows steadily and constantly in one direction. (Fig 4)

Fig 4



A.C. welding transformer and welding generator

Objectives : At the end of this lesson you shall be able to
- **state the features of A.C. welding transformers**
- **state the advantages and disadvantages of A.C. welding machines.**

A.C. welding transformer

An A.C. welding transformer is a type of A.C. welding machine which converts the A.C. main supply into an A.C. welding supply. (Figs 1 and 2)

The A.C. main supply has high voltage - low ampere.

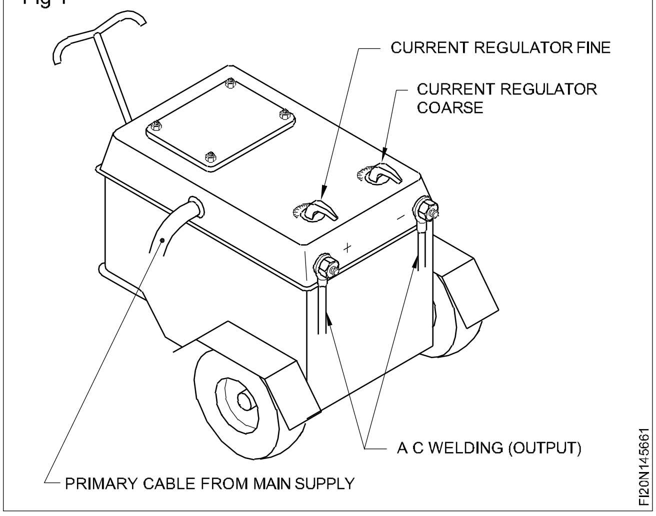
The A.C. welding supply has high ampere - low voltage.

It is a STEP-DOWN transformer which reduces the main supply voltage (220 or 440 volts) to the welding supply open circuit voltage (O.C.V.), between 40 and 100 volts.

It increases the main supply low current to the required output welding current in a hundred or thousand amperes.

The A.C. welding machine cannot be operated without the A.C. main supply.

Fig 1



Advantages

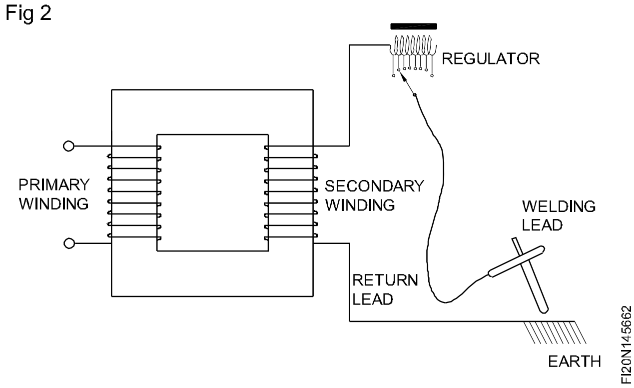
- Less initial cost
- Less maintenance cost
- Freedom from arc blow.

Magnetic effect which disturbs the arc is called the arc blow.

Disadvantages

- Not suitable for the welding of non-ferrous metals, light coated and special electrodes.
- The A.C. cannot be used without special safety precautions.

Fig 2



D.C. Arc-welding machines

Objectives : At the end of this lesson you shall be able to
- **state the features of a D.C. welding machine**
- **state its advantages and disadvantages.**

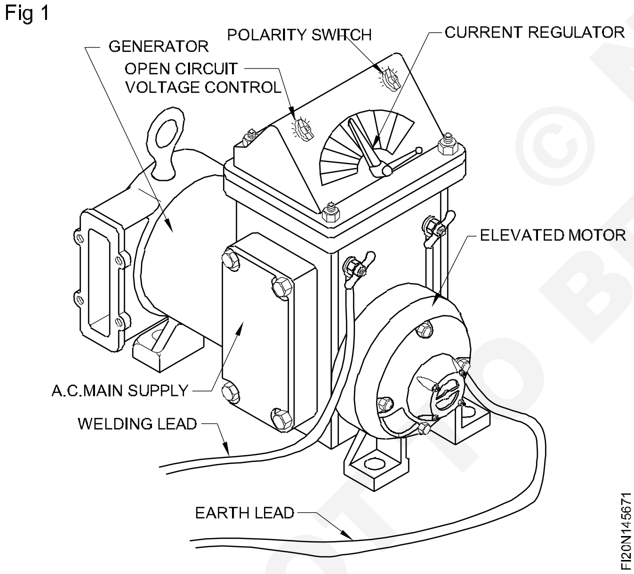
Motor generator set (Fig 1)

It is used to generate D.C. for arc-welding.

The generator is driven by an A.C. or D.C. motor.

Main supply is a must to run the machine.

Fig 1



Engine generator set (Fig 2)

Equipment is similar to the motor generator set except that the generator is driven by a petrol or diesel engine.

Its running and maintenance charges are higher.

It can be used anywhere in field work, away from electric lines.

Rectifier set (Fig 3)

It is used to convert A.C. into D.C. welding supply.

Basically it is an A.C. welding transformer. The output of the transformer is connected with a rectifier to change the A.C. into D.C.

Fig 2

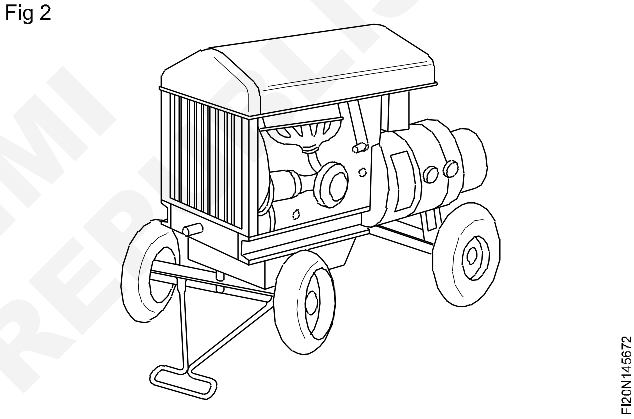
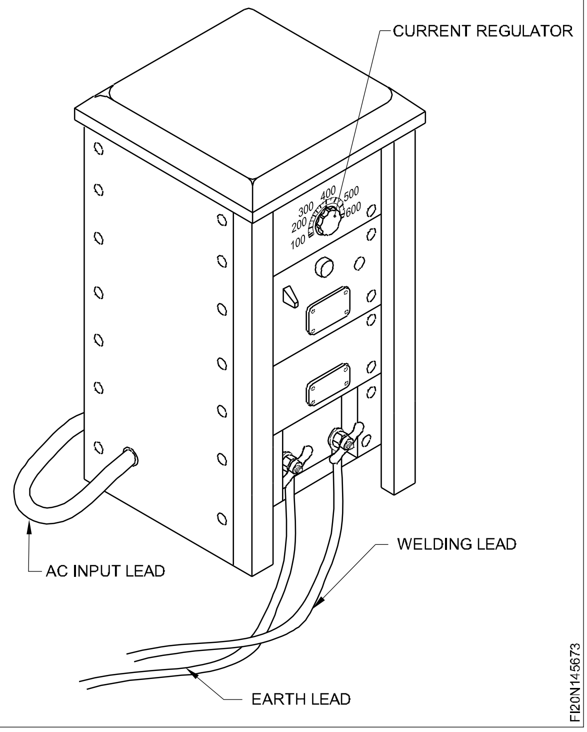


Fig 3



It may be designed to supply both A.C. and D.C. currents for welding (called A.C.-D.C. rectifier set).

Advantages

Suitable for welding all ferrous and non-ferrous metals using all types of electrodes

- Better heat distribution in the electrode and job due to polarity in the welding current supplies constant main load and accurate current setting.

It ensures safe working.

Disadvantages

- Initial cost is higher
- Maintenance cost is more
- Arc-blow trouble faced at certain times.

Polarity in arc welding

Objectives : At the end of this lesson you shall be able to
- **state what is polarity in arc welding**
- **state the types of polarity.**

Polarity in D.C. power source

The polarity of a machine refers to the direction of the current flow.

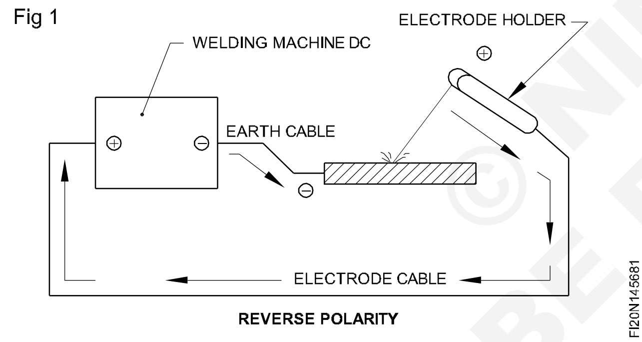
The polarity can be obtained only in D.C.

Polarity may be straight or reverse.

Reverse polarity (Fig 1)

When the electrode cable is connected to the positive terminal, it is called positive polarity or reverse polarity.

Fig 1



Straight polarity (Fig 2)

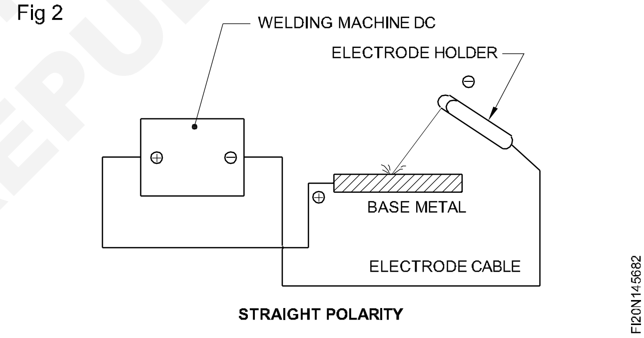
When the electrode cable is connected to the negative terminal as it is called negative polarity or straight polarity.

Remember

A.C. has no polarity

The total heat produced in D.C. arc consists of 2/3 heat from the POSITIVE Terminal (66%) and 1/3 heat from the NEGATIVE Terminal (33%).

Fig 2



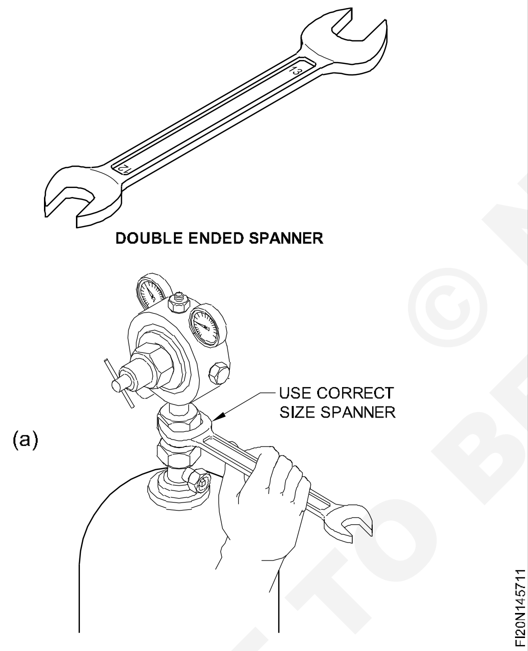
Welding hand tools

Objectives: At the end of this lesson you shall be able to
- **name the hand tools used by a welder**
- **state their uses**
- **state the care and maintenance to keep the hand tools in good working condition.**

The following are the details of different hand tools used by a welder.

Double ended spanner: A double ended spanner is shown in Fig.1 and 1a. It is made of forged chrome vanadium steel. It is used to loosen or tighten nuts, bolts with hexagonal or square heads. The size of the spanner is marked on it as shown in Fig.1. In welding practice the spanners are used to fix the regulator onto the gas cylinder valves, hose connector and protector to the regulator and blow pipe, fix the cable lugs to the arc welding machine output terminals, etc.

Fig 1



Do not use the spanner as a hammer; use the correct size spanner to avoid damage to the nut/bolt head.

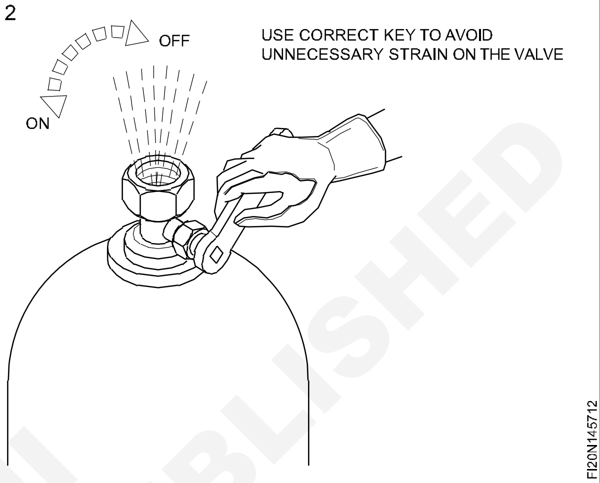
Cylinder key: A cylinder key is shown in Fig.2. It is used to open or close the gas cylinder valve socket to permit or stop the gas flow from the cylinder to the gas regulator.

Always use correct size key to avoid damage to the square rod used to operate the valve. The key must always be left on the valve socket itself so that the gas flow can be stopped immediately in case of flash back/back fire.

Nozzle or tip cleaner

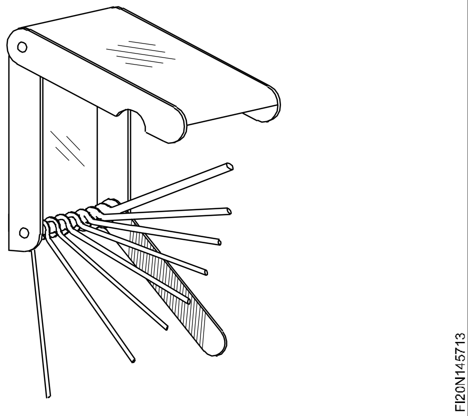
Cleaning the tip: All welding torch tips are made of copper. They can be damaged by the slightest rough handling-dropping, tapping or chopping with the tip on the work may damage the tip beyond repair.

Fig 2



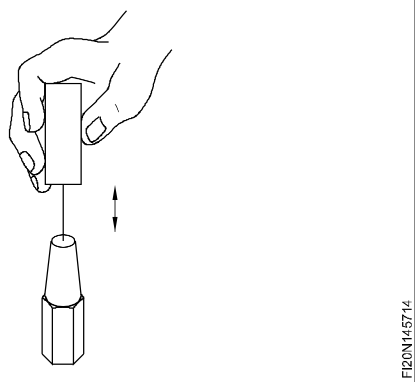
Tip cleaner: A special tip cleaner is supplied with the torch container. For each tip there is a kind of drill and a smooth file Fig.3.

Fig 3



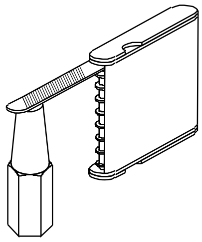
Before cleaning the tip, select the correct drill and move it, without turning, up and down through the hole in the tip Fig.4.

Fig 4



The smooth file is then used to clean the surface of the tip Fig.5. While cleaning, leave the oxygen valve partly open to blow out the dust.

Fig 5



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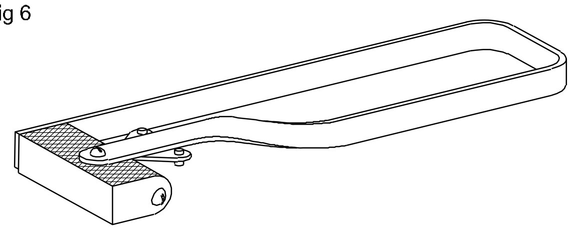
Spark lighter: The spark lighter, as illustrated in Fig.6 & 7 is used for igniting the torch. While welding, form the habit of always employing a spark lighter to light a torch. Never use matches. The use of matches for this purpose is very dangerous because the puff of the flame produced by the ignition of the acetylene flowing from the tip is likely to burn your hand.

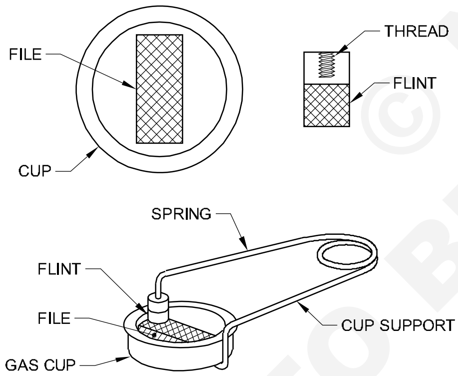
Fig 6



ALWAYS USE A SPARKLIGHTER TO LIGHT A TORCH

FI20N145716

Fig 7



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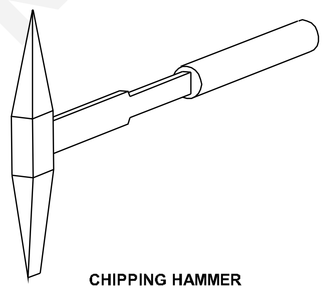
Chipping hammer: The chipping hammer (Fig.8) is used to remove the slag which covers the deposited weld bead. It is made of medium carbon steel with a mild steel handle. It is provided with a chisel edge on one end and a point on the other end for chipping off slag in any position.

Fig 8



CHIPPING HAMMER

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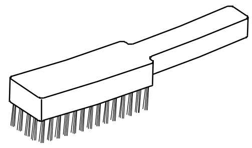
Care should be taken to maintain the sharp chisel edge and the point for effective chipping of slag.

Carbon steel wire brush: A carbon steel wire brush is shown in Fig.9. It is used for

Fig 9



WIRE BRUSH

FI20N145719

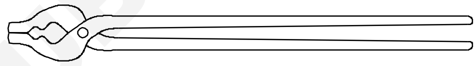
- Cleaning the work surface from rust, oxide and other dirt etc. prior to welding.
- Cleaning the interbreed weld deposits after chipping off the slag.
- General cleaning of the weldment.

A stainless steel wire brush is used for cleaning a non ferrous and stainless steel welded joint.

It is made of bunch of steel wires fitted in three to five rows on a wooden piece with handle. The wires are hardened and tempered for long life and to ensure good cleaning action.

Tongs: Fig.10 and Fig.11 shows a pair of tongs used to hold hot work pieces and to hold the job in position.

Fig 10



TONGS

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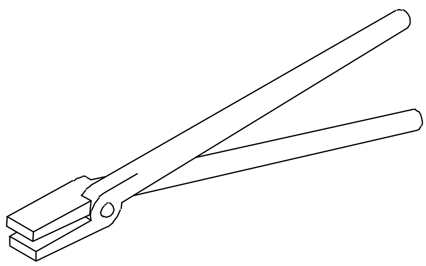
Fig 11



TONGS

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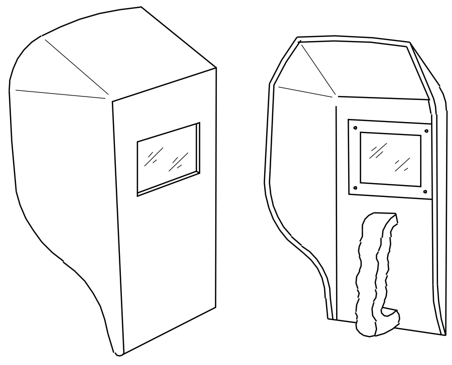
Welding hand screen (Fig 12)

A welding hand screen is used to shield and protect the face and the eyes from the arc radiation.

It is fitted with a filter lens, and plain glass to protect the lens.

Fig 12



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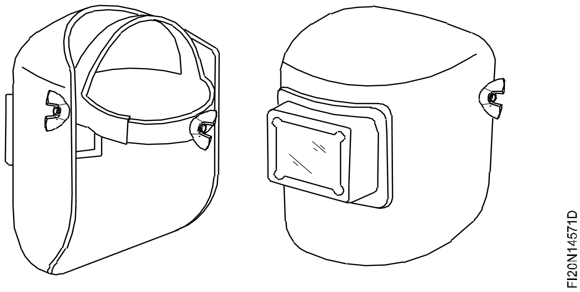
Welding helmet screen (Fig 13)

It is used as a hand screen but it can be worn on the head of the welder to enable him to use both his hands .

Fig 13

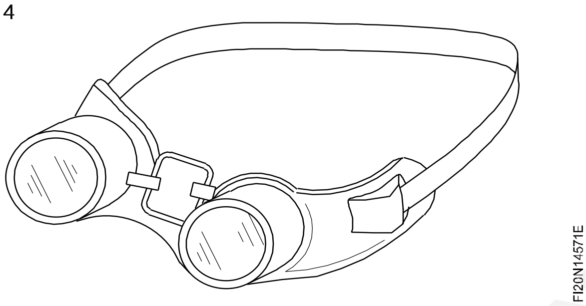


Chipping goggles (Fig 14)

Chipping goggles are used to protect the eyes while chipping the slag.

They are fitted with a plain glass to see the area to be cleaned.

Fig 14

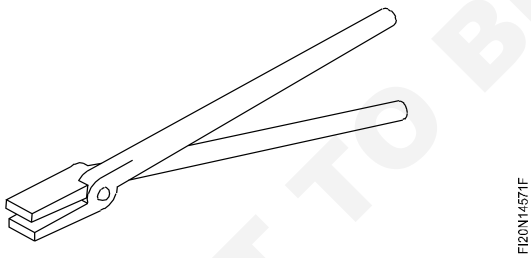


Tong (Fig 15)

Tongs are used to handle the hot metal-welding job while cleaning.

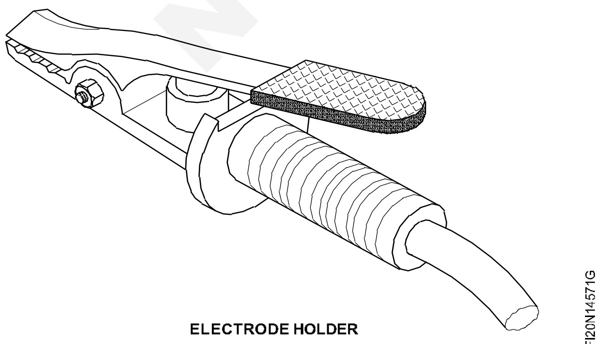
They are also used to hold the metal for hammering.

Fig 15



Electrode holder with cable (Fig 16)

Fig 16

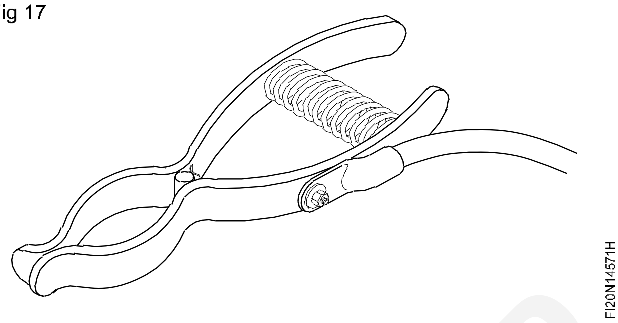


An electrode holder is used to hold and manipulate the electrode.

The cable is insulated with a good quality flexible rubber, and copper core wires, to carry the high current from the welding machines.

Earth clamp with cable (Fig 17)

Fig 17



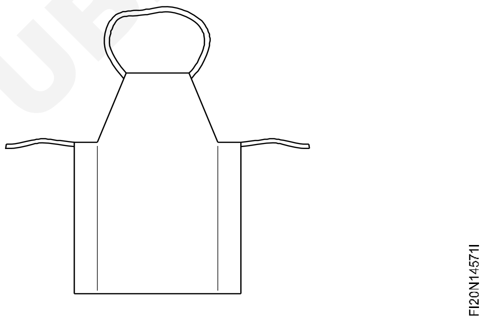
An earth clamp is used to connect the return lead firmly to the job or to the welding table.

Welding table

The welding table is used to keep the jobs and assemble the pieces during welding. The top of the table is made of metal.

Apron (Fig 18)

Fig 18



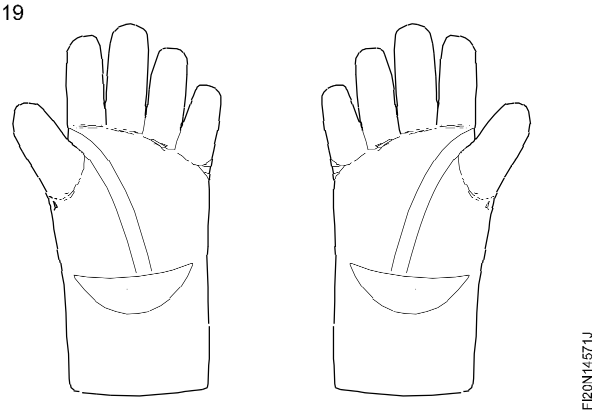
An apron is used to protect the body.

It should be made of leather and worn.

It must be worn for protection from the radiation of the heat rays and hot spatters.

Hand gloves (Fig 19)

Fig 19



Hand gloves are used to protect the hands from electrical shock, arc radiation, heat, and hot spatters.

The gloves are also made of leather.

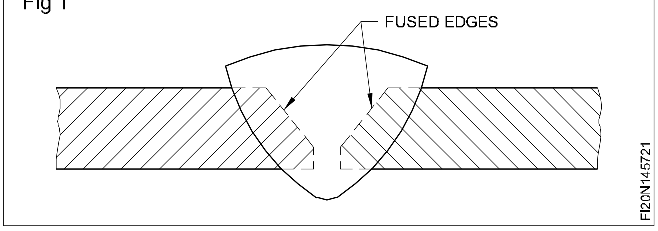
Welding description types and uses

Objectives : At the end of this lesson you shall be able to
- **state what is welding**
- **list the different types of welding and its uses.**

Fusion welding. (Fig 1)

Welding is a fabrication process where by two or more parts are fused together by means of heat pressure or both forming a join as the parts cool. Welding is usually used on metals and thermoplastics but can also be used on wood. The completed welded joint may be referred to as a weldment welding process.

Fig 1

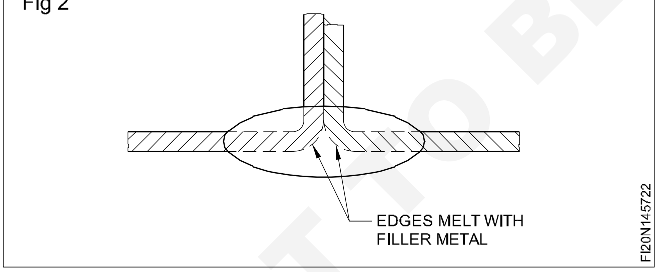


A method of welding in which similar metals are joined together by melting and fusing their joining edges with or without the addition of filler metal but without the application of any kind of pressure is known as fusion welding. The joint made is permanent .The common heating sources are arc welding and gas welding.

Non fusion welding

A method of welding in which similar or dissimilar metals are joined together without melting the edges is known as non - fusion welding. A low melting point filler rod is fused between the joints without the application of pressure (Fig 2) the joint made is temporary

Fig 2



The heat source may be arc, gas welding.

Examples of non - fusion welding are silver soldering, brazing etc.

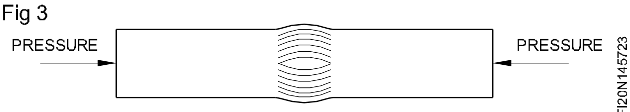
Pressure welding (Fig 3)

Pressure welding is a method of welding in which similar metals are joined together by heating them to plastic or molten state and are then joined by pressing or hammering without the use of the filler metal.

The joint made is permanent

The heat source may be a blacksmith forge (forge welding) or electric resistance (resistance welding).

Fig 3



Types of welding

There are many type welding the process differs greatly in the manner in which heat and pressure are applied and the type of equipment used.

They are

- Forge welding
- Shield metal ARC welding
- Carbon ARC welding
- Submerged ARC welding b
- Co_2 welding (gas metal ARC welding)
- TIG welding (gas tungsten ARC welding
- Atomic hydrogen welding
- Electro slag welding
- Plasma ARC welding
- Spot welding
- Seam welding
- Projection welding
- Butt welding
- Electron bean welding
- Laser welding
- MIG welding (Metal insert gas welding).

Applications of various welding processes

Forge welding : It is used in olden days for joining metals as a lap and butt joint.

Shielded Metal arc welding is used for welding all ferrous and non-ferrous metals using consumable stick electrodes.

Carbon arc welding is used for welding all ferrous and non-ferrous metals using carbon electrodes and separate filler metal. But this is a slow welding process and so not used now-a-days.

Submerged arc welding is used for welding ferrous metals, thicker plates and for more production.

Co_2 welding (Gas Metal Arc Welding) is used for welding ferrous metals using continuously fed filler wire and shielding the weld metal and the arc by carbon-di-oxide gas.

TIG welding (Gas Tungsten Arc Welding) is used for welding ferrous metals, stainless steel, aluminium and thin sheet metal welding.

Atomic hydrogen welding is used for welding all ferrous and non-ferrous metals and the arc has a higher temperature than other arc welding processes.

Electroslag welding is used for welding very thick steel plates in one pass using the resistance property of the flux material.

Plasma arc welding: The arc has a very deep pentrating ability into the metals welded and also the fusion is taking place in a very narrow zone of the joint.

Spot welding is used for welding thin sheet metal as a lap joint in small spots by using the resistance property of the metals being welded.

Seam welding is used for welding thin sheets similar to spot welding. But the adjacent weld spots will be overlapping each other to get a continuous weld seam.

Projection welding is used to weld two plates one over the other on their surfaces instead of the edges by making projection on one plate and pressing it over the other flat surface. Each projection acts as a spot weld during welding.

Butt welding is used to join the ends of two heavy section rods/blocks together to lengthen it using the resistance property of the rods under contact.

Flash butt welding is used to join heavy sections of rods/ blocks similar to butt welding except that arc flashes are produced at the joining ends to melt them before applying heavy pressure to join them.

Electron beam welding used aerospace, nuclear power and automotive industry

Laser beam welding used in automotive industry.

MIG welding is suitable for both thick and then sheets.

Co_2 welding equipment and process

Objectives: At the end of this lesson you shall be able to
- **state the main difference between shielded metal arc welding and co_2 welding**
- **state the principle of co_2 welding.**

Introduction to Co_2 welding: Fusion welding of metal plates and sheets is the best method of joining metals because in this process the welded joint will possess the same properties and strength as the base metal.

Without a perfectly shielded arc and molten puddle, the atmospheric oxygen and nitrogen will get absorbed by the molten metal. This will result in weak and porous welds.

In shielded metal arc welding (SMAW) the arc and molten metal are protected/shielded by the gases produced by the burning of the flux coated on the electrode.

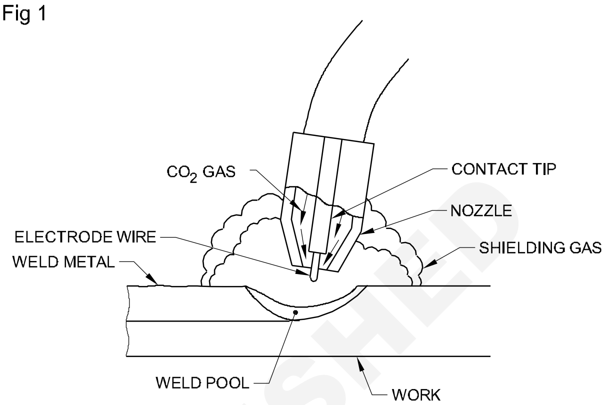
The above mentioned shielding action can be done by passing an inert gas such as argon, helium, carbon-di-oxide through the welding torch/gun. The arc is produced between the base metal and a bare wire consumable electrode fed continuously through the torch.

Principle of GMA welding: In this welding process, an arc is struck between a continuously fed consumable bare wire electrode and the base metal. The heated base metal, the molten filler metal and the arc are shielded by the flow of inert/noninert gas passing through the welding torch/gun. (Fig.1)

If an inert gas is used to protect the arc produced by a consumable metal electrode, this process is called Metal Inert Gas Welding (MIG).

When carbon-dioxide is used for shielding purposes, it is not fully inert and it partly becomes an active gas. So Co_2 welding is also called as Metal Active Gas (MAG) welding.

Fig 1



PRINCIPLE OF CO_2 WELDING

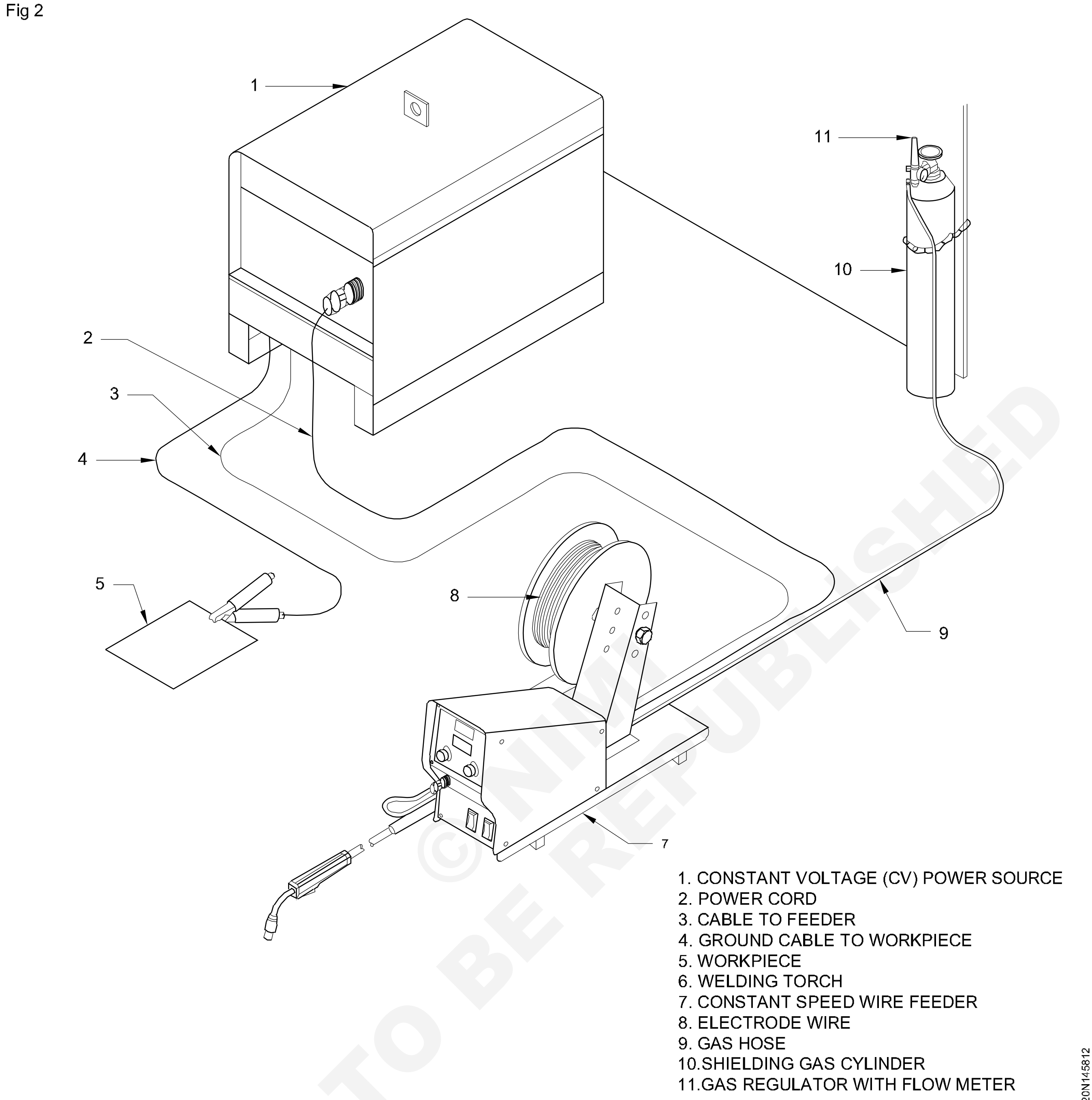
MIG/MAG welding is a name with respect to gas used for shields purpose

On the other hand Gas Metal Arc Welding is the common name.

Basic equipment for a typical GMAW semiautomatic setup (Fig 2)

- Welding Power Source - provides welding power.
- Wire Feeders - controls supply of wire to welding gun.
- Supply of Electrode Wire.
- Welding Gun - delivers electrode wire and shielding gas to the weld puddle.
- Shielding Gas Cylinder - provides a supply of shielding gas to the arc.

Fig 2



HP & LP welding equipment description, principle and method of operating

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

- **Explain the low pressure and the high pressure systems of oxy-acetylene plants and systems**
- **distinguish between low pressure and high pressure blowpipes**
- **State the advantages and disadvantages of both systems.**

Oxy-acetylene plants: An oxy-acetylene plant can be classified into:

high pressure plant

low pressure plant

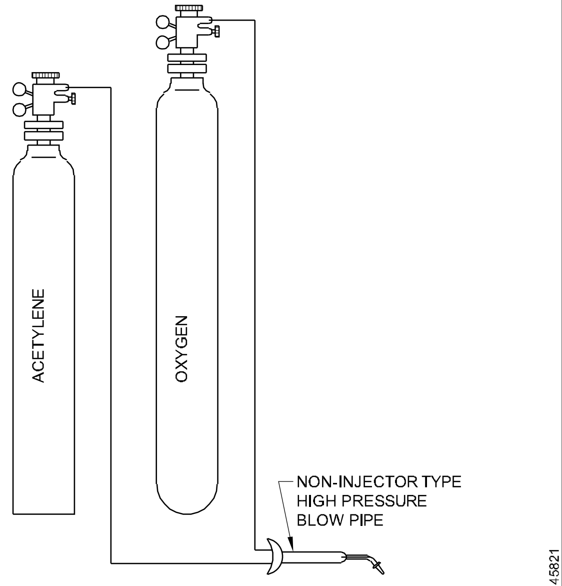
A high pressure plant utilises acetylene under high pressure (15 kg/cm) (Fig1)

Dissolved acetylene (acetylene in cylinder) is the commonly used source

Acetylene generated from a high pressure generator is not commonly used.

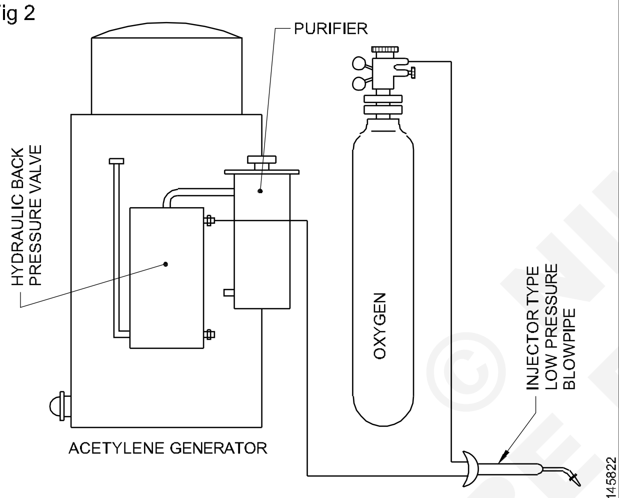
A low pressure plant utilizes acetylene under low pressure(0.017 kg/cm)produced by the acetylene generator only.(Fig 2)

Fig 1



HIGH PRESSURE OXY-ACETYLENE PLANT

Fig 2



LOW PRESSURE OXY-ACETYLENE PLANT

High pressure and low pressure plants utilize oxygen gas kept in compressed high pressure cylinders only at 120 to 150 kg/cm pressure.

Oxy-acetylene systems: A high pressure oxy-acetylene plant is also called a high pressure system.

A low pressure acetylene plant with a low pressure acetylene generator and a high pressure oxygen cylinder is called a low pressure system.

The terms low pressure and high pressure systems used in oxy-acetylene welding refer only to acetylene pressure, high or low.

Types of blowpipes: For the low pressure system, a specially designed injector type blowpipe is required, which may be used for high pressure system also.

In the high pressure system, a mixer type high pressure blowpipe is used which is not suitable for the low pressure system.

To avoid the danger of high pressure oxygen entering into the acetylene pipeline an injector is used in a low pressure blowpipe. In addition a non-return valve is also used in the blowpipe connection on the acetylene hose. As a further precaution to prevent the acetylene generator from exploding, a hydraulic back pressure valve is used between the acetylene generator and the blowpipe.

Advantages of high pressure system: Safe working and less chances of accidents. The pressure adjustment of gases in this system is easy and accurate, hence working efficiency is more. The gases being in cylinder are perfectly under control. The D.A cylinder is portable and can be taken easily from one place to another place.

The D.A cylinder can be fitted with a regulator quickly and easily, thus saving time. Both injector and non-injector type blowpipes can be used. No license is required for keep the D.A cylinder.

Sequence of steps

Slowly open the cylinder valve.

Open the shut-off valve or pressure reducing valve

Open the valve on torch.

Slowly screw in the adjusting screw. (The locking bolt opens.)

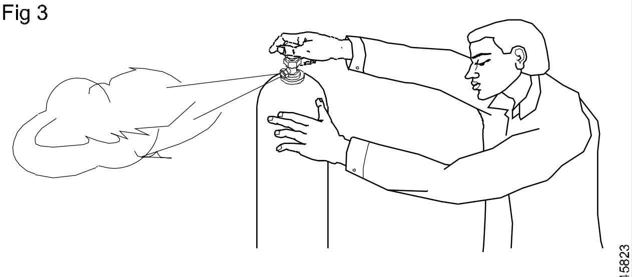
Watch the working pressure gauge.

Turn the adjusting screw until the desired pressure is reached. There is an equilibrium between the bottom adjusting spring and the pressure of the gas on the membrane, which is amplified by the spring of the locking pin.

Care and maintenance of regulators

Check the cylinder connection and crack the cylinder before fixing the regulator. (Fig 3)

Fig 3



SUDDENLY OPEN AND CLOSE THE
CYLINDER VALVE FOR 2 OR 3 SECONDS

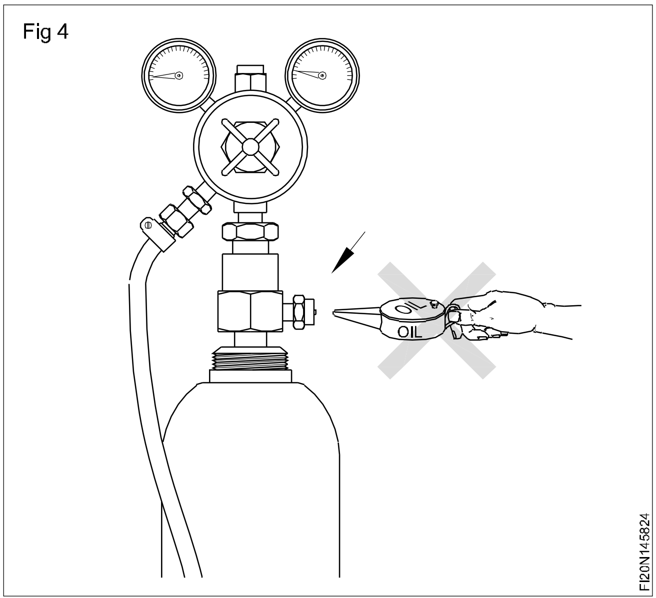
Open the cylinder valve slowly and allow the gas to pass to the regulator (cylinder) content gauge.

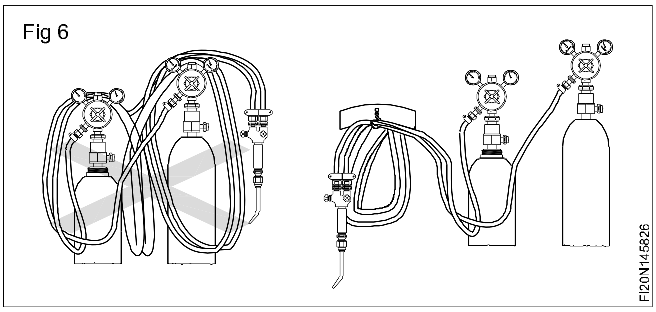
Loosen the pressure screw.

Do not use oil in regular connections. (Fig 4)

Do not fix the oxygen and acetylene regulators close together (Fig 5)

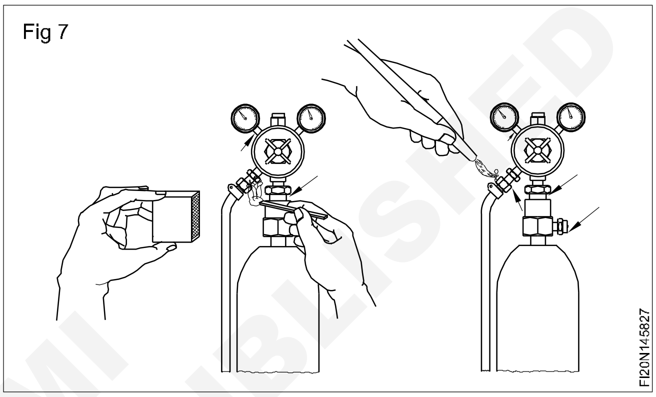
Do not wind the hose on the regulators (Fig 6)

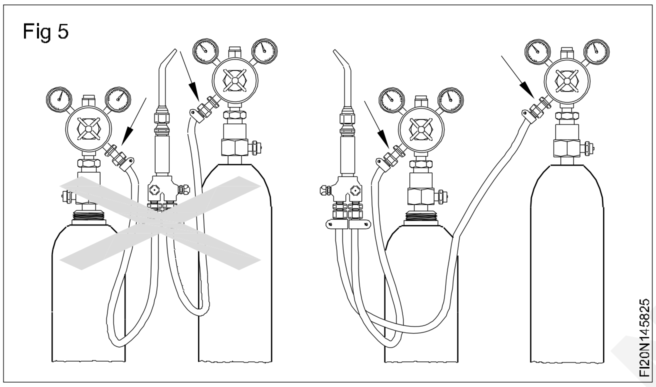




Use hose-clips before connecting to the regulator.

Use soap water to check the leakage in the acetylene regulator connections and plain water on the oxygen relator connections. Fig7





Gas welding torch its type and construction

Objectives : At the end of this lesson you shall be able to
- **State the uses of the different types of blowpipes**
- **describe the working principle of each type of blowpipe**
- **explain its care and maintenance.**

Types

There are two types of blowpipes.

High pressure blowpipe or non-injector by blowpipe

Low pressure blowpipe or injector type blowpipe.

Uses of blow pipes: Each type consists of a variety of designs depending on the work for which the blowpipe is required. i.e gas welding, brazing, very thin sheet welding, heating before and after welding, gas cutting.

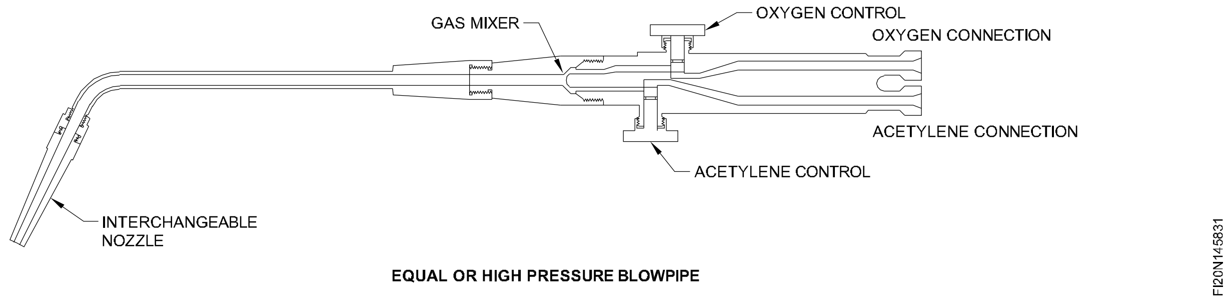
Equal or High pressure blowpipe (Fig 1): The H.P. blowpipe is simply a mixing device to supply approximately equal volume of oxygen and acetylene to the tip, and is fitted with valves to control the flow of the gases as required. i.e the blow pipes/ gas welding torches are used for welding of ferrous and non-ferrous metals, joining thin sheets by fusing the edges, preheating and post heating of jobs, brazing, for removing the dents formed by distortion and for gas cutting using a cutting blow pipe.

The equal pressure blow pipe (Fig.1) consists of two inlet connections for acetylene and oxygen gases kept in high pressure cylinders. Two control valves to control the quantity of flow of the gases and a body inside which the gases are mixed in the mixing chamber (Fig 2). The mixed gases flow through a neck pipe to the nozzle and then get ignited at the tip of the nozzle. Since the pressure of the oxygen and acetylene gases are set at the same pressure of 0.15 kg/cm^2 they mix together at the mixing chamber and flows through the blow pipe to the nozzle tip on its own. This equal pressure blow pipe/torch is also called as high pressure blow pipe/torch because this is used in the high pressure system of gas welding.

A set of nozzles is supplied with each blowpipe, the nozzles having holes varying in diameters, and thus giving various sized flames. The nozzles are numbered with their consumption of gas in litres per hour.

> **Important caution: A high pressure blowpipe should not be used on a low pressure system.**

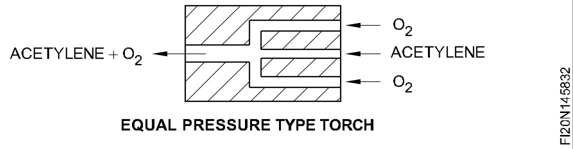
Fig 1



EQUAL OR HIGH PRESSURE BLOWPIPE

Fig 2

GAS PASSAGE IN THE GAS MIXING SECTION



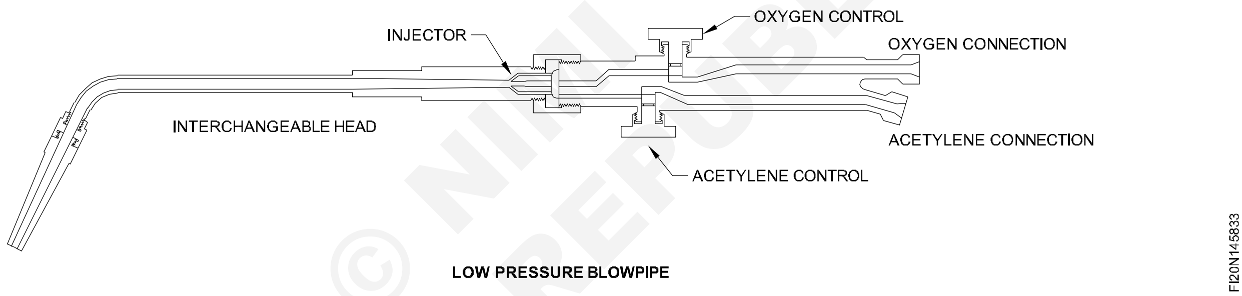
EQUAL PRESSURE TYPE TORCH

Low pressure blowpipe (Fig 3)

This blowpipe has an injector (Fig 3) inside its body through which the high pressure oxygen passes. This oxygen draws the low pressure acetylene from an acetylene generator into a mixing chamber and gives it the necessary velocity to get a steady flame and the injector also helps to prevent backfiring.

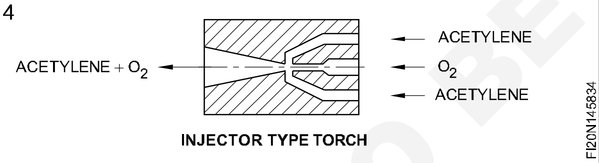
The low pressure blow pipe is similar to the equal pressure blow pipe except that inside its body an injector with a very small (narrow) hole in its centre through which high pressure oxygen is passed. This high pressure oxygen while coming out of the injector creates a vaccuum in the mixing chamber and sucks the low pressure acetylene from the gas generator (Fig.4)

Fig 3



LOW PRESSURE BLOWPIPE

Fig 4



INJECTOR TYPE TORCH

It is usual for the whole head to be interchangeable in this type, the head containing both the nozzle and injector. This is necessary, since there is a corresponding injector size for each nozzle.

The L.P. blowpipe is more expensive than the H.P. blowpipe but it can be used on a high pressure system, if required.

Care and maintenance

Welding tips made of copper may be damaged by careless handling.

Nozzles should never be dropped or used for moving or holding the work.

The nozzle seat and threads should be absolutely free from foreign matter in order to prevent any scoring/scratch on the fitting surfaces when tightening on assembly.

The nozzle orifice should only be cleaned with a tip cleaner specially designed for this purpose. (Fig 5, 6 & 7)

At frequent intervals the nozzle tip should be filed to remove any damage to the tip due to the excessive heat of the flame and the molten metal.

The inlet for acetylene has left hand thread and that for oxygen has right hand thread. Take care to fit the correct hose pipe with the blow pipe inlet. At frequent intervals, put off the flame and dip the blow pipe in cold water.

Fig 5

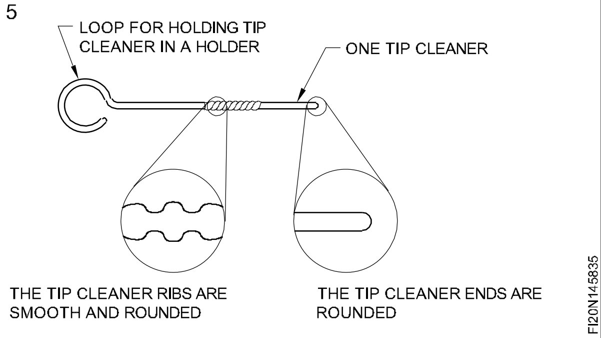
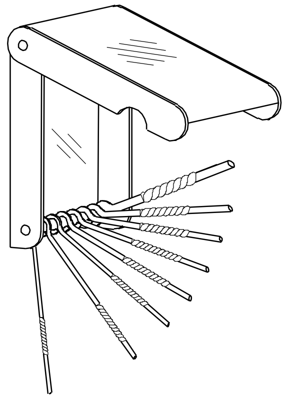
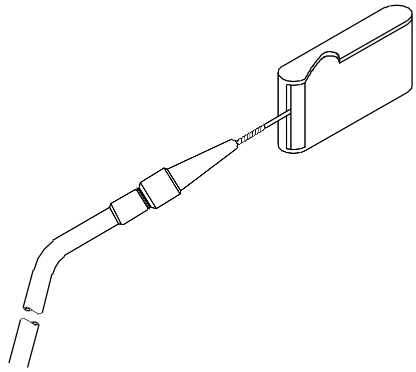


Fig 6



SET OF DIFFERENT SIZE TIP CLEANERS IN A HOLDER

Fig 7



METHOD OF TIP CLEANING

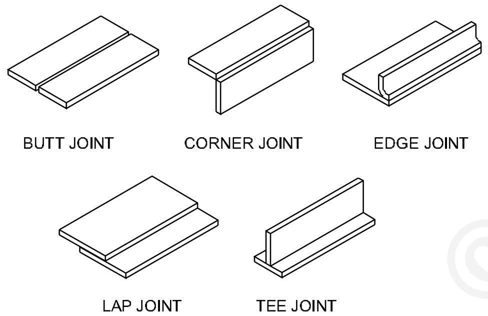
Types of welding joints (butt and fillet)

Objectives: At the end of this lesson you shall be able to
- **illustrate and name the basic welding joints**
- **explain the nomenclature of butt and fillet welds.**

Basic welding joints (Fig 1)

The various basic welding joints are shown in Fig 1.

Fig 1

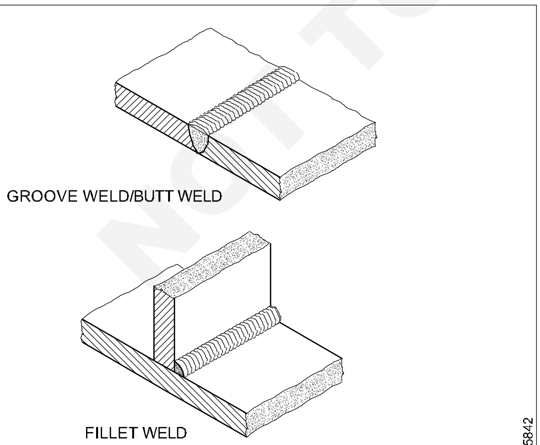


FUNDAMENTAL TYPE OF JOINTS

The above types mean the shape of the joint, that is, how the joining edges of the parts are placed together.

Types of weld: There are two types of weld.(Fig 2)

Fig 2



TYPE OF WELD

– Groove weld/butt weld

– Fillet weld

Nomenclature of butt and fillet weld (Figs 3 and 4)

Root gap: It is the distance between the parts to be joined. (Fig 3)

Fig 3

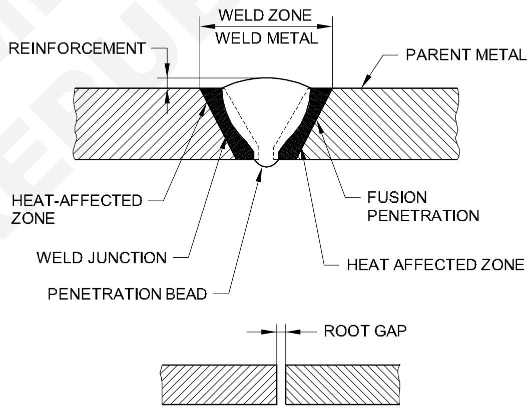
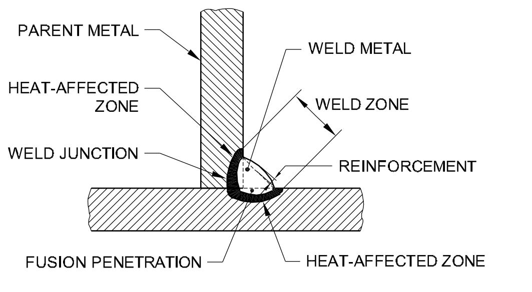


Fig 4



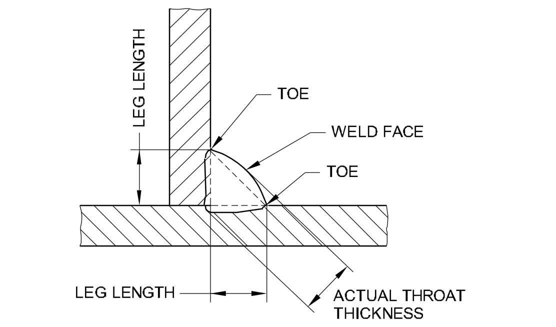
Heat affected zone: Metallurgical properties have been changed by the welding heat adjacent to weld.

Leg length: The distance between the junction of the metals and the point where the weld metal touches the base metal ' toe'. (Fig 5)

Parent metal: The material or the part to be welded.

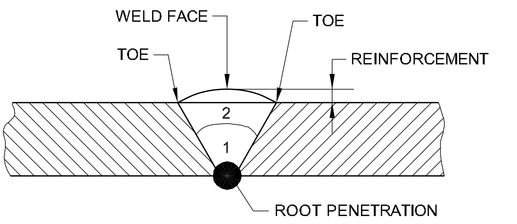
Fusion Penetration: The depth of fusion zone in the parent metal.(Fig.3 and 4)

Fig 5



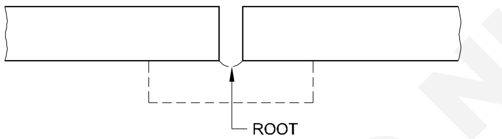
Reinforcement: Metal deposited on the surface of the parent metal or the excess metal over the line joining the two toes. (Fig 6)

Fig 6



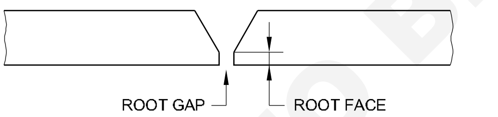
Root: The parts to be joined that are nearest together. (Fig 7)

Fig 7



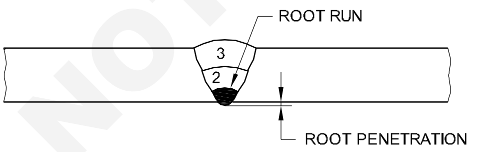
Root face: The surface formed by squaring off the root edge of the fusion face to avoid a sharp edge at the root. (Fig 8)

Fig 8



Root run: The first run deposited in the root of a joint. (Fig 9)

Fig 9



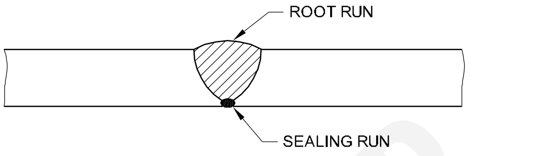
Root penetration: It is the projection of the root run at the bottom of the joint (Fig.6 and 9)

Run: The metal deposited during one pass.Fig.9.

The second run is marked as 2 which is deposited over the root run. The third run is marked as 3 which is deposited over the second run.

Sealing run: A small weld deposited on the root side of a butt or corner joint (after completion of the weld joint). (Fig 10)

Fig 10



Backing run: A small weld deposited on the root side of the butt or corner joint (before welding the joint).Fig.6

Throat thickness: The distance between the junction of the metals and the midpoint on the line joining the two toes.(Fig 5)

Toe of weld: The point where the weld face joins the parent metal.(Fig 5 & 6)

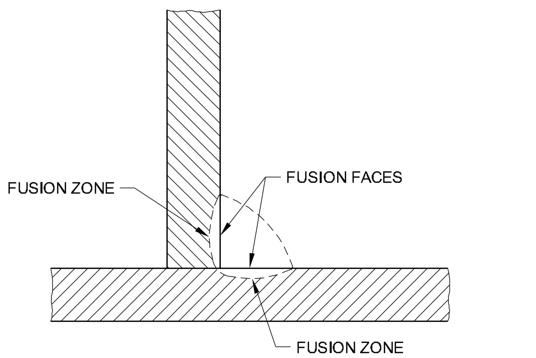
Weld face: The surface of a weld seen from the side from which the weld was made.(Fig 5 & 6)

Weld junction: The boundary between the fusion zone and the heat affected zone.(Fig.3 & 4)

Fusion face: The portion of a surface which is to be fused on making the weld.(Fig 11)

Fusion zone: The depth to which the parent metal has been fused. (Fig 11)

Fig 11



Gases and gas cylinders description, kinds, main difference and uses

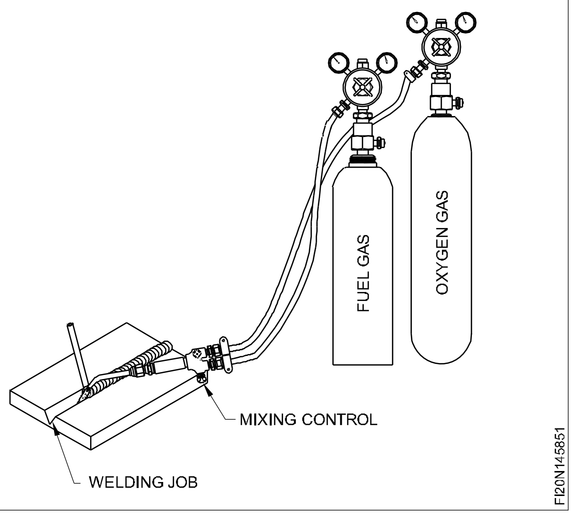
Objectives: At the end of this lesson you shall be able to
- **name the different types of gases used in gas welding**
- **state the different types of gas flame combinations**
- **state the temperatures and uses of the different gas flame combinations.**

In the different gas welding processes, the welding heat is obtained from the combustion of the fuel gases.

All the fuel gases require oxygen to support combustion.

As a result of the combustion of the fuel gases and oxygen, a flame is obtained. This is used to heat the metals for welding. (Fig 1)

Fig 1



Fuel gases used in welding

The following are the gases used as fuel for welding.

- Acetylene gas
- Hydrogen gas
- Coal gas
- Liquid petroleum gas (LPG)

Supporter of combustion gas

All gases burn with the help of oxygen. Hence it is known as the supporter of combustion.

Different gas flame combinations

Oxygen + Acetylene = Oxy - Acetylene gas flame

Oxygen + Hydrogen = Oxy - Hydrogen gas flame

Oxygen + Coal = Oxy - coal gas flame

Oxygen + LPG = Oxy - LP gas flame

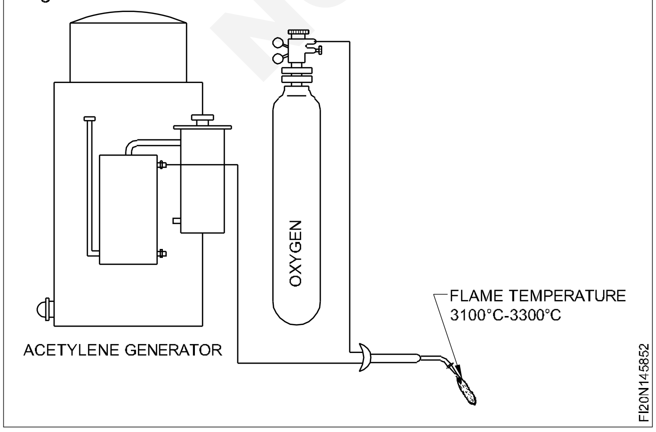
Temperature and uses of gas flame combinations

Oxy-acetylene gas flame (Fig 2)

Flame temperature : 3100° C to 3300° C

The Oxy - Acetylene gas flame is used for welding all ferrous and non-ferrous metals and their alloys, gas cutting, gouging, steel brazing, bronze welding, metal spraying and powder spraying.

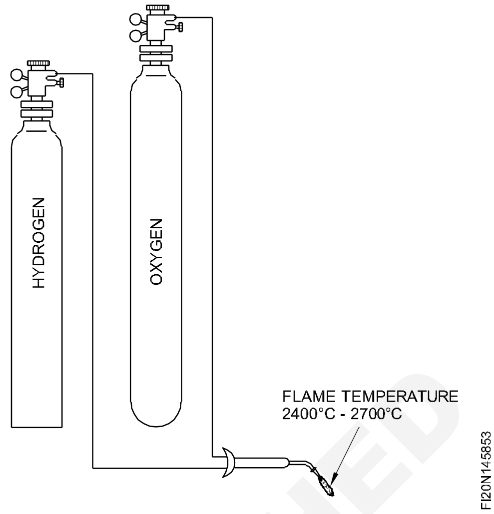
Fig 2



Oxy - Hydrogen gas flame (Fig 3)

Flame temperature : 2400°C to 2700°C

Fig 3



It has carbon and moisture effect in the flame. It is used only for brazing, silver soldering and underwater gas cutting of steel.

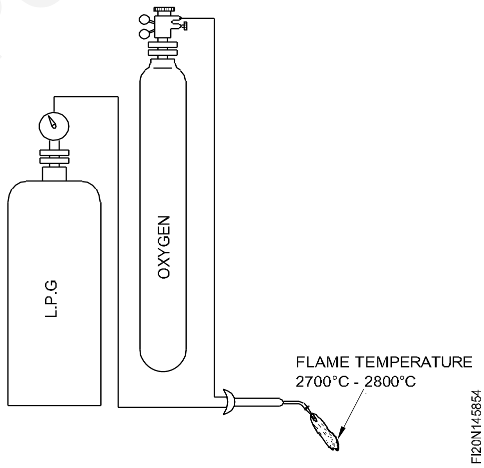
Oxy-liquid petroleum gas flame (Fig 4)

Flame temperature : 2700°C to 2800°C

This flame has carbon and moisture effect.

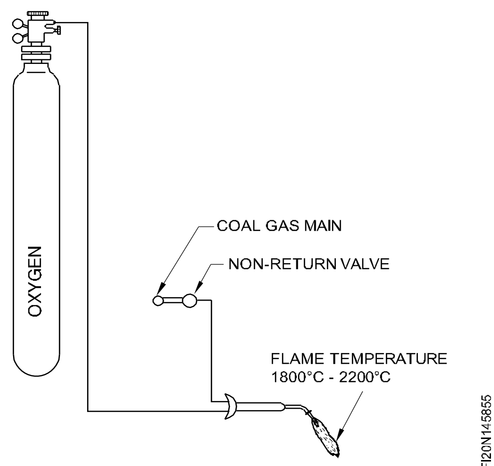
It is only used for gas cutting of steel, and for heating.

Fig 4



Oxy-coal gas flame (Fig 5)

Fig 5



Flame temperature : 1800°C to 2200°C

This flame has carbon effect in the flame and is used for silver soldering and brazing.

The most commonly used gas flame combination is OXY - ACETYLENE.

Oxygen gas cylinder

Objectives: At the end of this lesson you shall be able to
- **name different gas cylinders**
- **explain the constructional features of oxygen gas cylinder and the method of charging.**

Definition of a gas cylinder: It is a steel container, used to store different gases at high pressure safely and in large quantity for welding or other industrial uses.

Types and identifications of gas cylinders: Gas cylinders are called by names of the gas they are holding. (Table 1)

Table 1

Identification of gas cylinders

Name of gas cylinder	Colour coding	Valve threads
Oxygen	Black	Right hand
Acetylene	Maroon	Left hand
Coal	Red (with name coal gas)	Left hand
Hydrogen	Red	Left hand
Nitrogen	Grey (with black neck)	Right hand
Air	Grey	Right hand
Propane	Red (with larger diameter and name propane)	Left hand
Argon	Blue	Right hand
Carbon-di-oxide	Black (with white neck)	Right hand

Gas cylinders are identified by their body colour marks and valve threads. (Table 1)

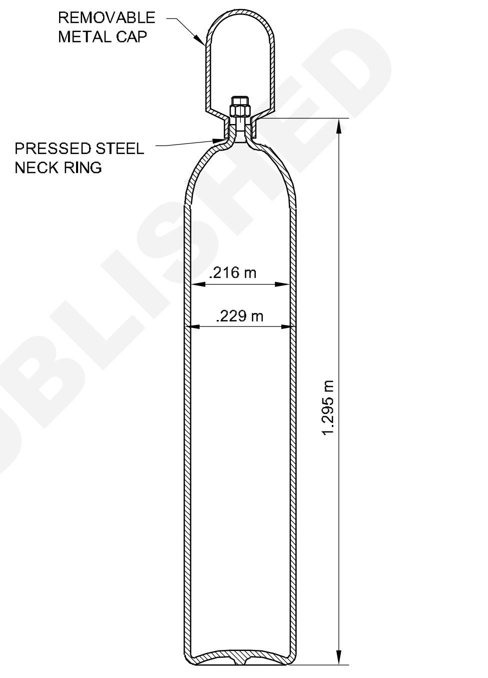
Oxygen gas cylinder: It is a seamless steel container used to store oxygen gas safely and in large quantity under a maximum pressure of 150 kg/cm^2, for use in gas welding and cutting.

Constructional features of oxygen gas cylinder (Fig 1)

It is made from seamless solid drawn steel and tested with a water pressure of 225kg/cm^2. The cylinder top is fitted with a high pressure valve made from high quality forged bronze. (Fig 2)

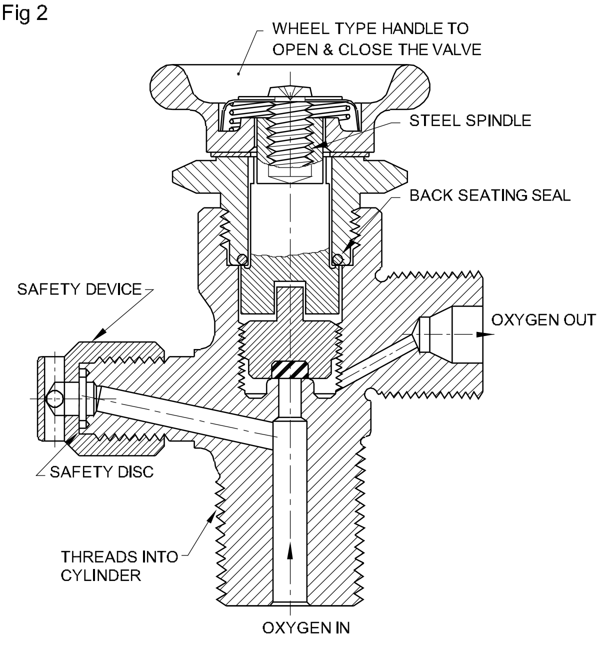
The cylinder valve has a pressure safety device, which consists of a pressure disc, which will burst before the inside cylinder pressure becomes high enough to break the cylinder body. The cylinder valve outlet socket fitting has standard right hand threads, to which all pressure regulators may be attached. The cylinder valve is also fitted with a steel spindle to operate the valve for opening and closing. A steel cap is screwed over the valve to protect it from damage during transportation. (Fig 1)

Fig 1



CONSTRUCTIONAL FEATURE OF OXYGEN GAS CYLINDER

Fig 2



CONSTRUCTIONAL FEATURES OF A CYLINDER VALVE

The cylinder body is painted black.

The capacity of the cylinder may be $3.5m^3$– $8.5m^3$.

Oxygen cylinders of $7m^3$ capacity are commonly used.

Charging of gas in oxygen cylinder: The oxygen cylinders are filled with oxygen gas under a pressure of 120-150 kg/cm^2. The cylinders are tested regularly and periodically. They are annealed to relieve stresses caused during 'on the job' handling. They are periodically cleaned using caustic solution.

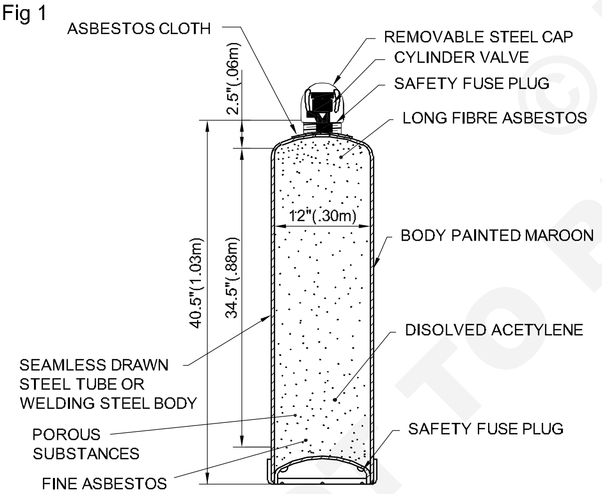
Dissolved acetylene gas cylinder

Objectives: At the end of this lesson you shall be able to
- **describe the constructional features of the DA gas cylinder and the method of charging**
- **state the safety rules for handling gas cylinders**
- **explain the safe procedure to be followed in handling an internally fired DA cylinder.**

Definition: It is a steel container used to store high pressure acetylene gas safely in dissolved state for gas welding or cutting purpose.

Constructional features (Fig 1): The acetylene gas cylinder is made from seamless drawn steel tube or welded steel container and tested with a water pressure of 100kg/cm^2 The cylinder top is fitted with a pressure valve made from high quality forged bronze. The cylinder valve outlet socket has standard left hand threads to which acetylene regulators of all makes may be attached. The cylinder valve is also fitted with a steel spindle to operate the valve for opening and closing. A steel cap is screwed over the valve to protect it from damage during transportation. The body of the cylinder is painted maroon. The capacity of the D A cylinder may be $3.5m^3$–$8.5m^3$.

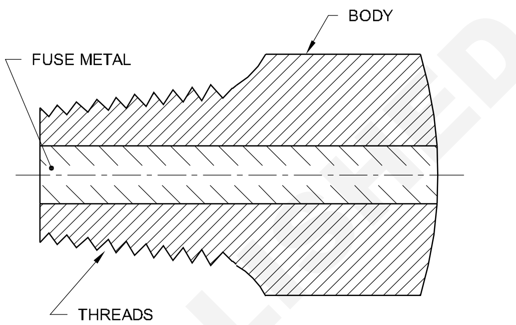
Fig 1



CONSTRUCTIONAL FEATURES OF A DISSOLVED ACETYLENE GAS CYLINDER

The base of the D A cylinder (curved inside) is fitted with fuse plugs which will melt at a temperature of app. 100°C. (Fig 2) In case the cylinder is subjected to high temperature, the fuse plugs will melt and allow the gas to escape, before the pressure increases enough to harm or rupture the cylinder. Fuse plugs are also fitted on the top of the cylinder.

Fig 2



CONSTRUCTIONAL FEATURE OF A FUSE PLUG FITTED WITH THE CYLINDER TOP AND BOTTOM

Method of charging D A gas cylinder: The storage of acetylene gas in its gaseous form under pressure above 1kg/cm^2 is not safe. A special method is used to store acetylene safely in cylinders as given below.

The cylinders are filled with porous substances such as:

– pith from corn stalk

– fullers earth

– lime silica

– specially prepared charcoal

– fibre asbestos.

The hydrocarbon liquid named acetone is then charged in the cylinder, which fills the porous substances (1/3rd of total volume of the cylinder).

Acetylene gas is then charged in the cylinder, under a pressure of app.15 kg/cm^2.

The liquid acetone dissolves the acetylene gas in large quantity as safe storage medium; hence, it is called dissolved acetylene. One volume of liquid acetone can dissolve 25 volumes of acetylene gas under normal atmospheric pressure and temperature. During the gas charging operation one volume of liquid acetone dissolves 25x15=375 volumes of acetylene gas under 15kg/cm^2 pressure at normal temperature. While charging cold water will be sprayed over the cylinder so that the temperature inside the cylinder does not cross certain limit.

Safety rules for gas cylinders

Oxy-acetylene equipment is safe if it is properly handled, but it may become a great destructive power if handled carelessly. It is important that the operator be familiar with all the safety rules before handling gas cylinders.

Keep the cylinders free of oil, grease or any type of lubrication.

Check leakage before use.

Open cylinder valves slowly.

Never fall or trip over gas cylinders.

A valve broken in the oxygen cylinder will cause it to become a rocket with tremendous force.

Keep the gas cylinders away from exposure to high temperature.

Remember the pressure in the gas cylinders increases with the temperature.

Store full and empty gas cylinders separately in a well ventilated place.

Mark the empty cylinders (MT/EMPTY) with chalk .

If a cylinder leaks due to defective valve or safety plug, do not try to repair it yourself, but move it to a safe area with a tag to indicate the fault and then inform the supplier to pick it up.

When the cylinders are not in use or they are being moved, put on the valve protection caps.

Cylinders should always be kept in upright position and properly chained when in use.

Close the cylinder valves both when they are full or empty.

Never remove the valve protection cap while lifting cylinders.

Avoid exposing the cylinders to furnace heat, open fire or sparks from the torch.

Never move a cylinder by dragging, sliding or rolling it on its sides.

Never apply undue force to open or close a cylinder valve.

Avoid the use of hammer or wrench.

Always use a proper cylinder (or spindle) key to open or close the cylinder valves.

Do not remove the cylinder key from the cylinder valve when it is in use. It may be needed immediately to close the gas in case of emergency.

Smoking or naked lights should be strictly prohibited near gas cylinders.

Never strike an arc or direct gas flame on a gas cylinder.

Safety procedure for handling an internally fired dissolved acetylene (D A) cylinder

In the case of severe backfire or flashback the D A cylinder may catch fire.

Close the blowpipe valve immediately (oxygen first).

No damage will occur to the cylinder if the backfire is arrested at the blowpipe.

The signs of severe backfire or flashback are:

– a squealing or hissing noise in the blowpipe
– a heavy black smoke and sparks coming out of the nozzle
– overheating of the blowpipe handle.

To control this:

– close the cylinder valves
– disconnect the regulator from the cylinder valve
– check the hosepipes and blowpipe before re-use.

If the cylinder catches fire externally due to the leakage of gas at the connection:

– close the cylinder valve immediately (wearing asbestos gloves as a safety measure)
– use carbon dioxide fire extinguisher to extinguish the fire
– rectify the leakage thoroughly before putting into further use.

If the cylinder becomes overheated due to internal or external fire:

– close the cylinder valve
– detach the regulator from the cylinder
– remove the cylinder to an open space, away from smoking or naked light
– cool the cylinder by spraying with water
– inform the gas cylinder supplier immediately.

Never keep such defective cylinders with the other cylinders.

Setting up parameter for arc welding machine

Objective: At the end of this lesson you shall be able to
- **select and set the electrode and current according to the plate thickness.**

Electrode size and AMPS used

The following will serve as a basic guide of the amp range that can be used for different size electrodes. Note that these ratings can be different between various electrode manufactures for the same size rod. Also the type coating on the eletrode could effect the amperage range. When possible, check the manufactures info of the electrode you wil be using for their recommended amperage settings.

Electrode Table

Electrode	AMP	Plate
1/16"	20 - 40	Up to 3/16"
3/32"	40 - 125	Up to 1/4"
1/8	75 - 185	Over 1/8"
5/32"	105 - 250	Over 1/4"
3/16"	140 - 305	Over 3/8"
1/4"	210 - 430	Over 3/8"
5/16"	275 - 450	Over 1/2"

Note : The thicker the material to be welded, the higher the current needed and the larger the electrode needed.

Selection and storage of electrodes

Objectives: At the end of this lesson you shall be able to
- **select a suitable electrode to weld a particular job**
- **state the necessity of baking a coated electrode**
- **store and handle the electrode properly for better weld quality.**

Selection/choice of electrodes: Selection of an electrode is very important in order to get a joint welded with the required strength.

Selection factors

Properties of base metal: Top quality weld should be as strong as the base metal.

Select an electrode that is recommended as per the properties of the base metal. (Fig 1)

Fig 1

BASE METAL	ELECTRODE SELECTED
MILD STEEL	MEDIUM COATED RUTILE M.S. ELECTRODE
MEDIUM CARBON STEEL	HEAVY COATED LOW HYDROGEN M.S. ELECTRODE
STAINLESS STEEL	COLUMBIAM BASED STABILISED STAINLESS STEEL ELECTRODE
COPPER	HEAVY COATED BRONZE ELECTRODE

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The size of the electrode depends on:

- thickness of metal to be welded
- edge preparation of joints
- root run, intermediate or covering run
- welding position
- welder's skill.

Never use a larger dia. electrode than the thickness of base metal.

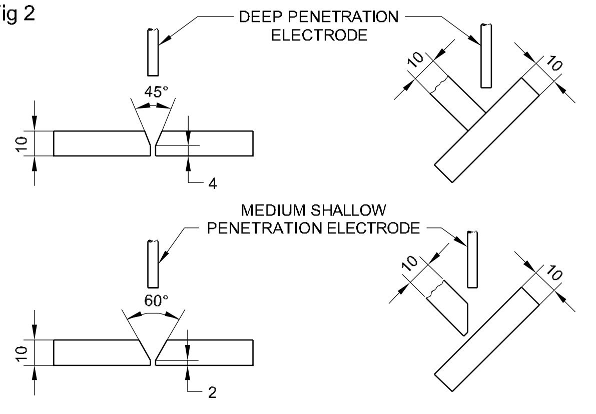
Joint design and fit up

Select:

- deep penetration electrodes for insufficiently bevelled joints
- medium penetration electrodes for open and sufficiently bevelled joints. (Fig 2)

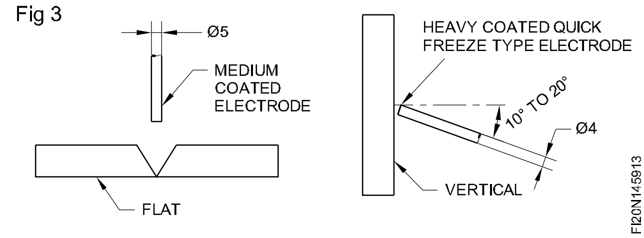
Welding position: Electrodes are manufactured for different positions, to produce better welds.

Fig 2



Select an electrode as per the welding position. (Fig 3)

Fig 3



Welding current: Electrodes are available for use with:

– AC or DC (straight or reverse polarity)

– AC and DC (both).

Select as per the availability of the welding machine.

Production efficiency: The deposition rate of electrode is important in production work. So select an iron powder electrode for production work.

Faster the weld, lower the cost.

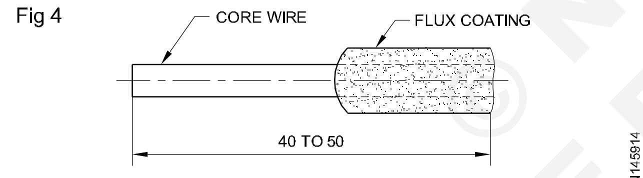
Select the electrode, which is designed for the particular production work.

Usage and storage of electrodes

Electrodes are costly, therefore, use and consume every bit of them.

Do not discard STUB ENDS more than 40-50 mm length. (Fig 4)

Fig 4



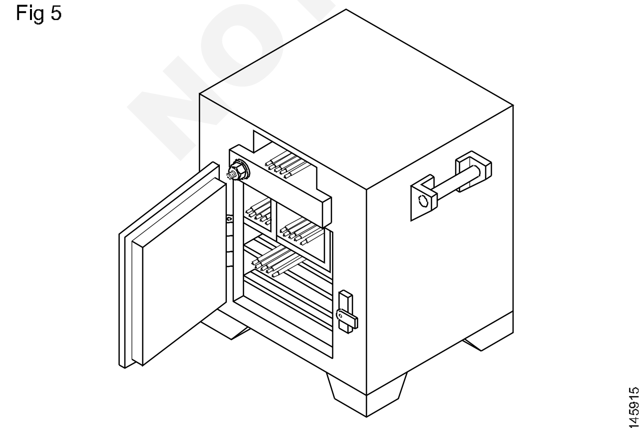
STUB END

Electrode coating can pick up moisture if exposed to atmosphere.

Store and keep the electrodes (air tight) in a dry place.

Heat the moisture affected/prone electrodes in an electrode drying oven at 110 - 150° C for one hour before using. (Fig 5)

Fig 5



ELECTRODE DRYING OVAN

Remember a moisture-affected electrode:

– has rusty stub end

– has white powder appearance in coating

– produces porous weld.

Always pick up the right electrode that will provide:

– good arc stability

– smooth weld bead

– fast deposition

– minimum spatters

– maximum weld strength

– easy slag removal.

Storage of electrodes: The efficiency of an electrode is affected if the covering becomes damp.

– Keep electrodes in unopened packets in a dry store.

– Place packages on a duckboard or pallet, not directly on the floor.

– Store so that air can circulate around and through the stack.

– Do not allow packages to be in contact with walls or other wet surfaces.

– The temperature of the store should be about 5^0C higher than the outside shade temperature to prevent condensation of moisture.

– Free air circulation in the store is as important as heating. Avoid wide fluctuations in the store temperature.

– Where electrodes cannot be stored in ideal conditions place a moisture-absorbent material (e.g silica-gel) inside each storage container.

Drying electrodes: Water in electrode covering is a potential source of hydrogen in the deposited metal and thus may cause:

– Porosity in the weld

– Cracking in the weld.

Indications of electrodes affected by moisture are:

– White layer on covering.

– Swelling of covering during welding.

– Disintegration of covering during welding.

– Excessive spatter.

– Excessive rusting of the core wire.

Electrodes affected by moisture may be dried before use by putting them in a controlled drying oven for approximately one hour at a temperature around 110 - 150^0C. This should not be done without reference to the conditions laid down by the manufacturer. It is important that hydrogen controlled electrodes are stored in dry, heated conditions at all times.

Warning: Special drying procedures apply to hydrogen controlled electrodes. Follow the manufacturer's instructions.

Oxy-acetylene cutting equipment

Objectives: At the end of this lesson you shall be able to
- **explain the features of the oxy-acetylene cutting equipment, its parts and cutting torch**
- **describe the oxy-acetylene cutting procedure**
- **differentiate between cutting and welding blowpipes.**

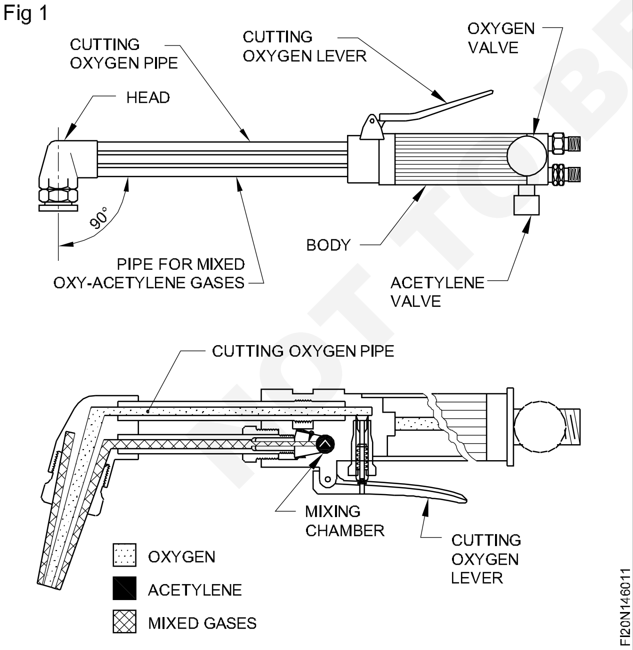
Cutting equipment: The oxy-acetylene cutting equipment is similar to the welding equipment, except that instead of using a welding blowpipe, a cutting blowpipe is used. The cutting equipment consists of the following.

- Acetylene gas cylinder
- Oxygen gas cylinder
- Acetylene gas regulator
- Oxygen gas regulator (Heavy cutting requires higher pressure oxygen regulator.)
- Rubber hose-pipes for acetylene and oxygen
- Cutting blowpipe

(Cutting accessories i.e. cylinder key, spark lighter, cylinder trolley and other safety appliances are the same as are used for gas welding.)

The cutting torch (Fig 1): The cutting torch differs from the regular welding blowpipe in most cases; it has an additional lever for the control of the cutting oxygen used to cut the metal. The torch has the oxygen and acetylene control valves to control the oxygen and acetylene gases while preheating the metal.

Fig 1



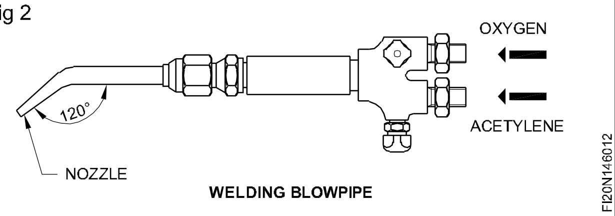
The cutting tip is made with an ORIFICE in the centre surrounded by five smaller holes. The centre opening permits the flow of the cutting oxygen and the smaller holes are for the preheating flame. Usually different tip sizes are provided for cutting metals of different thicknesses.

Oxy-acetylene cutting procedure: Fix a suitable size cutting nozzle in the cutting blowpipe. Ignite the cutting torch the same way as was done in the case of the welding blowpipe. Set the neutral flame for preheating. To start the cut, hold the cutting nozzle at angle 90° with the plate surface, and the inner cone of the heating flame 3 mm above the metal. Preheat the metal to bright red before pressing the cutting oxygen lever. If the cut is proceeding correctly, a shower of sparks will be seen to fall from the underside of the plate. Move the torch steadily on the punched line. If the edge of the cut appears to be too ragged, the torch is being moved too slowly. For a bevel cut, hold the cutting torch at the desired angle and proceed as is done in making a straight line cut. At the end of the cut, release the cutting oxygen lever and close the control valves of the oxygen and acetylene. Clean the cut and inspect.

Difference between cutting blowpipe and welding blowpipe: A cutting blowpipe has two control valves (oxygen and acetylene) to control the preheating flame and one lever type control valve to control the high pressure pure oxygen for making the cut.

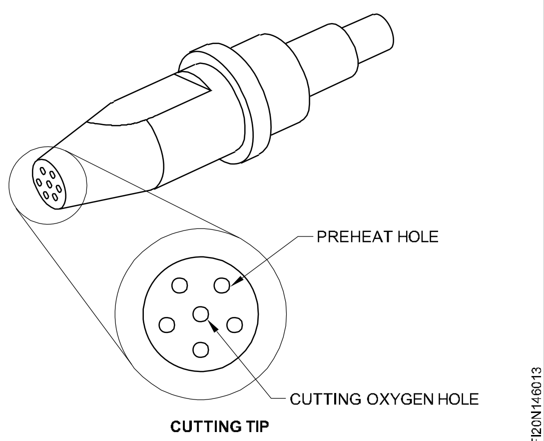
A welding blowpipe has only two control valves to control the heating flame. (Fig 2)

Fig 2



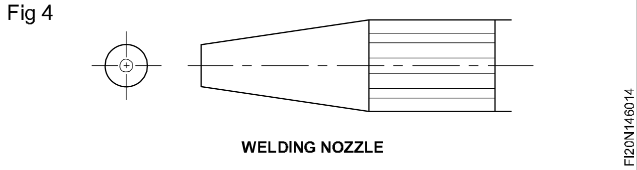
The nozzle of the cutting blowpipe has one hole in the centre for cutting oxygen and a number of holes around the circle for the preheating flame. (Fig 3)

Fig 3



The nozzle of the welding blowpipe has only one hole in the centre for the heating flame. (Fig 4)

Fig 4



WELDING NOZZLE

The angle of the cutting nozzle with the body is 90°.

The angle of the welding nozzle with the neck is 120°.

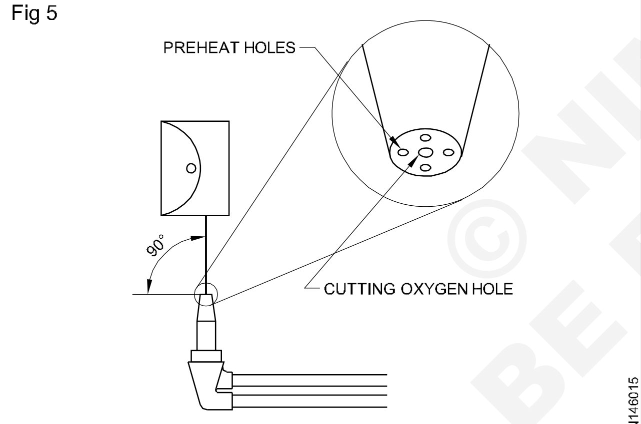
The cutting nozzle size is given by the diameter of the cutting oxygen orifice in mm.

The welding nozzle size is given by the volume of oxy-acetylene mixed gases coming out of the nozzle in cubic meter per hour.

Operating data for cutting mild steel

Cutting nozzle size - mm	Thickness of plate (mm)	Cutting oxygen pressure Kgf/cm²
0.8	3 - 6	1.0 - 1.4
1.2	6 - 19	1.4 - 2.1
1.6	19 - 100	2.1 - 4.2
2.0	100 - 150	4.2 - 4.6
2.4	150 - 200	4.6 - 4.9
2.8	200 - 250	4.9 - 5.5
3.2	250 - 300	5.5 - 5.6

Fig 5



CLEANING THE HOLES OF CUTTING NOZZLE

Care and maintenance: The high pressure cutting oxygen lever should be operated only for gas cutting purposes.

Care should be taken while fitting the nozzle with the torch to avoid wrong thread. Dip the torch after each cutting operation in water to cool the nozzle.

To remove any slag particles or dirt from the nozzle orifice use the correct size nozzle cleaner Fig.5. Use an emery paper if the nozzle tip is damaged to make it sharp and to be at 90^0 with the nozzle axis.

Method of handling cutting torch-description, parts, function and uses

Objectives: At the end of this lesson you shall be able to
- **explain the principle of gas cutting**
- **describe the cutting operation and its application.**

Introduction to gas cutting : The most common method of cutting mild steel is by an oxy-acetylene cutting process. With an oxy-acetylene cutting torch, the cutting (oxidation) can be confined to a narrow strip and with little effect of heat on the adjoining metal. The cut appears like a saw-cut on a wooden plank. The method can be successfully used to cut ferrous metals i.e. mild steel.

Non-ferrous metals and their alloys cannot be cut by this process.

Principle of gas cutting: When a ferrous metal is heated to red hot condition and then exposed to pure oxygen, a chemical reaction takes place between the heated metal and oxygen. Due to this oxidation reaction, a large amount of heat is produced and cutting action takes place.

When a piece of wire with a red hot tip is placed in a container of pure oxygen, it bursts into flame immediately and is completely consumed. Fig 1 illustrates this reaction. Similarly in oxy-acetylene cutting the combination of red hot metal and pure oxygen causes rapid burning and iron is changed into iron oxide (oxidation).

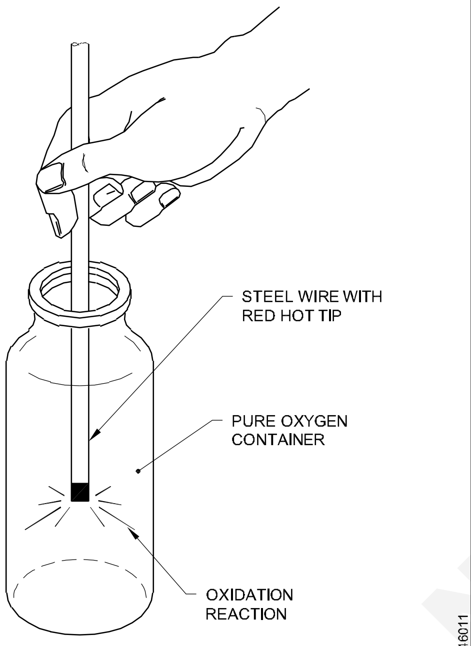
By this continuous process of oxidation the metal can be cut through very rapidly.

The iron oxide is less in weight than the base metal.

Also the iron oxide is in molten condition called slag. So the jet of oxygen coming from the cutting torch will blow the molten slag away from the metal making a gap called 'Kerf'. Fig.2

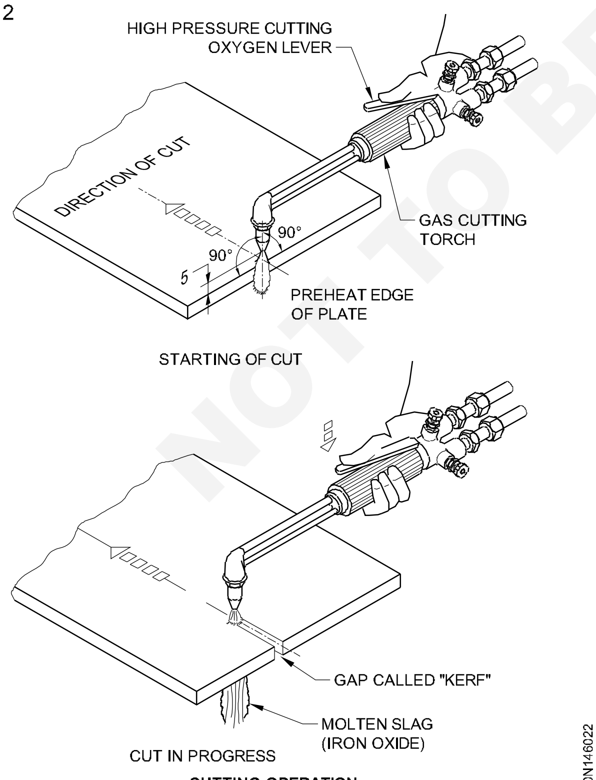
Cutting operation (Fig 2): There are two operations in oxy-acetylene gas cutting. A preheating flame is directed on the metal to be cut and raises it to bright red hot or ignition point (900°C app.). Then a stream of high pressure pure oxygen is directed on to the hot metal which oxidises and cuts the metal.

Fig 1



OXIDATION

Fig 2



CUTTING OPERATION

The two operations are done simultaneously with a single torch.

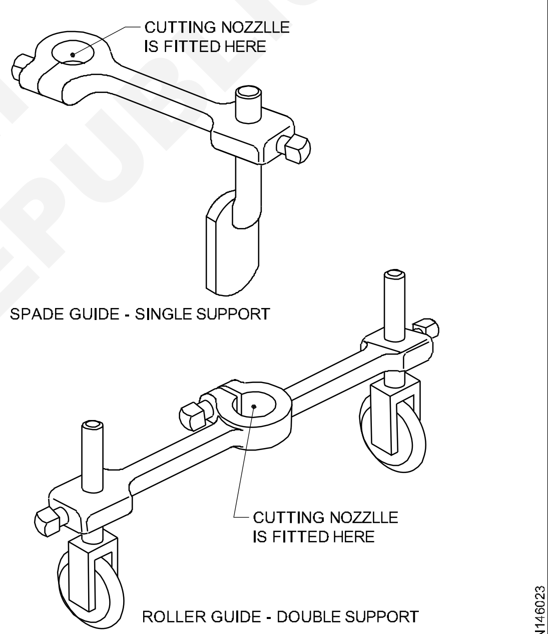
The torch is moved at a proper travel speed to produce a smooth cut. The removal of oxide particles from the line of cut is automatic by means of the force of oxygen jet during the progress of cut.

300 litres of oxygen are required to oxidize one kilogram of iron completely. The ignition temperature of steel for gas cutting is 875°C to 900°C.

Application of cutting torch: Oxy-acetylene cutting torch is used to cut mild steel plates above 4mm thickness. The M.S plate can be cut to its full length in straight line either parallel to the edge or at any angle to the edge of the plate. Bevelling the edges of a plate to any required angle can also be done by tilting the torch. Circles and any other curved profile can also be cut using the cutting torch by using a suitable guide or template.

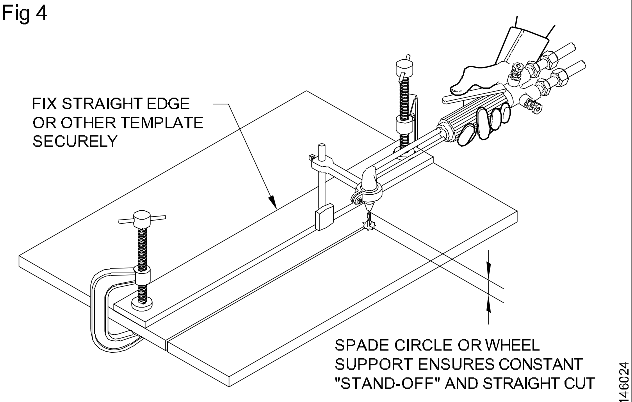
Fig.3 to Fig.7 shows the guides used to cut straight lines, bevel and small circles.

Fig 3



GUIDES

Fig 4



CUTTING WITH STRAIGHT EDGE AND SINGLE SUPPORT

Cutting torch guides: Guides are sometimes used during oxy acetylene cutting.

They can be either a roller guide, double support or spade guide with single support.

Fig 5

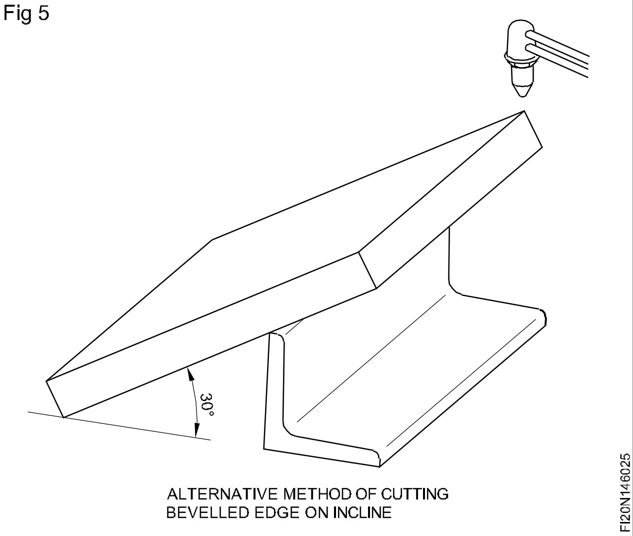


Fig 6

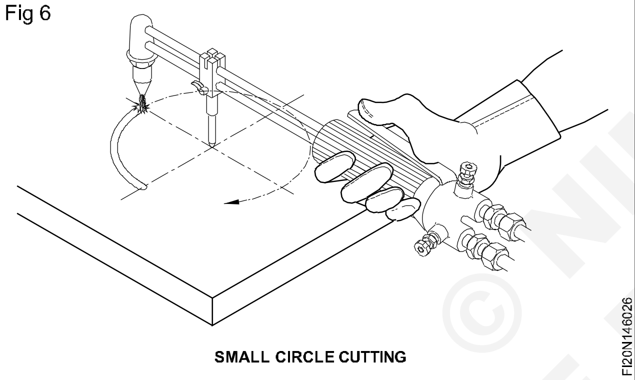
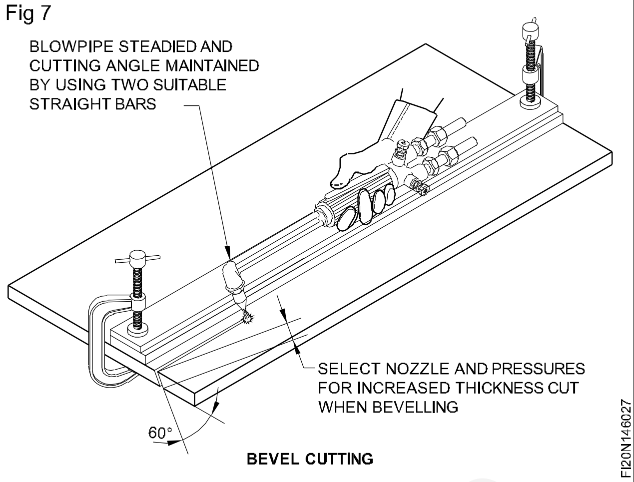


Fig 7



Cutting guides are held onto the nozzle of the cutting torch by tightening a clamp bolt. The clamps, where they are fitted, are adjusted so the inner cones of the preheat flames are approximately 2-3mm above the surface of the metal to be cut. The tip of the cutting nozzle is held at distance of 5-6mm above surface of the plate being cut.

Drills

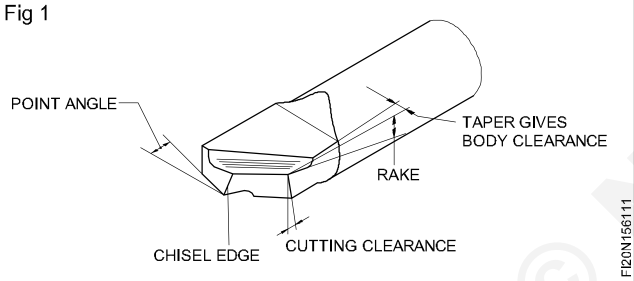
Objectives: At the end of this lesson you shall be able to
- **state drilling and drill material**
- **state the necessity of drilling**
- **name the types of drills used**
- **list the parts of a twist drill.**

Drilling: Drilling is the production of cylindrical holes of definite diameters in workpieces by using a multi-point cutting tool called a 'drill'. It is the first operation done internally for any further operation. The fluted part (or) body of a drill is made of either high carbon steel (or) High speed steel.

Types of drills and their specific uses

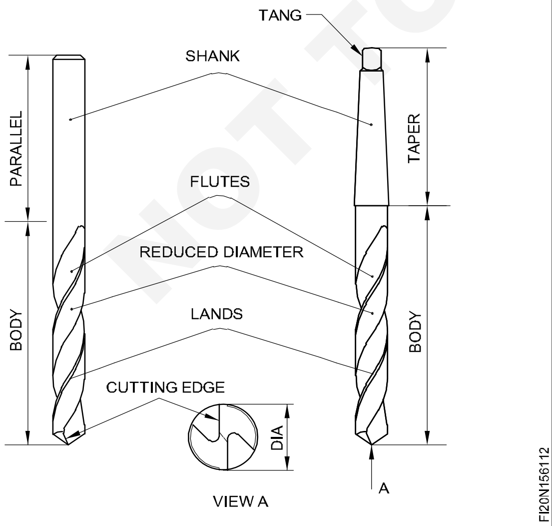
Flat drill (Fig 1) **:** The earliest form of drill was the flat drill which is easy to operate, besides being inexpensive to produce. The chip removal is poor and its operating efficiency is very low.

Fig 1



Twist drill : Almost all drilling operation is done using a twist drill. It is called a twist drill as it has two or more spiral or helical flutes formed along its length. The two basic types of twist drills are, parallel shank and taper shank. Parallel shank twist drills are available below 13mm size (Fig 2).

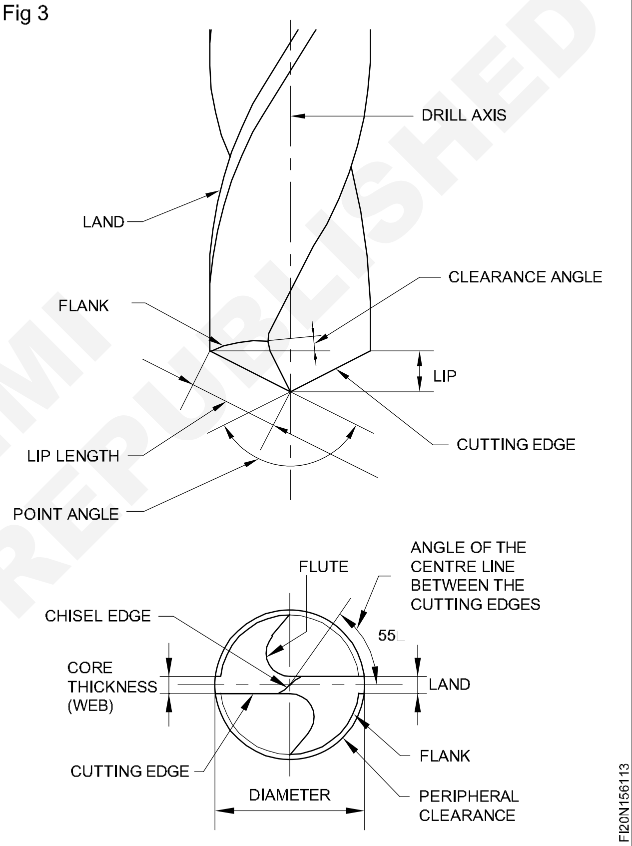
Fig 2



Parts of a twist drill : Drills are made out of high speed steel. The spiral flutes are machined at an angle of 27 1/2° to its axis.

The flutes provide a correct cutting angle which provides an escape path for the chips. It carries the coolant to the cutting edge during drilling. (Fig 3)

Fig 3



The portions left between the flutes are called 'lands'. The size of a drill is determined and governed by the diameter over the lands.

The point angle is the cutting angle, and for general purpose work, it is 118°. The clearance serves the purpose of clearing the back of the lip from fouling with the work. It is mostly 8°.

Deep hole drills

Deep hole drilling is done by using a type of drill known as 'D' bit (Fig 4)

Drills are made of high speed steel.

Drills are manufactured with varying helix angles for drilling different materials. General purpose drills have a standard helix angle of 27 1/2°. They are used on mild steel and cast iron. (Fig 5a)

Fig 4

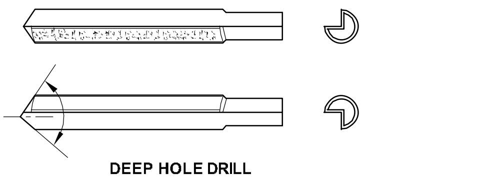
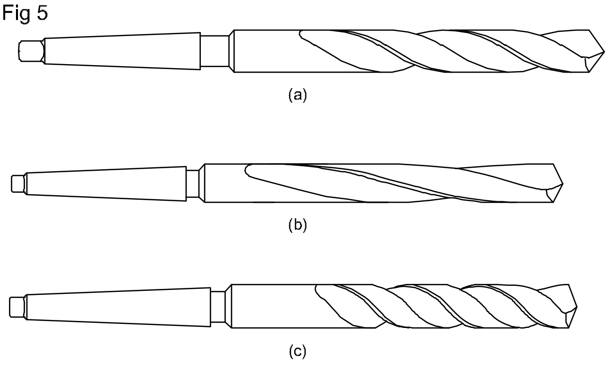


Fig 5



A slow helix drill is used on materials like brass, gun metal, phosphor-bronze and plastics. (Fig 5b)

A quick helix drill is used for copper, aluminium and other soft metals (Fig 5c)

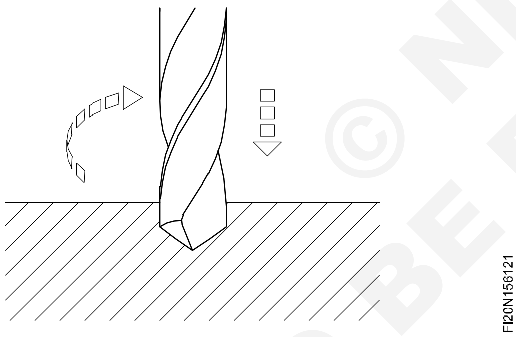
> **A quick helix drill should never be used on brass as it will 'dig in' and the workpiece may be thrown from the machine table.**

Drill (Parts and functions)

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

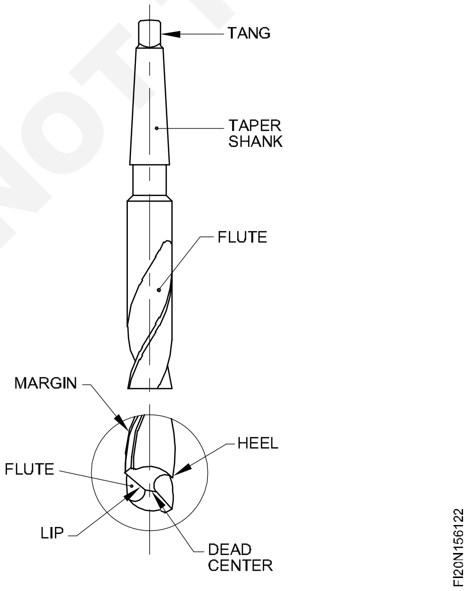
Drilling is a process of making holes on workpieces. The tool used is a drill. For drilling, the drill is rotated with a downward pressure causing the tool to penetrate into the material. (Fig 1)

Fig 1



Parts of a Drill (Fig 2)

Fig 2



The various parts of a drill can be identified from figure 2.

Point

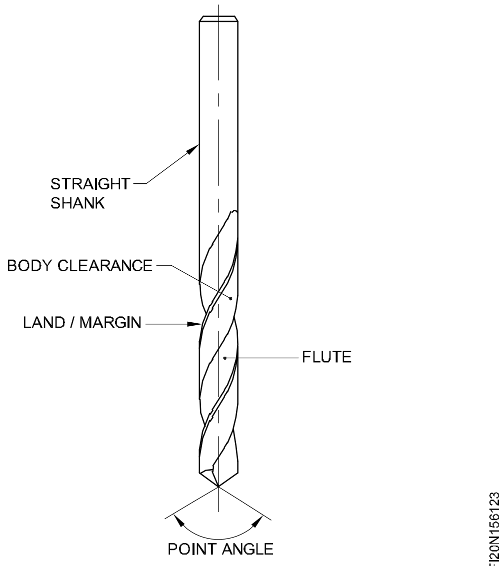
The cone shaped end which does the cutting is called the point. It consists of a dead centre, lips or cutting edges, and a heel.

Shank

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

Taper shank, used for larger diameter drills, and straight shank, used for smaller diameter drills. (Fig 3)

Fig 3



Tang

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

Body

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

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

Flutes (Fig 3)

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

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

Land/Margin (Fig 3)

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

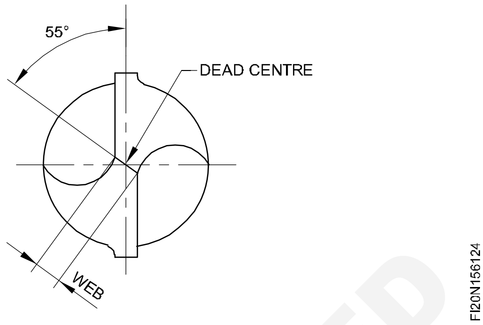
The diameter of the drill is measured across the land/ margin.

Body clearance (Fig 3)

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

Web (Fig 4)

Fig 4



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

— — — — — —

Drill angles

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

Like all cutting tools the drills are provided with certain angles for efficiency in drilling.

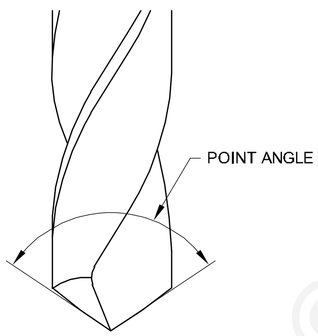
Drill angles

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

Point angle, helix angle, rake angle, clearance angle and chisel edge angle.

Point angle/ cutting angle (Fig 1)

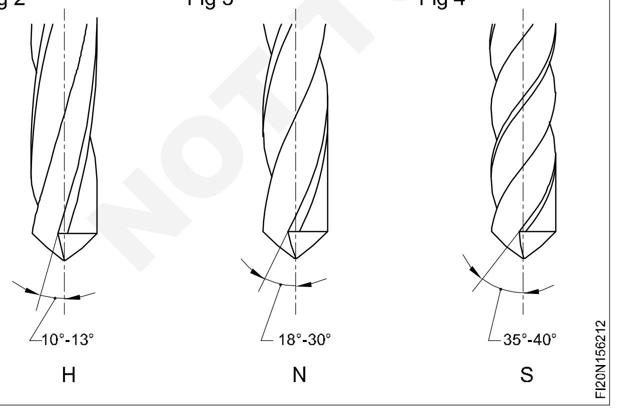
Fig 1



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

Helix angle (Figs 2,3 and 4)

Fig 2 Fig 3 Fig 4



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

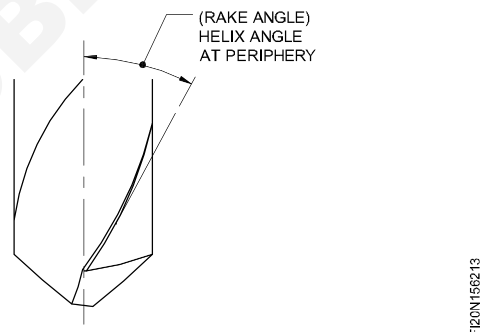
The helix angles vary according to the material being drilled. According to indian standards, three types of drills are used for drilling various materials.

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

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

Rake angle (Fig 5)

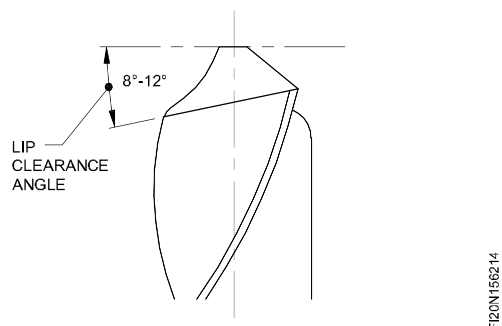
Fig 3



Rake angle is the angle of flute (helix angle).

Clearance angle (Fig 6)

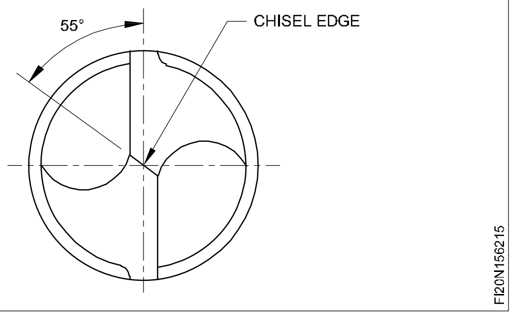
Fig 4



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

Chisel edge angle/web angle (Fig 7)

Fig 5



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

Designation of drills

Twist drills are designated by the

- Diameter
- Tool type
- Material

Example

A twist drill of 9.50 mm dia. of tool type 'H' for right hand cutting and made from HSS is designated as:

Twist drill 9.50 - H - IS5101 - HS

where H = tool type

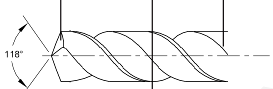
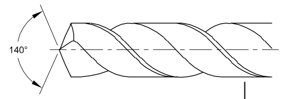
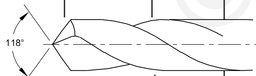
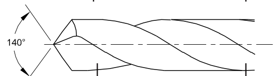
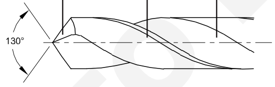
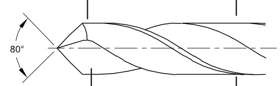
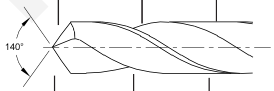
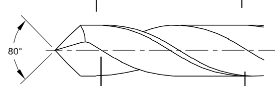
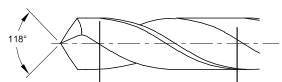
IS5101 = IS Number

HS = tool material

9.5 = diameter of the drill.

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

DRILLS FOR DIFFERENT MATERIALS

Recommended drills								
Material to be drilled	**Point angle**	**Helix angle** d=3.2-5	5-10	10-	**Material to be drilled**	**Point angle**	**Helix angle** d=3.5-5	5-
Steel and cast steel up to 70 kgf/mm^2 strength Gray cast iron Malleable cast iron Brass German silver, nickel.	 118°	22°	25°	30°	Copper (up to 30 mm drill diameter) Al-alloys, forming curly chips Celluloid	 140°	35°	40°
Brass, CuZn 40	 118°	12°	13°	13°	Austenitic steels Magnesium alloys	 140°	12°	13°
Steel and cast steel 70...120 Kgf/mm^2	 130°	22°	25°	30°	Moulded plastics (with thickness s>d)	 80°	35°	40°
Stainless steel; Copper (drill diameter more than 30 mm) Al-alloy, forming short broken chips	 140°	22°	25°	30°	Moulded plastics, with thickness s<d Laminated plastics, hard rubber (ebonite) marble, slate, coal	 80°	12°	13°
					Zinc alloys	 118°	35°	40°

Drilling - Cutting speed, feed and r.p.m , drill holding devices

Objectives: At the end of this lesson you shall be able to
- **define cutting speed**
- **state the factors for determining the cutting speed**
- **determine r.p.m/spindle speed.**

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

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

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

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

The recommended cutting speeds for different materials are given in the Table 1. Based on the cutting speed recommended, the r.p.m, at which a drill has to be driven is determined.

TABLE 1

Recommended cutting speeds

Materials being drilled (HSS Tool)	
Aluminium	70 - 100
Brass	35 - 50
Bronze(phosphor)	20 - 35
Cast iron (grey)	25 - 40
Copper	35 - 45
Steel (medium carbon/mild steel)	20 - 30
Steel (alloy, high tensile)	5 - 8
Thermosetting plastic (low speed due to abrasive properties)	20 - 30

Cutting speed calculation

Cutting speed (V) π x d x h

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

n - r.p.m.

v - Cutting speed in m/min.

d - diameter of the drill in mm.

π = 3.14

Examples

Calculate the r.p.m for a high speed steel drill ∅ 24 to cut mild steel.

The cutting speed for mild steel is taken as 30 m/min from the table.

$$n = \frac{1000 \times 30}{3.14 \times 24} = 398 \text{ r.p.m}$$

It is always preferable to set the spindle speed to the nearest available lower range.

The r.p.m. will differ according to the diameter of the drills. The cutting speed being the same, larger diameter drills will have lesser r.p.m and smaller diameter drills will have higher r.p.m.

The recommended cutting speeds are achieved only by actual experiment.

Feed in drilling

Objectives: At the end of this lesson you shall be able to
- **state what is meant by feed**
- **state the factors that contribute to an efficient feed rate.**

Feed is the distance a drill advances into the work in one complete rotation. (Fig 1)

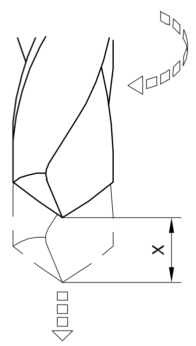
Feed is expressed in hundredths of a millimeter.

Example - 0.040mm/ rev

The rate of feed is dependent up on a number of factors.

- The finish required
- Type of drill (drill material)
- Material to be drilled

Fig 1



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Factors like rigidity of the machine, holding of the work-piece and the drill, will also have to be considered while determining the feed rate. If these are not to the required standard, the feed rate will have to be decreased.

It is not possible to suggest a particular feed rate taking all the factors into account.

The table gives the feed rate which is based on the average feed values suggested by the different manufacturers of drills. (Table 1)

Too coarse a feed may result in damage to the cutting edges or breakage of the drill.

Too slow a rate of feed will not bring improvement in surface finish but may cause excessive wear of the tool point, and lead to chattering of the drill.

> **For optimum results in the feed rate while drilling, it is necessary to ensure the drill cutting edges are sharp. Use the correct type of cutting fluid.**

TABLE 1

Drill diameter (mm) H.S.S	**Rate of feed** (mm/rev)
1.0 - 2.5	0.040 - 0.060
2.6 - 4.5	0.050 - 0.100
4.6 - 6.0	0. 075 - 0.150
6.1 - 9.0	0.100 - 0.200
9.1 - 12.0	0.150 - 0.250
12.1 - 15.0	0.200 - 0.300
15.1 - 18.0	0.230 - 0.330
18.1 - 21.0	0.260 - 0.360
21.1 - 25.0	0.280 - 0.380

Cutting Tool	**Mild Steel**	**Carbon steel**	**Aluminium**	**Brass**	**Cast iron**	**Stainless steel**
HSS	100	80	250 to 350	175	100	80 to 100
Carbide	300	200	750 to 1000	500	250	200 to 250

Drill-holding devices

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

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

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

Drill chucks: Straight shank drills are held in drill chucks. (Fig 1A) For fixing and removing drills, the chucks are provided either with a pinion and key or a knurled ring.

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

Taper sleeves and sockets (Fig 2): Taper shank drills have a Morse taper.

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

The drills are provided with five different sizes of Morse tapers, and are numbered from MT 1 to MT 5.

In order to make up the difference in sizes between the shanks of the drills and the bore 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 2)

Fig 1

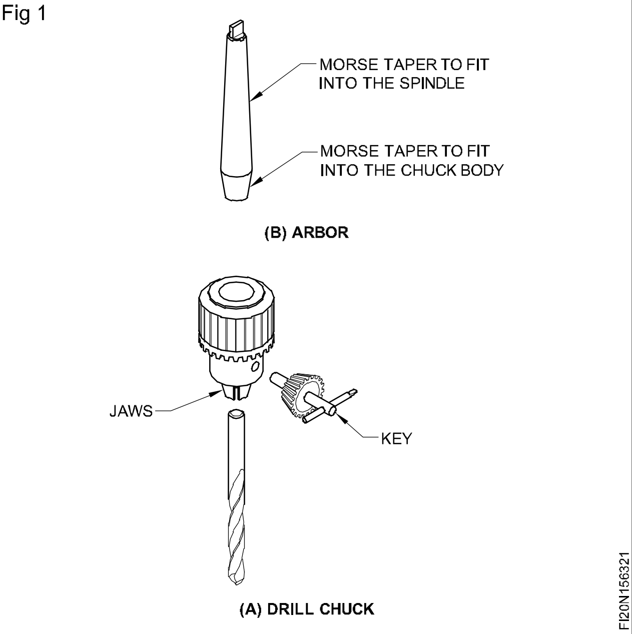
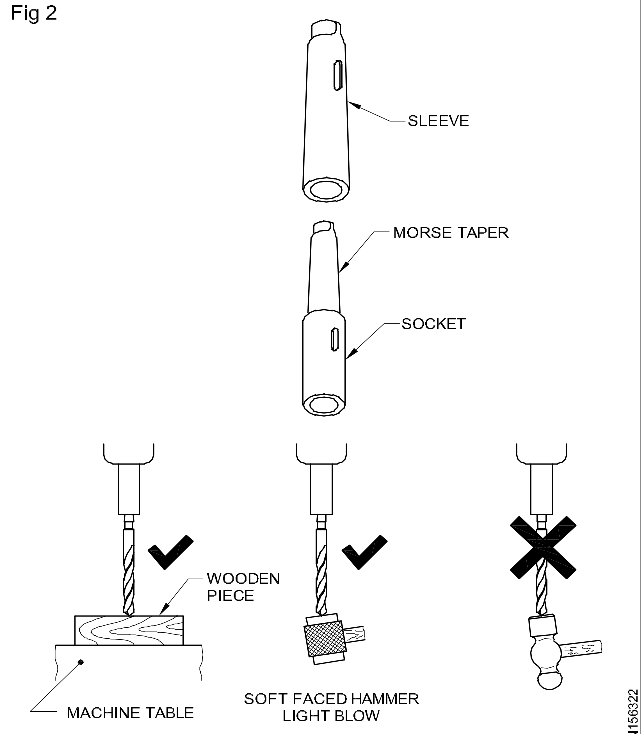


Fig 2



FIXING DRILLS ON SPINDLE

While fixing the drill in a socket or sleeve, the tang portion should align in the slot. This will facilitate the removal of the drill or sleeve from the machine spindle.

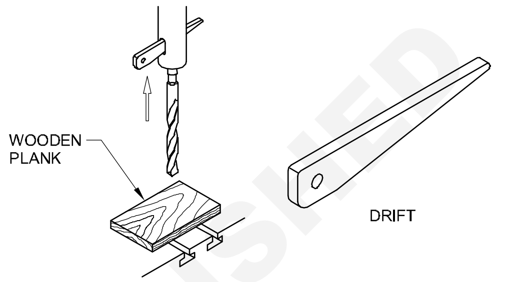
Use a drift to remove drills and sockets from the machine spindle. (Fig 3)

While removing the drill from the sockets/sleeves don't allow it to fall on the table or jobs.

Drill chucks are made from special alloy steel

Drill sleeves are made from case hardened steel

Fig 3



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Counter sinking

Objectives: At the end of this lesson you shall be able to
- **What is countersinking**
- **list the purposes of countersinking**
- **state the angles of countersinking for the different applications**
- **name the different types of countersinks**
- **distinguish between Type A and Type B counter sink holes.**

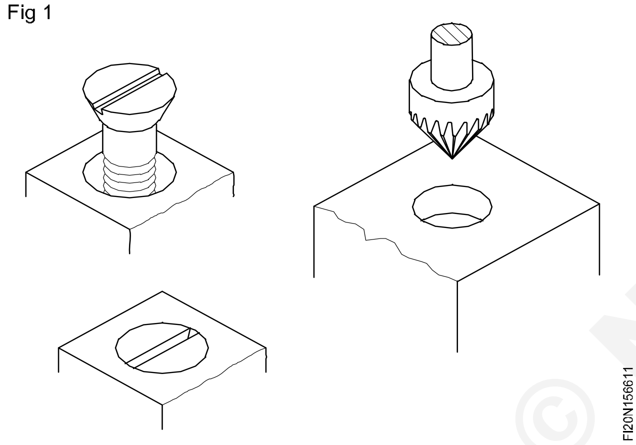
What is countersinking?

Countersinking is an operation of beveling the end of a drilled hole. The tool used is called a countersink.

Countersinking is carried out for the following purposes:

- To provide a recess for the head of a countersink screw, so that it is flush with the surface after fixing (Fig 1)

Fig 1



- To deburr a hole after drilling
- For accommodating countersink rivet heads
- To chamfer the ends of holes for thread cutting and other machining processes.

Angles for countersinking

Countersinks are available in different angles for different uses.

75° countersink riveting

80° countersink self tapping screws

90° countersink head screws and deburring

120° chamfering ends of holes to be threaded or other machining processes.

Countersinks: Countersinks of different types are available.

The commonly used countersinks have multiple cutting edges and are available in taper shank and straight shank. (Fig 2)

For countersinking small diameter holes special countersinks with two or one flute are available. This will reduce the vibration while cutting.

Countersinks with Pilot (Fig 3)

For precision countersinking, needed for machine tool assembling and after machining process, countersinks with pilots are used.

Fig 2

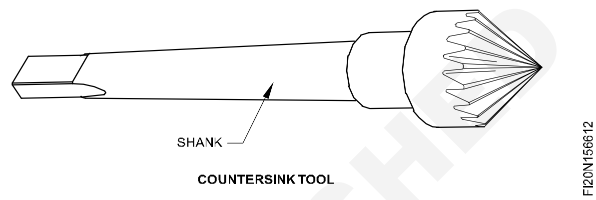
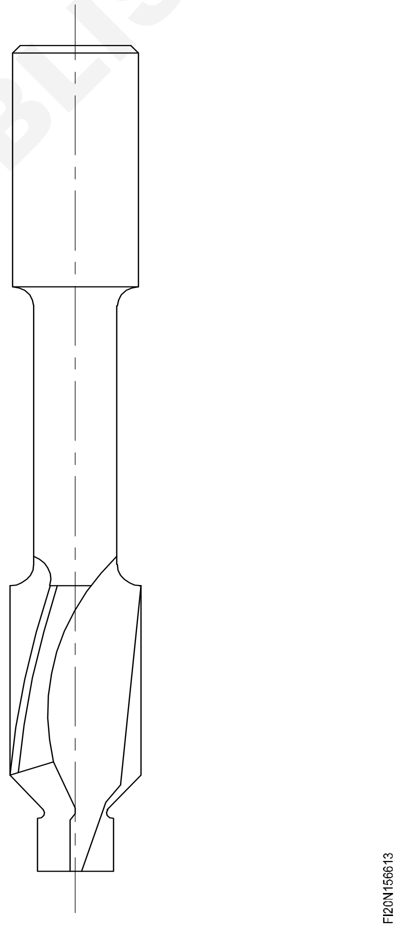


Fig 3



They are particularly useful for heavy duty work.

The pilot is provided at the end for guiding the countersink concentric to the hole.

Countersinks with pilots are available with interchangeable and solid pilots.

Countersink hole sizes: The countersink holes according to Indian Standard IS 3406 (Part 1) 1986 are of four types: Type A, Type B, Type C and Type E.

Type A is suitable for slotted countersink head screws, cross recessed and slotted raised countersink head screws.

These screws are available in two grades i.e. medium and fine.

The dimensions of various features of the Type 'A' countersink holes, and the method of designation are given in Table 1. (Fig 4 & 5)

Type 'B' countersink holes are suitable for countersink head screws with hexagon socket.

The dimensions of the various features and the method of designation are given in Table II. (Fig 6)

Type 'C' countersink holes are suitable for slotted raised countersink (oval) head tapping screws and for slotted countersink (flat) head tapping screws.

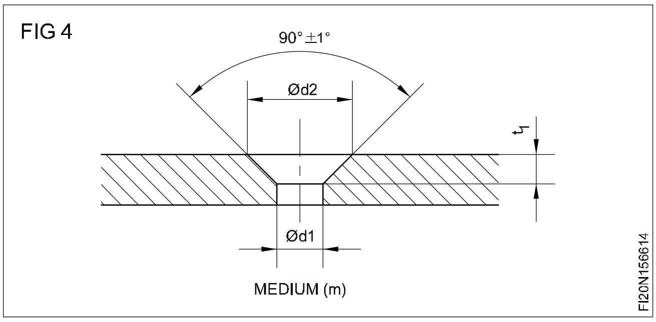
The dimension of the various features and the method of designation are given in Table III. (Fig 7)

Type 'E' countersinks are used for slotted countersink bolts used for steel structures.

The dimensions of the various features and the method of designation are given in Table IV. (Fig 8)

Table I

Dimensions and designation of countersink - Type A according to IS 3406 (Part 1) 1986



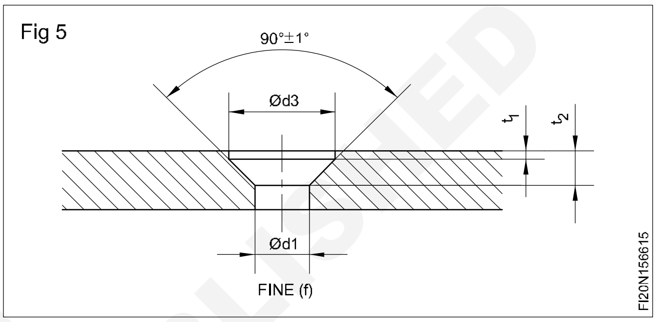


Table I

For Nominal Size		**1**	**1.2**	**(1.4)**	**1.6**	**(1.8)**	**2**	**2.5**	**3**	**3.5**	**4**	**(4.5)**
Medium Series (m)	d_1 H13	1.2	1.4	1.6	1.8	2.1	2.4	2.9	3.4	3.9	4.5	5
	d_2 H13	2.4	2.8	3.3	3.7	4.1	4.6	5.7	6.5	7.6	8.6	9.5
	t_1 [3]	0.6	0.7	0.8	0.9	1	1.1	1.4	1.6	1.9	2.1	2.3
Fine Series (f)	d_1 H12	1.1	1.3	1.5	1.7	2	2.2	2.7	3.2	3.7	4.3	4.8
	d_3 H12	2	2.5	2.8	3.3	3.8	4.3	5	6	7	8	9
	t_1 [3]	0.7	0.8	0.9	1	1.2	1.2	1.5	1.7	2	2.2	2.4
	t_2 + 0.1 0	0.2	0.15	0.15	0.2	0.2	0.15	0.35	0.25	0.3	0.3	0.3

For Nominal Size		**5**	**6**	**8**	**10**	**12**	**(14)**	**16**	**(18)**	**20**
Medium Series (m)	d_1 H13	5.5	6.6	9	11	13.5	15.5	17.5	20	22
	d_2 H13	10.4	12.4	16.4	20.4	23.9	26.9	31.9	36.4	40.4
	t_1 [3]	2.5	2.9	3.7	4.7	5.2	5.7	7.2	8.2	9.2
Fine Series (f)	d_1 H12	5.3	6.4	8.4	10.5	13	15	17	19	21
	d_3 H12	10	11.5	15	19	23	26	30	34	37
	t_1 [3]	2.6	3	4	5	5.7	6.2	7.7	8.7	9.7
	t_2 + 0.1 0	0.2	0.45	0.7	0.7	0.7	0.7	1.2	1.2	1.7

Note 1 : **Size shown in brackets are of second preference.**

Note 2 : Clearance hole d_1 according to medium and fine series of IS : 1821 ' Dimensions for clearance holes for bolts and screws (second revision)'

Designation : A countersink Type A with clearance hole of fine (f) series and having nominal size 10 shall be designated as – Countersink A f 10 - IS : 3406.

Table II

Dimensions and designation of countersink - Type B according to IS 3406 (Part 1) 1986

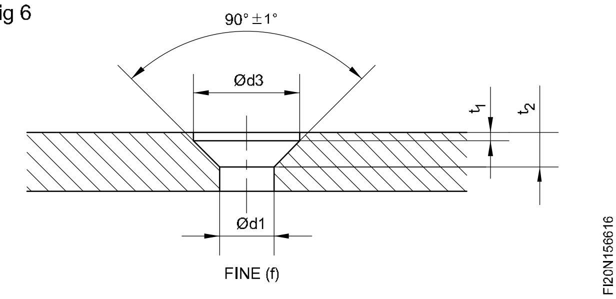


Fig 6

For Nominal Size		3	4	5	6	8	10	12	(14)	16	(18)	20	22 24
Fine	d_1 H12	3.2	4.3	5.3	6.4	8.4	10.5	13	15	17	19	21	23 25
Series	d_2 H12	6.3	8.3	10.4	12.4	16.5	20.5	25	28	31	34	37	48.2 52
(f)	t_1 ³	1.7	2.4	2.9	3.3	4.4	5.5	6.5	7	7.5	8	8.5	13.1 14
	t_2 + 0.1	0.2		0.3		0.4				0.5			1

Note 1: **Sizes shown in brackets are of second preference.**
Note 2: Clearance hole d1 according to medium and fine series of IS : 1821- 1982.

Designation : A countersink Type A with clearance hole of fine (f) series and having nominal size 10 shall be designated as – Countersink A f 10 - IS : 3406.

Table III

Dimensions and designation of countersink - Type C according to IS 3406 (Part 1) 1986

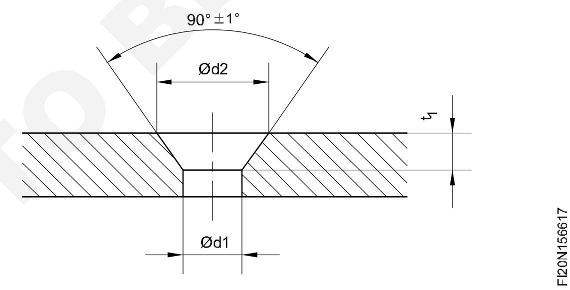


Fig 7

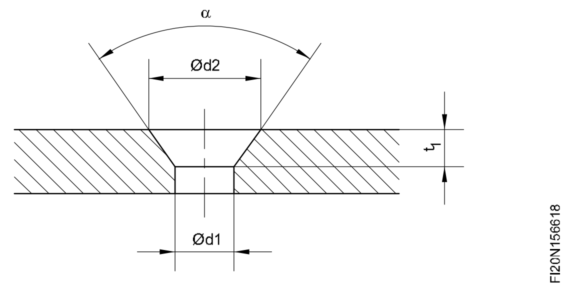
For Screw Size No.	(0)	(1)	2	(3)	4	(5)	6	(7)	8	10	(12)	14	(16)
d_1 H12	1.6	2	2.4	2.8	3.1	3.5	3.7	4.2	4.5	5.1	5.8	6.7	8.4
d_2 H12	3.1	3.8	4.6	5.2	5.9	6.6	7.2	8.1	8.7	10.1	11.4	13.2	16.6
t_1 ³	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.6	3	3.4	3.9	4.9

Note : Sizes given in brackets are of second preference.

Designation : A countersink Type C for screw size 2 shall be designated as – Countersink C 2 - IS : 3406.

Table IV

Fig 8



Dimension and designation of countersink - Type E according to IS 3406 (Part 1) 1986

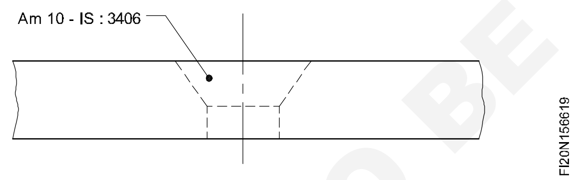
For Nominal No.	10	12	16	20	22	24
d_1 H12	10.5	13	17	21	23	25
d_2 H12	19	24	31	34	37	40
t_1 ³	5.5	7	9	11.5	12	13
α ± 1°	75°			60°		
Note: Clearance hole d_1 according to fine series of IS : 1821 - 1982						

Designation : A countersink Type E for nominal size 10 shall be designated as – Countersink E 10 - IS : 3406.

Methods of representing countersink holes in drawings

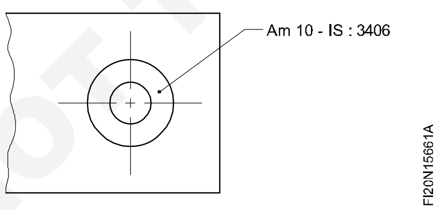
Countersink hole sizes are identified by code designation or using dimension.(Fig 9 - 12)

Fig 9



Use of code designation

Fig 10



Use of dimension

The dimension of the countersink can be expressed by the diameter of the countersink and the depth of the countersink.

Fig 11

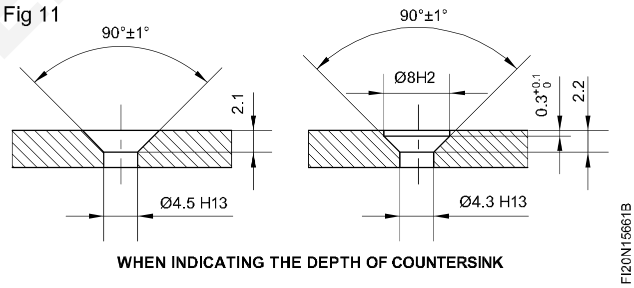
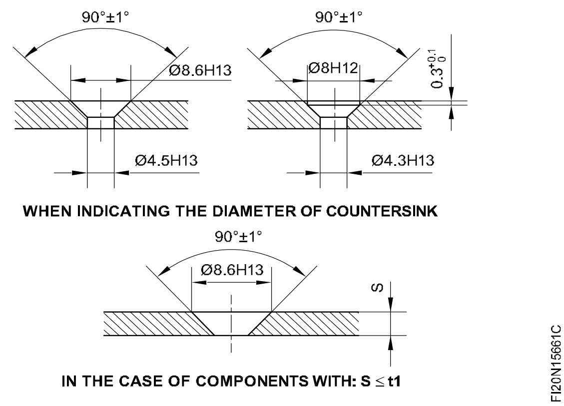


Fig 12



Counterboring and spot facing

Objectives: At the end of this lesson you shall be able to
- **differentiate counterboring and spot facing**
- **state the types of counterbores and their uses**
- **determine the correct counterbore sizes for different holes.**

Counterboring

Counterboring is an operation of enlarging a hole to a given depth, to house heads of socket heads or cap screws with the help of a counterbore tool. (Fig 1)

Fig 1

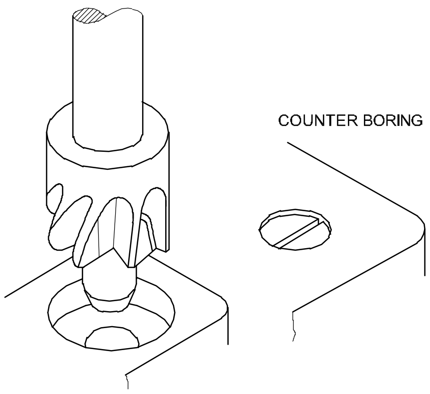
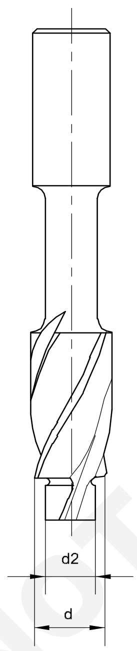


Fig 2



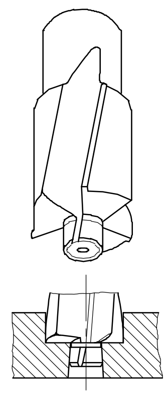
Counterbore (Tool)

The tool used for counterboring is called a counterbore. (Fig 2) Counterbores will have two or more cutting edges.

At the cutting end, a pilot is provided to guide the tool concentric to the previously drilled hole. The pilot also helps to avoid chattering while counterboring. (Fig 3)

Counterbores are available with solid pilots or with interchangeable pilots. The interchangeable pilot provides flexibility of counterboring on different diameters of holes.

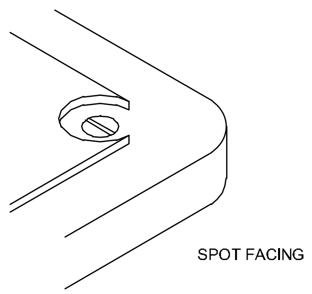
Fig 3



Spot facing

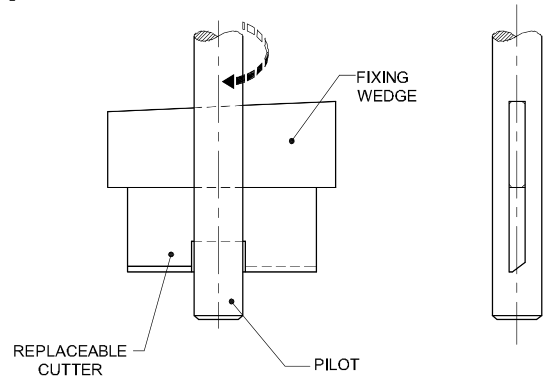
Spot facing is a machining operation for producing a flat seat for bolt head, washer or nut at the opening of a drilled hole. The tool is called a spot facer or a spot facing tool. Spot facing is similar to counterboring, except that it is shallower. Tools that are used for counterboring can be used for spot facing as well. (Fig 4)

Fig 4



Spot facing is also done by fly cutters by end-cutting action. The cutter blade is inserted in the slot of the holder, which can be mounted on to the spindle. (Fig 5)

Fig 5



Counterbore sizes and specification

Counterbore sizes are standardised for each diameter of screws as per BIS.

There are two main types of counterbores. Type H and Type K.

The type H counterbores are used for assemblies with slotted cheese head, slotted pan head and cross recessed pan head screws. The type K counterbores are used in assemblies with hexagonal socket head capscrews.

For fitting different types of washers the counterbore standards are different in Type H and Type K.

The clearance hole d1 are of two different grades i.e. medium (m) and fine (f) and are finished to H13 and H12 dimensions.

The table given below is a portion from IS 3406 (Part 2) 1986. This gives dimensions for Type H and Type K counterbores.

Counterbore and Clearance Hole Sizes for Different Sizes of Screws

Dimensions for H and K Type counter bores

While representing counterbores in drawings, counterbores can be indicated either by code designation or using the dimensions.

Fig 6

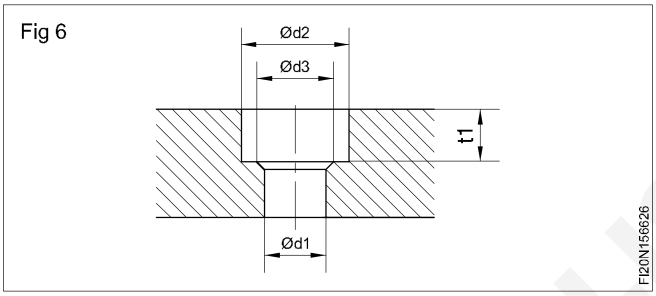


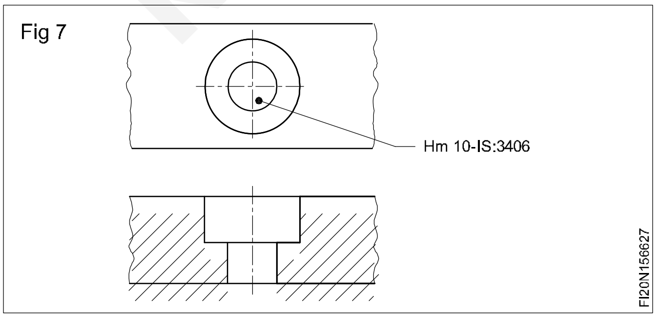
Table - 1

		1	1.2	1.4	1.6	1.8	2	2.5	3	(3.5)	4	5	6	8	10	12	(14)	16	18	20	22	24	27	30	33	36
For Nominal size		1	1.2	1.4	1.6	1.8	2	2.5	3	(3.5)	4	5	6	8	10	12	(14)	16	18	20	22	24	27	30	33	36
d1	Medium (m) H13	1.2	1.4	1.6	1.8	2.1	2.4	2.9	3.4	3.9	4.5	5.5	6.6	9	11	13.5	15.5	17.5	20	22	24	26	30	33	36	39
d1	fine (f) H12	1.1	1.3	1.5	1.7	2	2.2	2.7	3.2	3.7	4.3	5.3	6.4	8.4	10.5	13	15	17	19	21	23	25	-	-	-	-
d2 H13		2.2	2.5	2.8	3.3	3.8	4.3	5	6	6.5	8	10	11	15	18	20	24	26	30	33	36	40	43	48	53	57
d3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	15.5	17.5	19.5	22	24	26	28	33	36	39	42
t1	Type H	0.8	0.9	1	1.2	1.5	1.6	2	2.4	2.9	3.2	4	4.7	6	7	8	9	10.5	11.5	12.5	13.5	14.5	-	-	-	-
t1	Type K	-	-	1.6	1.8	-	2.3	2.9	3.4	-	4.6	5.7	6.8	9	11	13	15	17.5	19.5	21.5	23.5	25.5	28.5	32	35	38
Tolerances			+0.1 0				+0.2 0									+0.4 0						+0.6 0				

Note : Sizes given in brackets are of second preference. For details refer IS : 3406 (Part2) 1986.

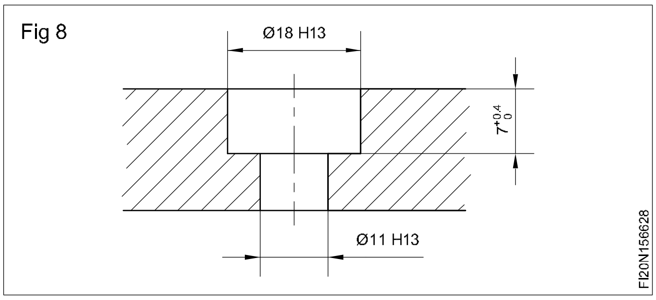
Using code designation (Fig 7)

Fig 7



Using dimensions (Fig 8)

Fig 8



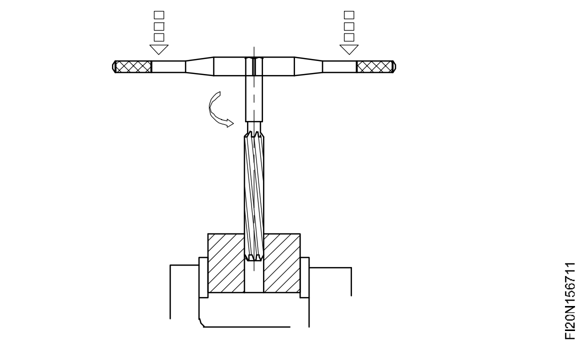
Reamers

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

What is a reamer?

A reamer is a multipoint cutting tool used for enlarging by finishing previously drilled holes to accurate sizes. (Fig 1)

Fig 1



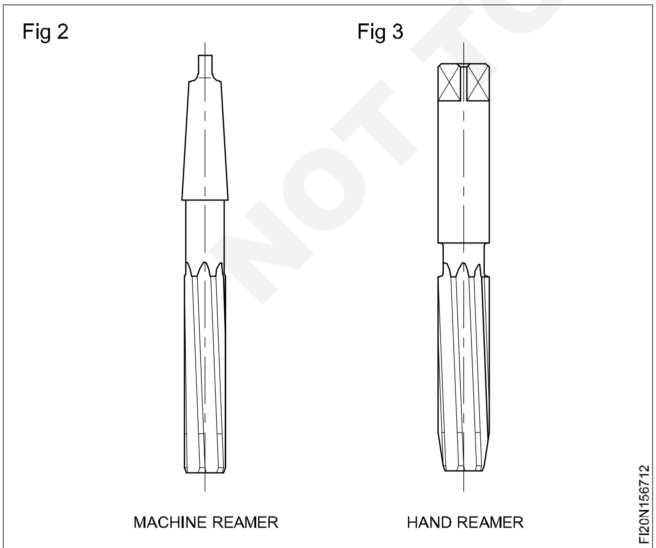
Advantages of 'reaming'

Reaming produces

- High quality surface finish
- 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. (Figs 2a and 2b)



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

Machine reamers are fitted on spindles of machine tools and rotated for reaming.

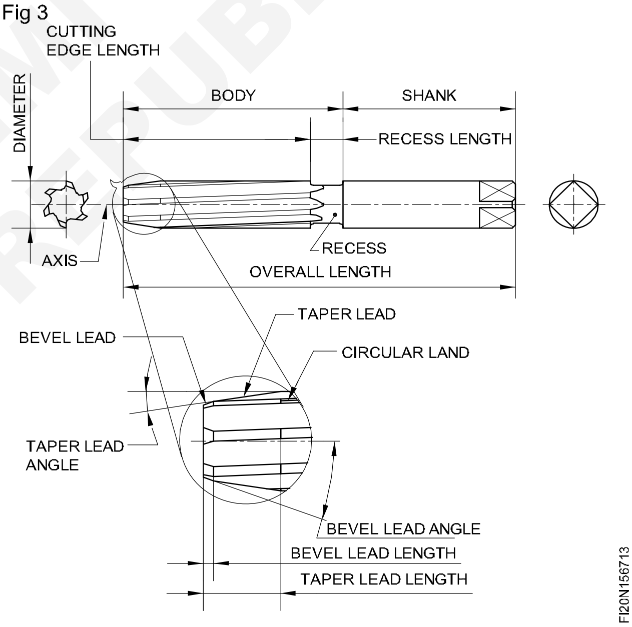
Machine reamers are provided with mores taper shanks for holding on machine spindles.

Hand reamers have straight shanks with 'square' at the end, for holding with tap wrenches. (Figs 2 (a) and (b)

Parts of a hand reamer

The parts of a hand reamer are listed hereunder. Refer to Fig 3.

Fig 3



Axis: The longitudinal centre line of the reamer.

Body: The portion of the reamer extending from the entering end of the reamer to the commencement of the shank.

Recess: The portion of the body which is reduced in diameter below the cutting edges, pilot or guide diameters.

Shank: The portion of the reamer which is held and driven. It can be parallel or taper.

Circular land: The cylindrically ground surface adjacent to the cutting edge on the leading edge of the land.

Bevel lead: The bevel lead cutting portion at the entering end of the reamer cutting its way into the hole. It is not provided with a circular land.

Taper lead: The tapered cutting portion at the entering end to facilitate cutting and finishing of the hole. It is not provided with a circular land.

Bevel lead angle: The angle formed by the cutting edges of the bevel lead and the reamer axis.

Taper lead angle: The angle formed by the cutting edges of the taper and the reamer axis.

Terms relating to cutting geometry

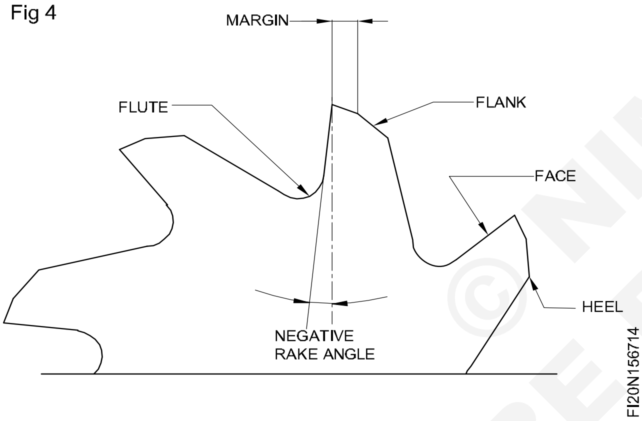
Flutes: The grooves in the body of the reamer to provide cutting edges, to permit the removal of chips, and to allow the cutting fluid to reach the cutting edges. (Fig 4)

Heel: The edge formed by the intersection of the surface left by the provision of a secondary clearance and the flute. (Fig 4)

Cutting edge: The edge formed by the intersection of the face and the circular land or the surface left by the provision of primary clearance. (Fig 4)

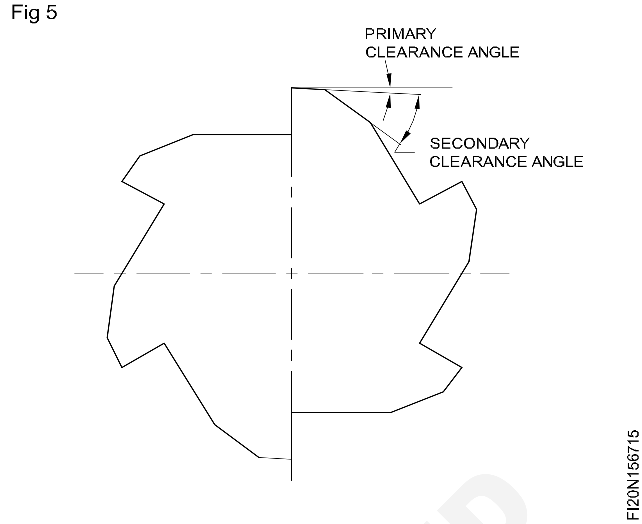
Face: The portion of the flute surface adjacent to the cutting edge on which the chip impinges as it is cut from the work. (Fig 4)

Fig 4



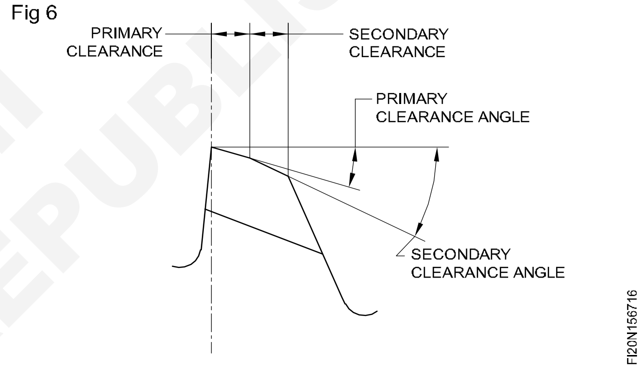
Rake angles: The angles in a diametric plane formed by the face and a radial line from the cutting edge. (Fig 5)

Fig 5



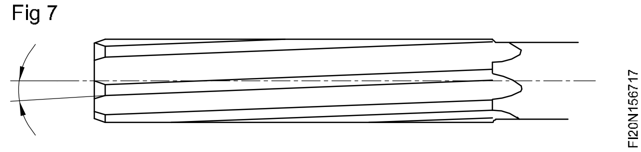
Clearance angle: The angles formed by the primary or secondary clearances and the tangent to the periphery of the reamer at the cutting edge. They are called primary clearance angle and secondary clearance angle respectively. (Fig 6)

Fig 6



Helix angle: The angle between the edge and the reamer axis. (Fig 7)

Fig 7



Hand reamers

Objectives: At the end of this lesson you shall be able to
- **state the general features of hand reamers**
- **identify the types of hand reamers**
- **distinguish between the uses of straight fluted and helical fluted reamers**
- **name the materials from which reamers are made and specify reamers.**

General features of hand reamers (Fig 1)

Hand reamers are used to ream holes manually using tap wrenches.

These reamers have a long taper lead.(Fig 2) This allows to start the reamer straight and in alignment with the hole being reamed.

Most hand reamers are for right hand cutting.

Helical fluted hand reamers have left hand helix. The left hand helix will produce smooth cutting action and finish.

Most reamers, machine or hand, have uneven spacing of teeth. This feature of reamers helps to reduce chattering while reaming. (Fig 3)

Types, features and functions: Hand reamers with different features are available for meeting different reaming conditions. The commonly used types are listed here under:

Fig 1

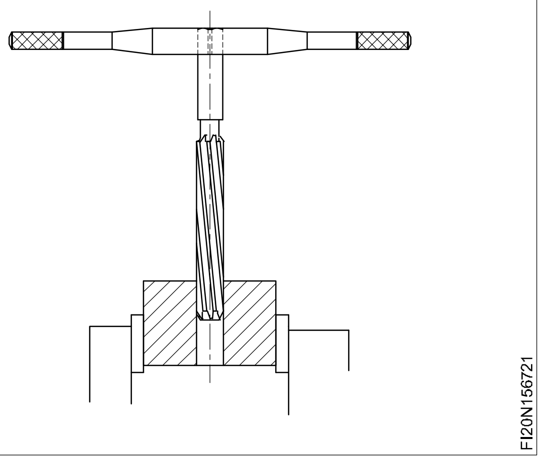


Fig 2

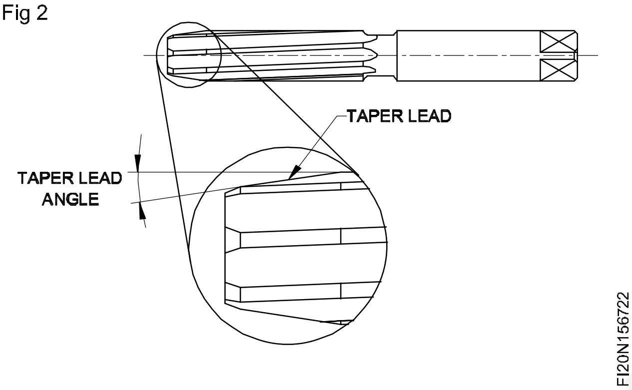
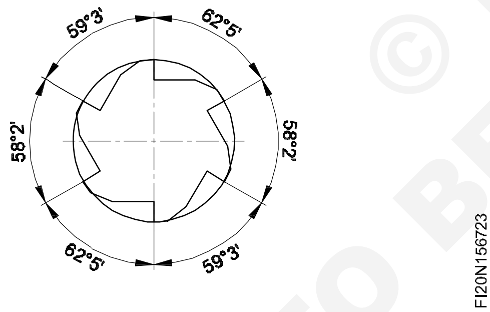


Fig 3



Parallel hand reamer with parallel shank (Fig 4a)

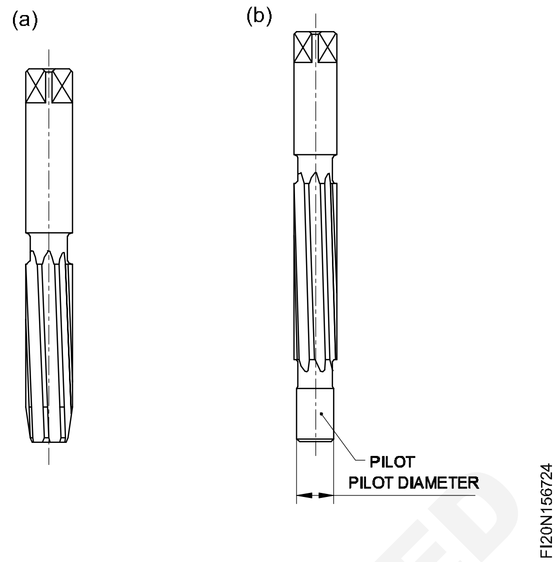
A reamer which has virtually parallel cutting edges with taper and bevel lead. The body of the reamer is integral with a shank. The shank has the nominal diameter of the cutting edges. One end of the shank is square shaped for tuning it with a tap wrench. Parallel reamers are available with straight and helical flutes. This is the commonly used hand reamer for reaming holes with parallel sides.

Reamers commonly used in workshop produce H7 holes.

Hand reamer with pilot (Fig 4b)

For this type of reamer, a portion of the body is cylindrically ground to form a pilot at the entering end. The pilot keeps the reamer concentric with the hole being reamed.

Fig 4



Socket reamer with parallel shank (Figs 5a and 5b)

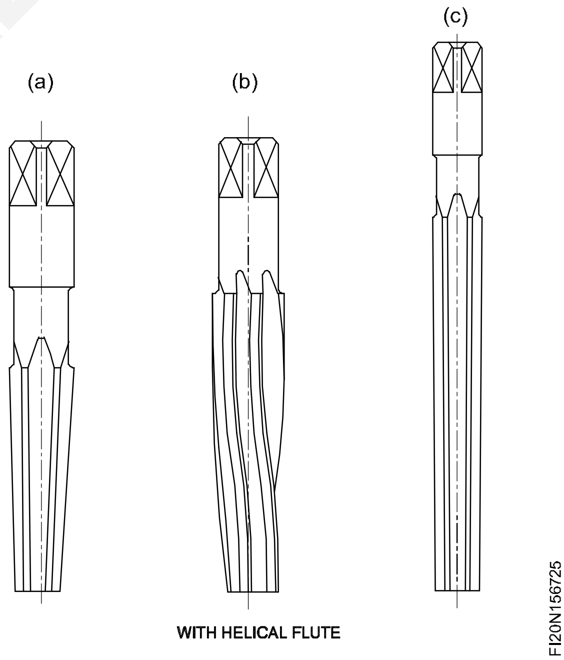
This reamer has tapered cutting edges to suit metric morse tapers. The shank is integral with the body, and is square shaped for driving. The flutes are either straight or helical.

The socket reamer is used for reaming internal morse tapered holes.

Taper pin hand reamer (Fig 5c)

This reamer has tapered cutting edges for reaming taper holes to suit taper pins. A taper pin reamer is made with a taper of 1 in 50. These reamers are available with straight or helical flutes.

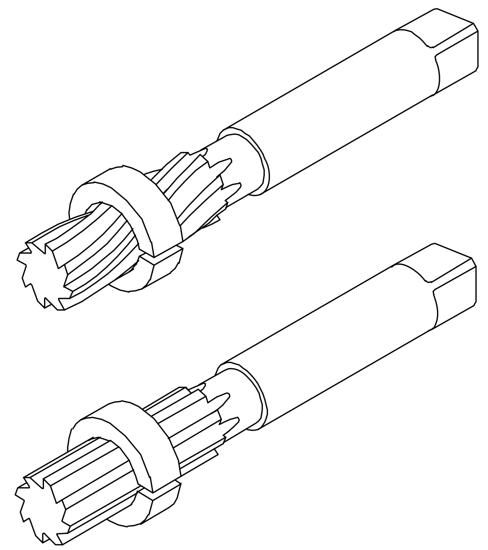
Fig 5



Use of straight and helical fluted reamers (Fig 6)

Straight fluted reamers are useful for general reaming work. Helical fluted reamers are particularly suitable for reaming holes with keyway grooves or special lines cut into them. The helical flutes will bridge the gap and reduce binding and chattering.

Fig 6



Material of hand reamers

When the reamers are made as a one-piece construction, high speed steel is used. When they are made as two-piece construction then the cutting portion is made of high speed steel while the shank portion is made of carbon steel. They are butt-welded together before manufacturing.

Specifications of a reamer: To specify a reamer the following data is to be given.

- Type
- Flute
- Shank end
- Size

Example : Hand reamer, Straight flute, Parallel shank of Ø 20 mm.

Drill size for reaming

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

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

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

Calculating drill size for reamer: A method generally practised in workshop is by applying the following formula.

Drill size = Reamed size – (Undersize + Oversize)

Finished size: Finished size is the diameter of the reamer.

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

Table 1

Undersizes for reaming

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

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

For light metals the undersize will be chosen 50% larger.

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

Drill size = Reamed size – (Undersize + Oversize)

(Finished size)	=	10 mm
Undersize as per table	=	0.2 mm
Oversize	=	0.05 mm
Drill size	=	10 mm -- 0.25 mm
	=	9.75 mm

Determine the drill hole sizes for the following reamers:

i 15 mm
ii 4 mm
iii 40 mm
iv 19 mm

Answer

i ____________________
ii ____________________
iii ____________________
iv ____________________

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

Always inspect the condition of the reamer before commencing reaming.

For obtaining good surface finish

Use a coolant while reaming. Remove metal chips from the reamer frequently. Advance the reamer slowly into the work.

Defects in reaming - Causes and Remedies

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

- Always inspect the condition of the reamer before using.

- **Surface finish rough**
  - The causes may be any one of the following or a combinations thereof.
  - Incorrect application
  - Swarf accumulated in reamer flutes
  - Inadequate flow of coolant
  - Feed rate too fast
  - While reaming apply a steady and slow feed-rate.
  - Ensure a continuous supply of the coolant.
  - Do not turn the reamer in the reverse direction.

Determining the drill size for reaming

Use the formula,

drill diameter = reamed hole size. (undersize + oversize)

Refer to the Table 1 for the recommended undersizes in Related Theory on DRILL SIZES FOR REAMING.

Reaming

Objective : At the end of this lesson you shall be able to
- **state the procedure for hand reaming and machine reaming.**

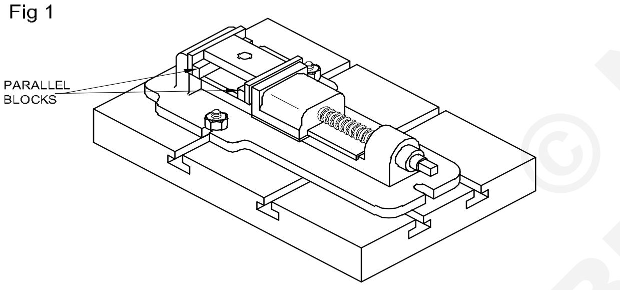
Reaming: Reaming is the operation of finishing and sizing a hole which has been previously drilled, bored, casteed holes. The tool used is called a reamer, which has multiple cutting edges. Manually it is held in a tap wrench and reamed. Machine reamer are used in drilling machine using sleeves (or) socket. Normally the speed for reaming will be 1/3rd speed of drilling.

Hand Reaming

Drill holes for reaming as per the sizes determined.

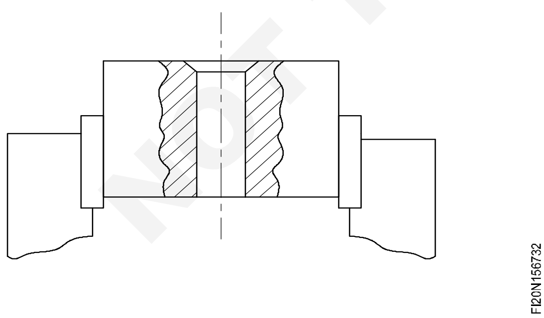
Place the work on parallels while setting on the machine vice. (Fig 1)

Fig 1



Chamfer the hole ends slightly. This removes burrs and will also help to align the reamer vertically. (Fig 2) Fix the work in the bench vice. Use vice clamps to protect the finished surfaces. Ensure that the job is horizontal. (Fig 2)

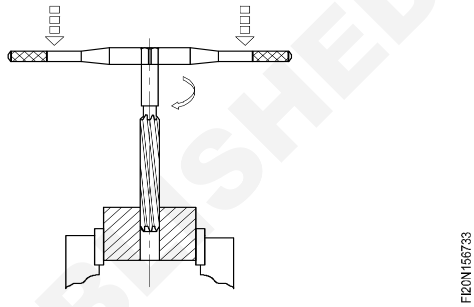
Fig 2



Fix the tap wrench on the square end and place the reamer vertically in the hole. Check the alignment with a try square. Make corrections, If necessary. Turn the tap wrench in a clockwise direction applying a slight downward pressure at the same time. (Fig 3) Apply pressure evenly at both ends of the tap wrench.

Apply cutting force: Turn the tap wrench steadily and slowly, maintaining the downward pressure.

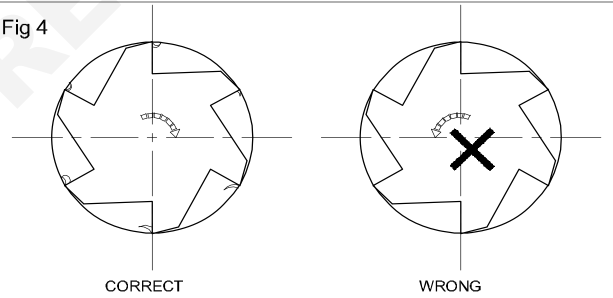
Fig 3



Do not turn in reverse direction it will scratch the reamed hole. (Fig 4)

Ream the hole through, ensure that the taper lead length of the reamer comes out well and clear from the bottom of the work. Do not allow the end of the reamer to strike on the vice.

Fig 4

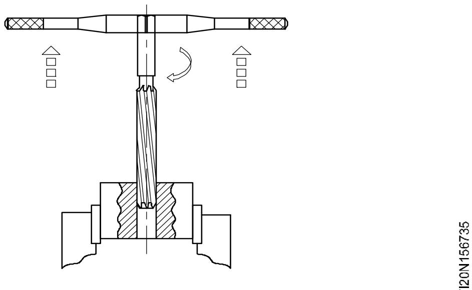


Remove the reamer with an upward pull until the reamer is clear of the hole. (Fig 5)

Remove the burrs from the bottom of the reamed hole.

Clean the hole. Check the accuracy with the cylindrical pins supplied.

Fig 5



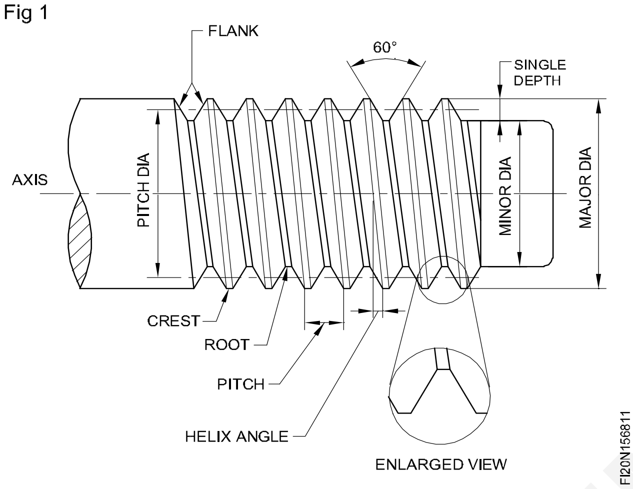
Screw thread and elements

Objectives: At the end of this lesson you shall be able to
- **state the terminology of screw threads**
- **state the types of screw threads.**

Screw thread terminology

Parts of screw thread (Fig 1)

Fig 1



Crest: The top surface joining the two sides of a thread.

Root: The bottom surface joining the two sides of adjacent threads.

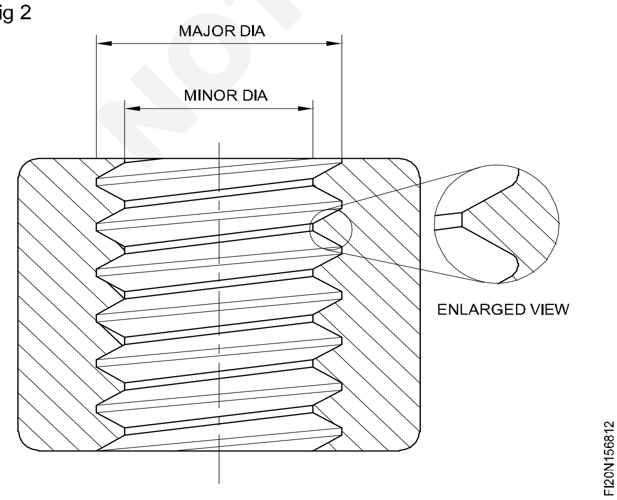
Flank: The surface joining the crest and the root.

Thread angle: The included angle between the flanks of adjacent threads.

Depth: The perpendicular distance between the roots and crest of the thread.

Major Diameter: In the case of external threads it is the diameter of the blank on which the threads are cut and in the case of internal threads it is the largest diameter after the threads are cut that are known as the major diameter. (Fig 2)

Fig 2



This is the diameter by which the sizes of screws are stated.

Minor Diameter: For external threads, the minor diameter is the smallest diameter after cutting the full thread. In the case of internal threads, it is the diameter of the hole drilled for forming the thread which is the minor diameter.

Pitch Diameter (effective diameter): The diameter of the thread at which the thread thickness is equal to one half of the pitch.

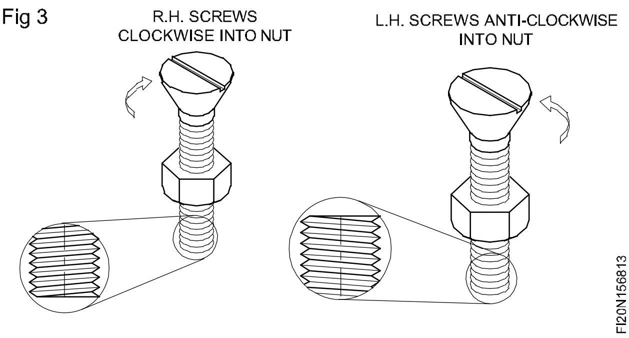
Pitch: It is the distance from a point on one thread to a correspond ing point on the adjacent thread measured parallel to the axis.

Lead: Lead is the distance of a threaded component moves along the matching component during one complete revolution. For a single start thread the lead is equal to the pitch.

Helix Angle: The angle of inclination of the thread to the imaginary perpendicular line.

Hand: The direction in which the thread is turned to advance. A right hand thread is turned clockwise to advance, while a left hand thread is turned anticlockwise.(Fig 3)

Fig 3



Screw threads - types of V threads and their uses

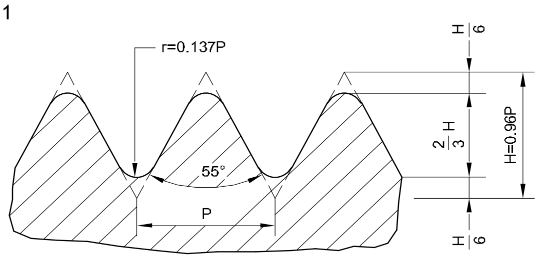
Objectives: At the end of this lesson you shall be able to
- **state the different standards of V threads**
- **indicate the angle and the relation between the pitch with the other elements of the thread**
- **state the uses of the different standards of V threads.**

The different standards of V threads are:

- BSW thread: British Standard Whitworth thread
- BSF thread: British Standard fine thread
- BSP thread: British Standard pipe thread
- B.A thread: British Association thread
- I.S.O Metric thread: International Standard Organisation metric thread
- ANS: American National or sellers' thread
- BIS Metric thread: Bureau of Indian Standard metric thread.

BSW thread (Fig 1): It has an included angle of 55° and

Fig 1



WHITWORTH THREAD (BSW)

the depth of the thread is 0.6403 x P. The crest and root are rounded off to a definite radius . The Fig 1 shows the relationship between the pitch and the other elements of the thread.

BSW thread is represented in a drawing by giving the major diameter. For example : 1/2" BSW, 1/4" BSW. The table indicates the standard number of TPI for different diameters. BSW thread is used for general purpose fastening threads.

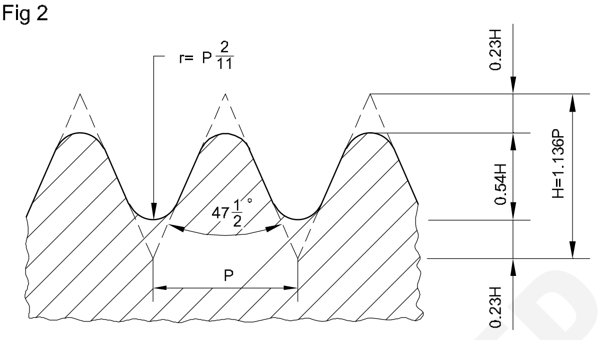
BSF thread: This thread is similar to BSW thread except the number of TPI for a particular diameter. The number of threads per inch is more than that for the BSW thread for a particular diameter. For Example, 1" BSW has 8 TPI and 1 "BSF has 10 TPI. The table indicates the standard number of TPI for different dia. of BSF threads. It is used in automobile industries.

BSP thread: This thread is recommended for pipe and pipe fittings. The table shows the pitch for different diameters. It is also similar to BSW thread. The thread is cut externally with a small taper for the threaded length. This avoids the leakage in the assembly and provides for further adjustment when slackness is felt.

BA thread (Fig 2): This thread has an included angle of 47 1/2°. Depth and other elements are as shown in the figure. It is used in small screws of electrical appliances, watch screws, screws of scientific apparatus.

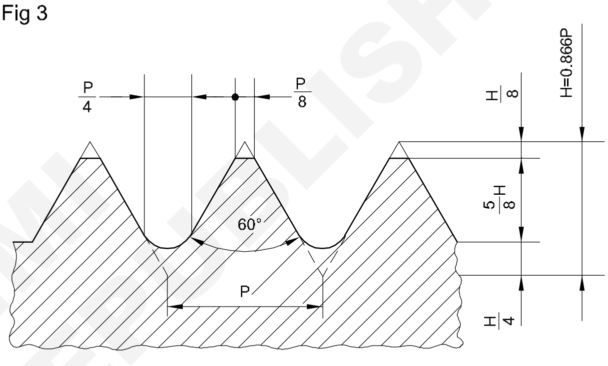
Unified thread (Fig 3): For both the metric and inch series, ISO has developed this thread. Its angle is 60°. The crest and root are flat and the other dimensions are as shown in the Fig 3. This thread is used for general fastening purposes.

Fig 2



BRITISH ASSOCIATION THREAD

Fig 3



ISO METRIC THREAD, UNIFIED INCH SERIES THREAD

This thread of metric standard is represented in a drawing by the letter 'M' followed by the major diameter for the coarse series.

Ex : M14, M12 etc.

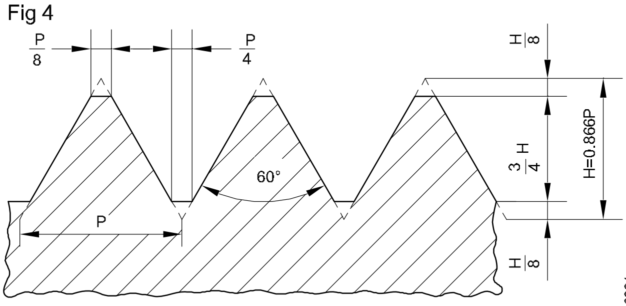
For the fine series, the letter 'M' is followed by the major diameter and pitch.

Ex : M14 x 1.5

M24 x 2

American National Thread (Fig 4)**:** These threads are also called as seller's threads. It was more commonly used prior to the introduction of the ISO unified thread.

Fig 4



AMERICAN NATIONAL THREAD,SI & DIN METRIC THREADS

Screw pitch gauge

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a screw pitch gauge**
- **state the features of a screw pitch gauge.**

Purpose

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

It is also used to compare the profile of threads.

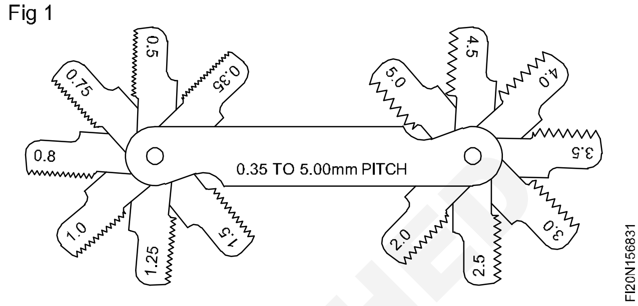
Constructional features

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

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

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

Fig 1



Taps

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

Use of hand taps: Hand taps are used for internal threading of components.

Features (Fig 1): They are made from high speed steel.

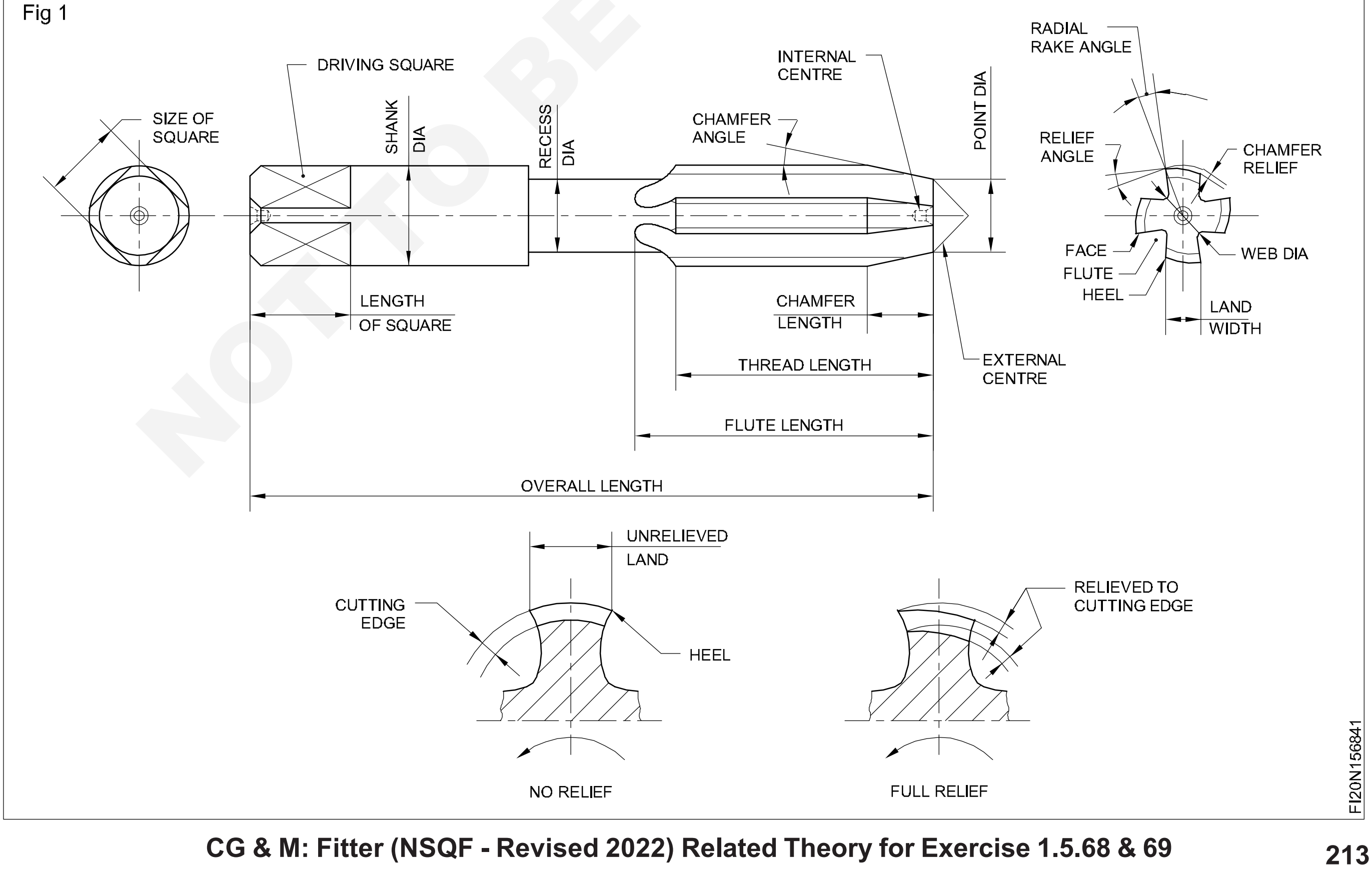
The threads are cut on the periphery and are accurately finished.

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

The end of the shank of the tap is made of square shape for the purpose of holding and turning the taps.

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

Fig 1



The size of the taps, the thread standard, the pitch of the thread, the dia. of the tapping hole are usually marked on the shank.

Marking on the shank are also made to indicate the type of tap i.e. first, second and plug.

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 tap 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 1,2 and 3 or rings are marked on the shank.

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

Fig 2

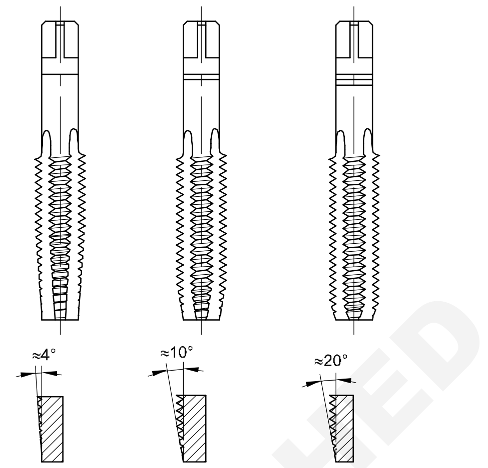


Table for tap drill size

B.S.W. (55°)		
Tap size (inch)	**Threads per inch**	**Tap drill size (mm)**
3/16	24	3.7mm
7/32	24	4.5mm
1/4	20	5.1mm
5/16	18	6.5mm
3/8	16	7.94mm
7/16	14	9.3mm
1/2	12	10.5mm
9/16	12	12.1mm
5/8	11	13.5mm
11/16	11	15mm
3/4	10	16.257mm
7/8	9	19.25mm
1”	8	22mm

B.S.F. (55°)		
Tap size (inch)	**Threads per inch**	**Tap drill size (mm)**
3/16	32	3.97mm
7/32	28	4.6mm
1/4	26	5.3mm
5/16	22	6.75mm
3/8	20	8.2mm
7/16	18	9.7mm
1/2	16	11.11mm
9/16	16	12.7mm
5/8	14	14mm
11/16	14	15.5mm
3/4	12	16.75mm
7/8	11	19.84mm
1”	10	22.75mm

NPT National pipe thread

Tap size (inch)	**Threads per inch**	**Tap drill size inch**	**Tap size (inch)**	**Threads per inch**	**Tap drill size inch**
1/8	27	11/32	1	11 1/2	1 5/32
1/4	18	7/16	1 1/4	11 1/4	1 1/2
3/8	18	19/32	1 1/2	11 1/2	1 23/32
1/2	14	23/32	2	11 1/2	2 23/16
3/4	14	15/16	2 1/2	8	2 5/8

Tap drill sizes ISO Inch (Unified) thread

NC National coarse			NF National Fine		
Tap size (inch)	**Threads per inch**	**Tap drill size inch**	**Tap size (inch)**	**Threads per inch**	**Tap drill size inch**
1/4	20	13/64	1/4	28	7/32
5/16	18	17/64	5/16	24	17/64
3/8	16	5/16	3/8	24	21/64
7/16	14	3/8	7/16	20	25/64
1/2	13	27/64	1/2	20	29/64
9/16	12	31/64	9/16	18	33/64
5/8	11	17/32	5/8	18	37/64
3/4	10	21/32	3/4	16	11/16
7/8	9	49/64	7/8	14	13/16
1”	8	7/8	1”	14	15/16
1 1/8	7	63/64	1 1/8	12	1 3/6
1 1/4	7	17/64	1 1/4	12	1 11/6
1 3/8	6	17/32	1 3/8	12	1 19/64
1 1/2	6	1 11/32	1 1/2	12	1 27/64
1 3/4	5	1 9/16			
2”	4 1/2	1 25/32			

Machine taps

Objectives: At the end of this lesson you shall be able to
- **state the characteristics of machine taps**
- **name the different types of machine taps**
- **state the features and uses of different types of machine taps.**

Machine taps: Machine taps of different types are available. The two important features of machine taps are

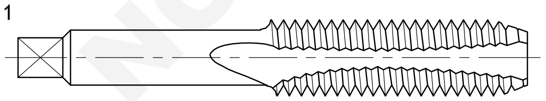
– Ability to withstand the torque needed for threading holes

– Provision for eliminating chip jamming.

Types of machine taps

Gun tap (Spiral pointed tap) (Fig 1)

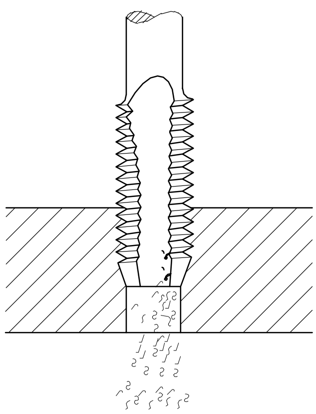
Fig 1



These taps are especially useful for machine tapping of through holes. In the case of blind hole tapping, there should be sufficient space below to accommodate the chips. While tapping, the chips are forced out ahead of the tap. (Fig 2)

This prevents the clogging of the chips and thus reduces the chances of tap breakage. These taps are stronger since the flutes are shallow. The flutes of these taps do not convey chips.

Fig 2



Flute-less spiral pointed tap (Stub flute taps) (Fig 3)

These taps have short angular flutes ground on the chamfered end, and the rest of the body is left solid. These taps are stronger than gun taps.

Flute-less taps are used for tapping through holes on materials which are not thicker than the diameter of the holes. Flutes spiral point taps are best suited for tapping soft materials or thin metal sections.

Helical fluted taps/spiral fluted taps: These taps have spiral flutes which bring out the chips from the hole being tapped. (Fig 4)

Fig 3

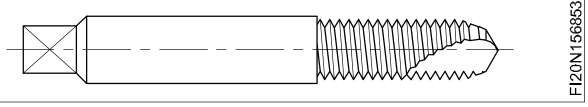
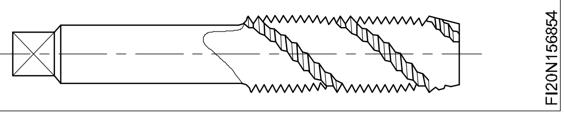


Fig 4



These are useful for tapping holes with slots. The helical land of the tap will bridge the interruption of the surface being threaded. The helical flutes of the tap provide a shear cutting action, and are mostly used to tap holes in ductile materials like aluminium, brass, copper etc.

Spiral fluted taps are also available with fast spiral. (Fig 5) These taps are best suited for tapping deep holes as these can clear the chips faster from the hole. (Fig 6)

Thread forming taps (Fluteless taps)

These taps form threads in the hole by displacing the material and not by cutting action. (Fig 7)

Fig 5

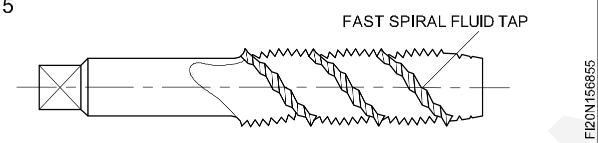


Fig 6

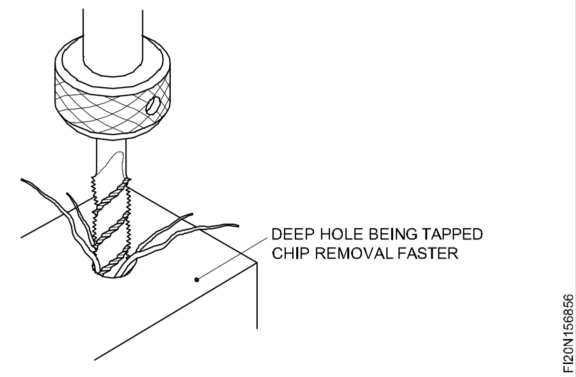
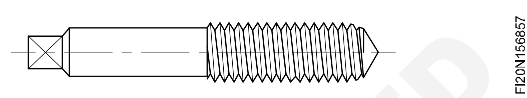
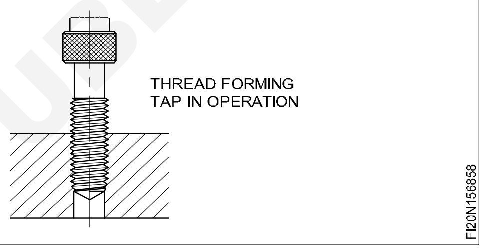


Fig 7



These taps have projecting lobes which actually help in forming the thread. (Fig 8) Since there are no chips in the process, it is very valuable in places where chip removal poses problems. These taps are excellent for tapping copper, brass, aluminium, lead etc. The thread finish is also comparatively better than in the fluted taps.

Fig 8

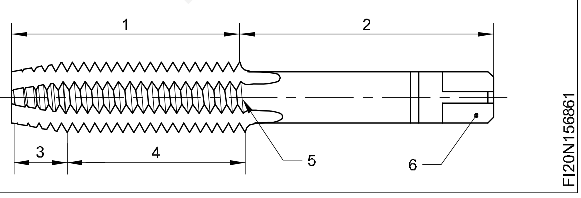


General informative points on taps

Objectives: At the end of this lesson you shall be able to
- **differentiate between hand tap and machine tap**
- **identify the parts of a machine tap**
- **state the constructional features of a machine tap.**

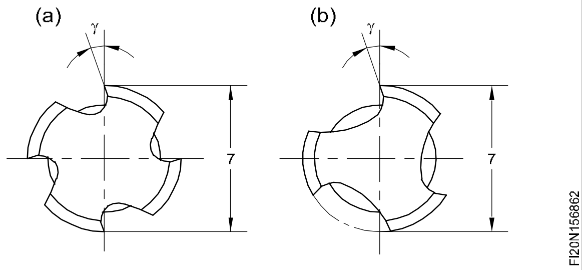
Unlike tapping with the three piece set of hand taps, the machine tap cuts the entire threaded profile in one operation. The machine tap is normally made of tool steel and consists of the shank (2) and the cutting section (1) as shown in (Fig 1). The cutting section itself is subdivided into two areas. The start (3), which serves for cutting, and the guiding section (4) for the feeding motion and smoothing of the newly cut thread. (Fig 1)

Fig 1



The number of flutes (5), may be even or odd. With an even number of flutes, measuring of the diameter (7) is easier. (Figs 2a and 2b)

Fig 2



Straight and spiral groove machine taps are available. The diameter of the shank and the shape of its end vary between the various standards. The shank diameter may be smaller, equal to or larger than the thread diameter. The shank ends are available in straight design, with square ends as shown in (6) or with driving shoulders.

Chip removal (flow) takes place at the start of the tap. The rake angle must be adapted to the material to be machined. Hard and brittle materials require a small rake angle and soft materials need a larger rake angle.

Accordingly three types of taps are available.

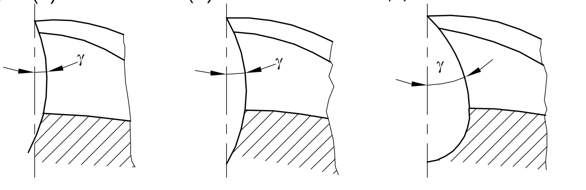
Type normal (Fig 3b) with a rake angle of approximately 12°.

Type soft (Fig 3c) with a rake angle of approximately 20°.

Type hard (Fig 3a) with a rake angle of approximately 3°.

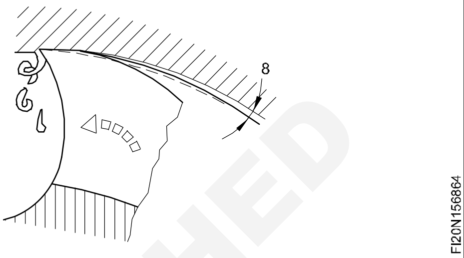
The normal type of rake angle taps can be used in most cases. The start must be ground symmetrical. Before using the tap, it is necessary to check that the cutting edges are not chipped, and all the edges are sharp.

Fig 3



The 'hard' type tap is used for tapping brittle materials like cast iron. In case a 'normal' type tap is used on cast iron, the tap cutting edges get blunt soon and the tap cannot be used again on ductile materials like mild steel. The fine cast iron splinters wear the external diameter of the cutting edges of the tap causing them to tend to become blunt, and when the same tap is used on steel which is more flexible it is elastically pressed away (8) at the cutting point. Behind the cutting edge the material returns to the machined diameter. The depth of the groove also causes jamming of the guiding section of the tap. (Fig 4)

Fig 4



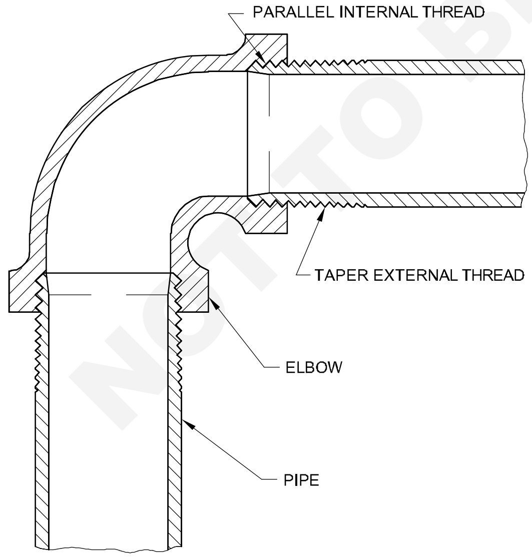
Pipe Threads and Pipe Taps

Objectives: At the end of this lesson you shall be able to
- **state parallel and taper pipes threads**
- **determine the wall thickness and threads per inch (TPI) of BSP threads**
- **state the method of sealing pipe joints**
- **determine blank sizes for threading as per B.S 21 - 1973 and I.S. 2643 - 1964.**

Pipe threads

The standard pipe fittings are threaded to British Standard pipe (BSP). The internal pipe threads have parallel threads whereas the external pipes have tapered threads as shown in Fig 1.

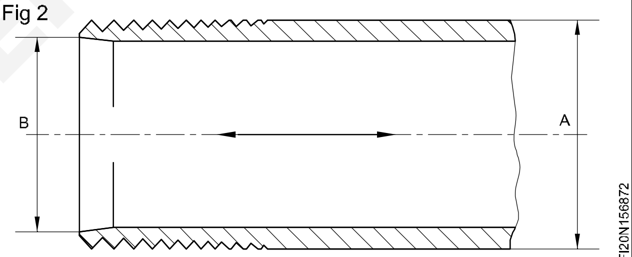
Fig 1



B.S.P. threads

Galvinized iron pipes are available in sizes ranging from 1/2" to 6" in several different wall thickness. The table 1 shows outside diameters and threads per inch from 1/2" to 4". (Fig 2)

Fig 2



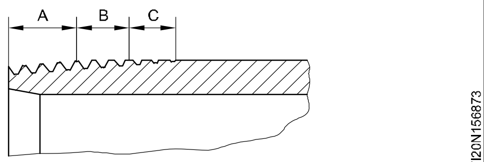
The next two threads have fully formed bottoms but that tops. (B)

The last four threads have flat tops and bottoms. (C)

Sealing pipe joint

Fig 3 shows that the pipe has several fully formed threads at the end. (A)

Fig 3



The pipe joint shown in Fig 4 consists of the following:

1 Parallel female thread

2 Tapered male thread

3 Hemp packing

Fig 4

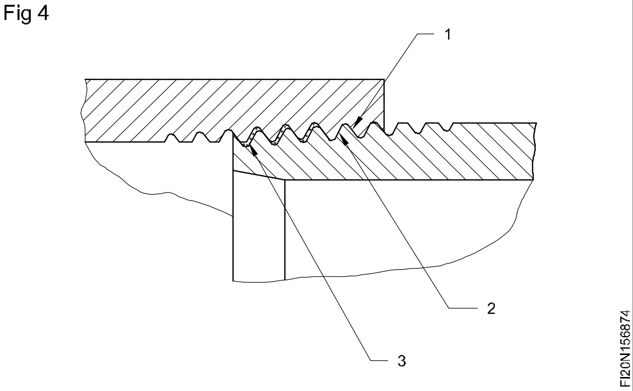


Table 1

BSP - Pipe sizes or DIN 2999 (inside) (B)	Threads inch	Outside diameter/ mm of the pipe (A)
1/2”	14	20.955 mm
3/4”	14	26.441
1”	11	33.249
11/4”	11	41.910
11/2”	11	47.803
2”	11	59.614
2 1/2”	8	75.184
3”	8	87.884
4”	8	113.030

The hemp packing issued to ensure that any small space between two metal threads (male and female threads) is sealed to prevent any leakage.

Pipe taps

Internal pipe threads are usually cut with standard taper pipe taps. (Fig 5)

Fig 5

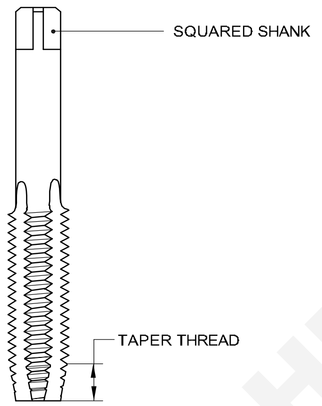
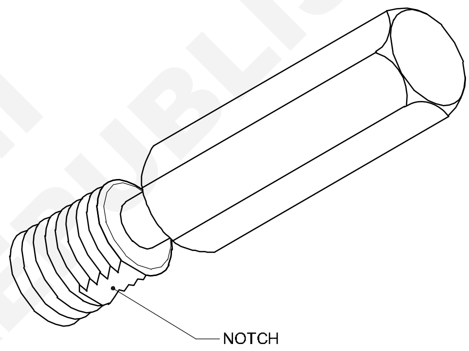


Fig 6



Tap wrenches, removal of broken tap, studs

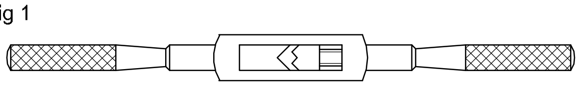
Objectives : At the end of this lesson you shall be able to
- **name the different types of tap wrenches**
- **state the uses of the different types of wrenches.**

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, such as double-ended adjustable wrench, T- handle tap wrench, solid type tap wrench etc.

Double - ended adjustable tap wrench or bar type tap wrench (Fig 1)

Fig 1



This is the most commonly used type of tap wrench. It is available in various sizes- 175, 250, 350mm long. These tap wrenches are more suitable for large diameter taps, and can be used in open places where there is no obstruction to turn the tap.

It is important to select the correct size of wrench.

T- handle tap wrench (Fig 2)

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. Most suitable for smaller sizes of taps.

Solid type tap wrench (Fig 3)

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.

Tap Material: Made from a single piece of solid Cast iron (or) steel. Cast iron and steel are used because of strong, durable and unlikely to deform under pressure.

Fig 2

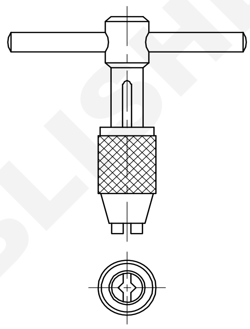
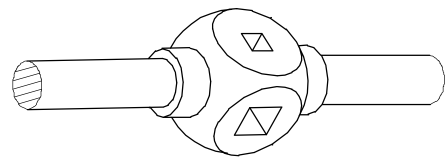


Fig 3



Removing broken taps

Objectives: At the end of this lesson you shall be able to
- **name the different methods of removing broken taps**
- **state the methods of removing broken taps.**

A tap broken above the surface of the workpiece can be removed using gripping tools like pliers.

Taps broken below the surface pose a problem for removing. Any one of the several methods given below can be used.

Use of tap extractor (Fig 1)

This is a very delicate tool and need very careful handling.

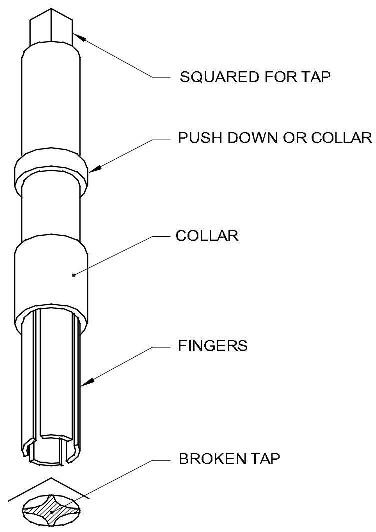
This extractor has fingers which can be inserted on the flutes of the broken tap. The sliding collar is then brought to the surface of the work and the extractor turned anticlockwise to take out the broken tap.

A light blow on the broken tap with a punch will help to relieve the tap if it is jammed inside the hole.

Use of punch (Fig 2)

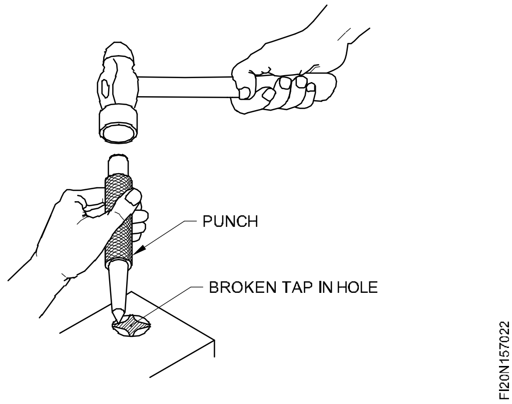
In this method the point of the punch is placed in the flute of the broken tap in an inclination and struck with a hammer

Fig 1



the positioning of the punch should be such that the broken tap is rotated anticlockwise when struck.

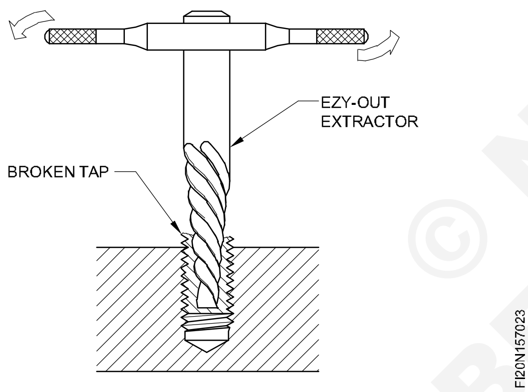
Fig 2



Annealing and drilling the tap

This is a method adopted when other method fail. In the process the broken tap is heated by flame or by other methods for annealing. A hole is then drilled on the annealed tap. The remaining piece can be removed either by using a drift or using an EZY - OUT (extractor). This method is not suitable for workpieces with low melting temperatures such as aluminium, copper etc. (Fig 3)

Fig 3



Use of arc welding

This is a suitable method when a small tap is broken at the bottom of materials like copper, aluminium etc. In this method the electrode is brought in contact with the broken tap and stuck so that it is attached with the broken tap. The tap may be removed by rotating the electrode.

Use of nitric acid

In this method nitric acid is diluted in a proportion of about one part acid to five parts of water is injected inside. The action of the acid loosens the tap and then it is removed with an extractor or with a nose plier. The workpiece should be thoroughly cleaned for preventing further action of the acid.

While diluting acid mix acid to water.

Use of spark erosion

For salvaging certain precision components damaged due to breakage of taps, spark erosion can be used. In this process, the metal (broken tap) is removed by means of repetitive spark discharges. The electrical discharge occurs between an electrode and the electro - conductive workpiece (tap) and the minute particles are eroded both from the electrode and the workpiece. In many cases it may not be necessary to remove the broken tap completely. (After a small portion has been eroded, a screw- driver or punch can be used to remove the remaining portion of the tap.) The shape of the electrode also need not be round. It can be for assisting the tools for routing the broken tap.

Removing broken stud

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

The stud is used in place of a bolt ,when there is insufficient space to accommodate the bolt head or to avoid use of an unnecessarily long bolt. Studs are generally used to fix up cover plates or to connect cylinder covers to engine cylinders.

Reasons for breakage of stud/bolt.

Excessive torque is applied while screwing the stud into the hole.

Corrosive attack on the thread.

Matching threads are not of proper formation.

Threads are seized.

Methods of removing broken studs

Prick punch method

If the stud is broken very near to the surface, drive it in an anticlockwise direction, using a prick punch and hammer to remove it. (Fig 1)

Filing square form

When the stud is broken a little above the surface form a square on the projecting portion to suit a standard spanner. Then turn it anticlockwise using a spanner to remove it. (Fig 2)

Fig 1

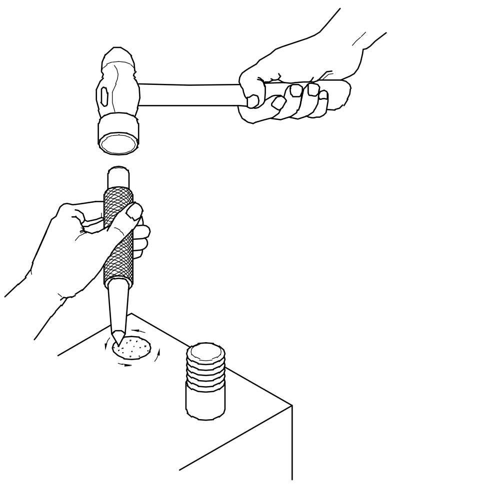
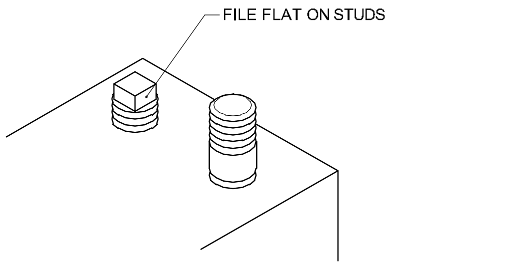


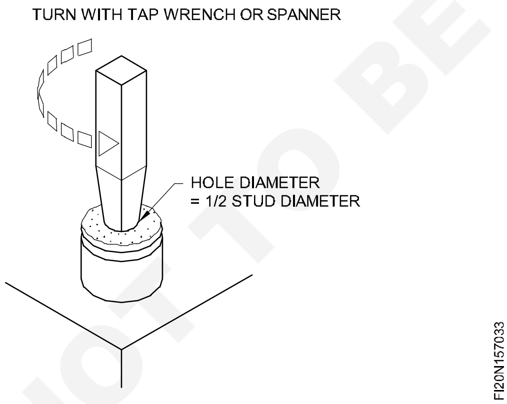
Fig 2



Using square taper punch

Broken stud can also be removed by drilling a blind hole (hole diameter equals to half of stud diameter) and driving a square taper punch into the hole as shown in Fig 3. Turn the punch using a suitable spanner in an anti - clock- wise direction to unscrew the stud.

Fig 3

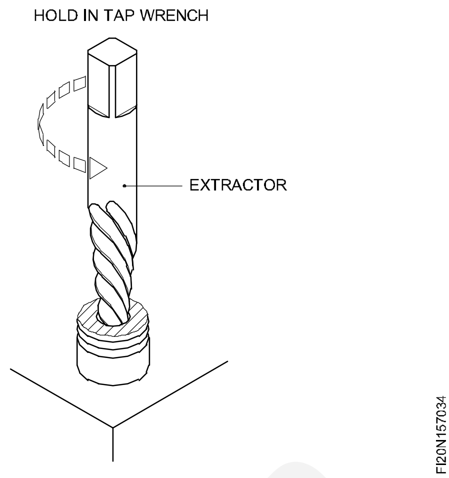


EZY - out method (Fig 4)

Ezy - out or a stud extractor is a hand tool, somewhat similar to the form of a taper reamer but has left hand spiral. It is available in a set of 5 pieces. The recommended drill size is punched on each ezy - out .

After drilling the hole recommended ezy - out is set on it and turned in an anti - clockwise direction by a tap wrench. As it is rotated it penetrates into the hole increasing its grip and in the process the broken stud gets unscrewed. (Fig 4)

Fig 4



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

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

Fig 5

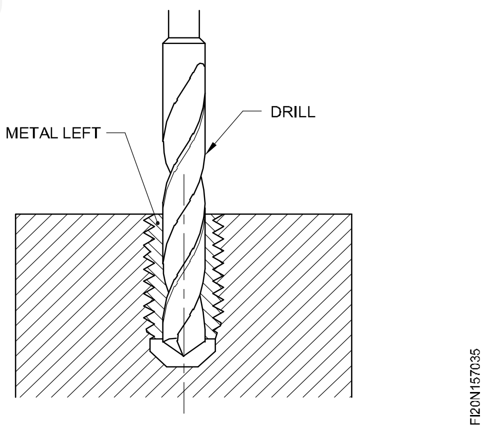
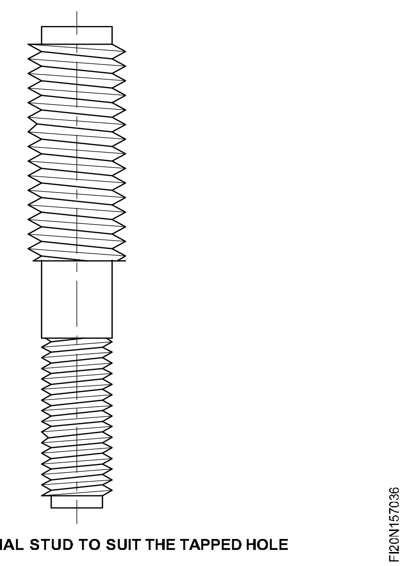


Fig 6



OVERSIZE SPECIAL STUD TO SUIT THE TAPPED HOLE

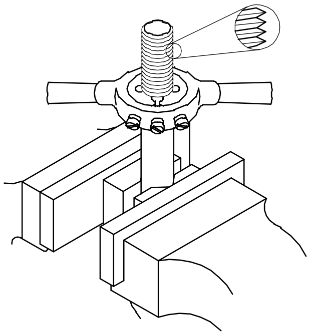
Dies and die stock

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

Uses of dies

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

Fig 1



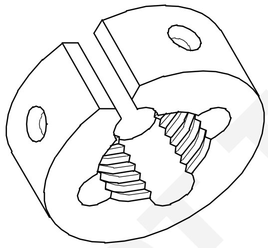
Types of dies

The following are the different types of dies.

- Circular split die (Button die)
- Half die
- Adjustable screw plate die

Circular split die/button die (Fig 2)

Fig 2

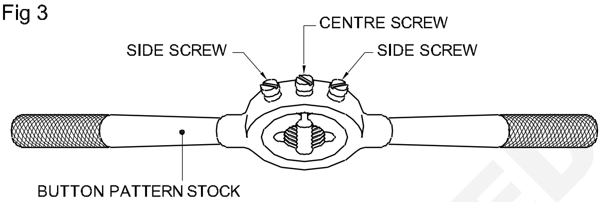


This has a slot cut to permit slight variation in size.

Dies are made of high speed steel

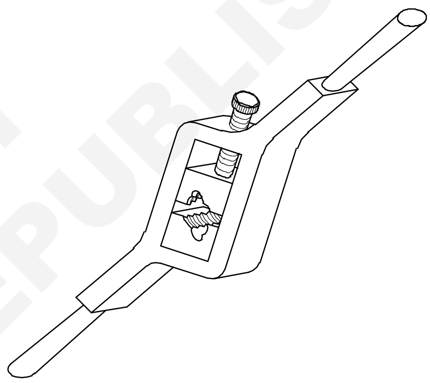
When held in the diestock, variation in the size can be made by using the adjusting screws. This permits increasing or decreasing of the depth of cut. When the side screws are tightened the die will close slightly. (Fig 3) For adjusting the depth of the cut, the centre screw is advanced and locked in the groove. This type or die stock is called button pattern stock

Fig 3



Half die (Fig 4)

Fig 4



Half dies are stronger in construction.

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

These dies are available in matching pairs and should be used together.

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

They need a special die holder.

Adjustable screw plate die (Fig 5)

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

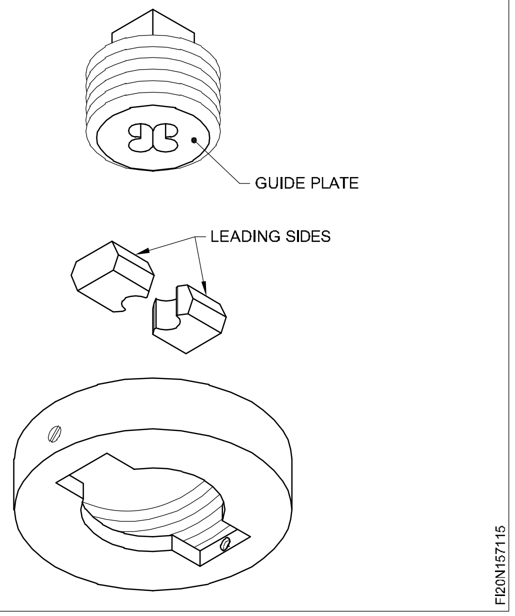
This provides greater adjustment than the split die.

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

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

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

Fig 5



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

Both pieces should have the same serial numbers.

Die Nut (Solid Die) (Fig 7)

Fig 6

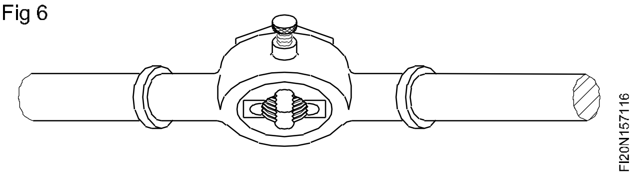
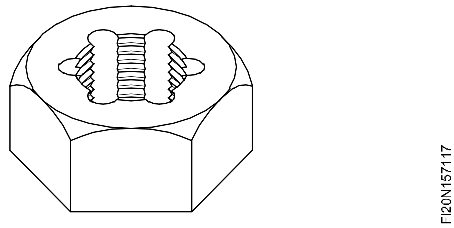


Fig 7



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

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

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

The die nut is turned with a spanner.

Blank size for external threading

Objective: At the end of this lesson you shall be able to
- **determine the diameter of blank size for external thread cutting.**

Why should the blank size be less?

It has been observed from practice that the threaded diameters of steel blank**s** show a slight increase in diameter. such increase in the diameter will make assembly of external and internal threaded components very difficult. To overcome this, the diameter of the blank is slightly reduced before commencing the threading.

What should be the blank size?

The diameter of the blank should be less by 1/10th of the pitch of the thread.

Example

For cutting the thread of M12 with 1.75mm pitch the diameter of the blank is 11.80.

Formula, D = d - p/10

= 12mm - 0.175mm

= 11.825 or 11.8 mm.

d = diameter of bolt

D = the blank diameter

p = pitch of thread

Calculate the blank size for preparing a bolt of M16 x1.5?

Answer

....

....

....

External threading using dies

Objective: At the end of this lesson you shall be able to
- **cut external threads using dies.**

Check blank size.

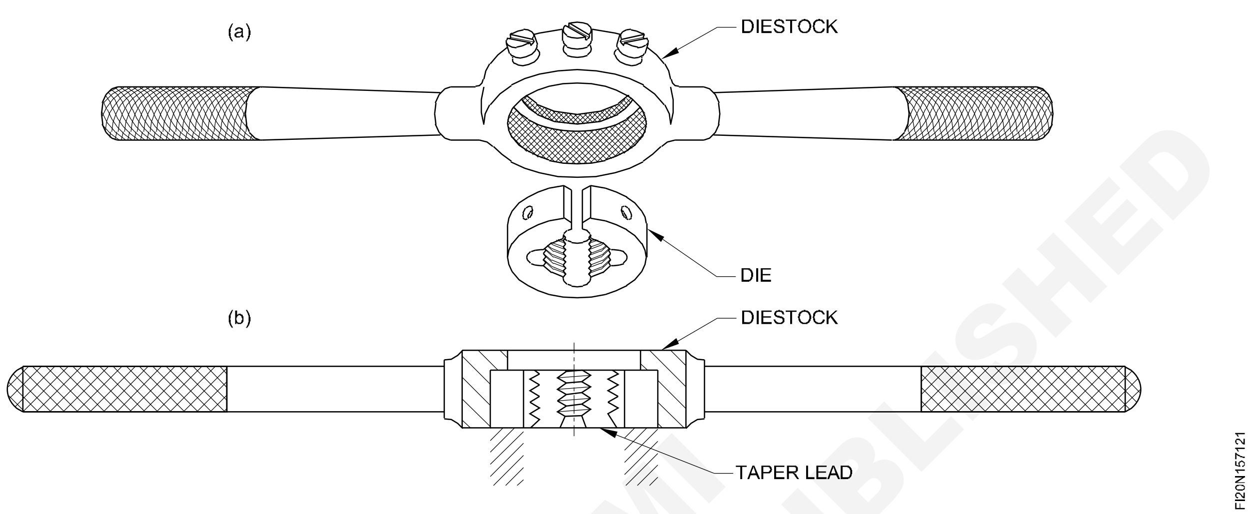
Blank size = Threads size -0.1 × pitch of thread

Procedure: Fix the die in the diestock and place the leading side of the die opposite to the step of the diestock. (Figs 1a & 1b)

Use false jaws for ensuring a good grip in the vice.

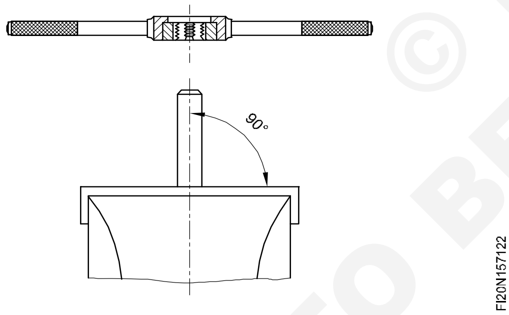
Project the blank above the vice - just the required thread length only.

Fig 1



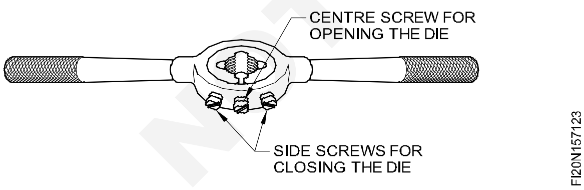
Place the leading side of the die on the chamfer of the work (Fig 2)

Fig 2



Make sure that the die is fully open by tightening the centre screw of the diestock. (Fig 3)

Fig 3



Start the die, square to the bolt centre line. (Fig 4)

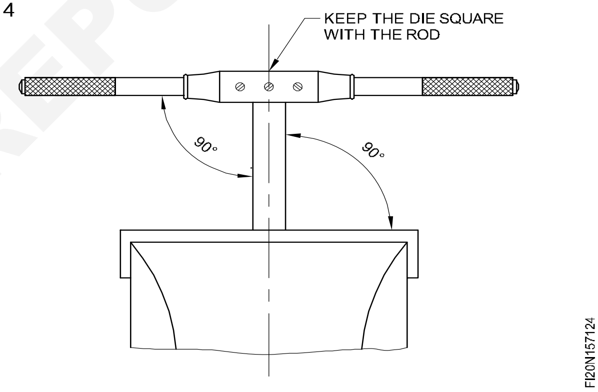
Apply pressure on the diestock evenly and turn clockwise direction to advance the die on the bolt blank. (Fig 5)

Cut slowly and reverse the die for a short distance in order to break the chips

Use a cutting lubricant.

Increase the depth of the cut gradually by adjusting the outer screws.

Fig 4



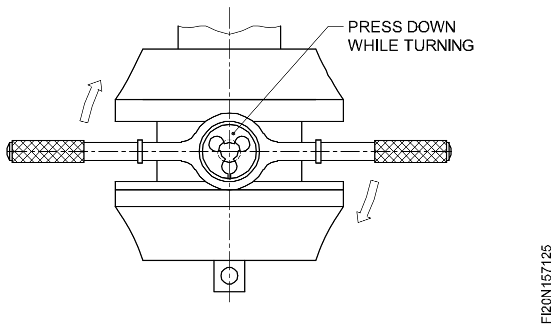
Check the thread with a matching nut.

Repeat the cutting until the nut matches.

Too much depth of cut at one time will spoil the threads. It can also spoil the die.

Clean the die frequently to prevent the chips from clogging and spoiling the thread.

Fig 5



Drill troubles - Causes and remedy, drill kinds

Objectives: At the end of this lesson you shall be able to
- **list the common drilling defects**
- **explain the causes of drilling defects**

The common defects in drilling are listed below.

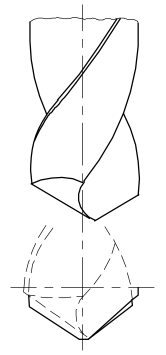
- Oversized holes
- Overheated drills
- Rough holes
- Unequal and interrupted flow of chips
- Split webs or broken drills

Oversized holes

Oversized holes can be due to:

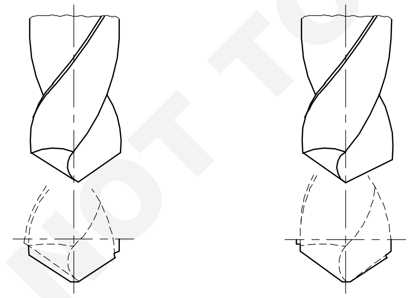
- The unequal length of the cutting edges (Fig 1)

Fig 1



- The unequal angle of the cutting edges (Fig 2)

Fig 2



- The unequal thinning of the point (Fig 3)
- The spindle running out of centre
- The drill point not being in centre. (Fig 4)

Fig 3

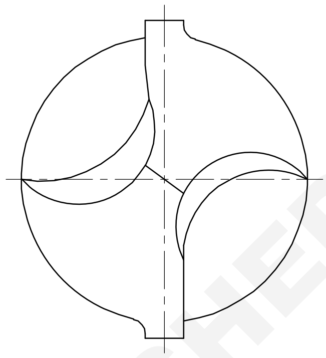
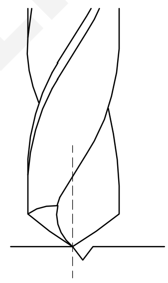


Fig 4



Overheated drills

The drills may get overheated if the:

- Cutting speed is too high
- Feed rate is too high
- Clearance angle is incorrect
- Cooling is ineffective
- Point angle is incorrect
- Drill is not sharp.

Rough holes

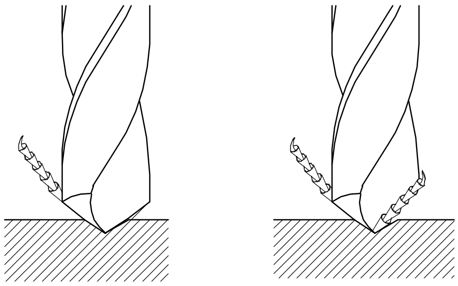
Rough holes are caused if the:

- Feed rate is too much
- Drill cutting edges are not sharp
- Cooling is ineffective.

Unequal flow of chips (Fig 5)

Unequal flow of chips is caused if the cutting edges are not equal and the point angle is not in the centre of the drill.

Fig 5



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Broken drill or split web

Broken drill or split web occurs when the:

- Cutting speed is too high
- Feed rate is too high
- Work is not held rigidly
- Drill is not held correctly
- Drill is not sharp
- Point angle is incorrect
- Cooling is insufficient
- Flutes are clogged with chips.

Letter and number drills

Objectives: At the end of this lesson you shall be able to
- **state the range of drill sizes in number and letter drill series**
- **determine the number and letter drills for given diameters referring to the chart.**

Generally drills are manufactured to standard sizes in the metric system. These drills, are available in specified steps. The drills, which are not covered under the above category, are manufactured in number and letter drills.

These drills are used where odd sizes of holes are to be drilled.

Letter drills: The letter drill series consists of drill sizes from 'A' to 'Z'. The letter 'A' drill is the smallest with 5.944 mm diameter, and the letter 'Z' is the largest, with a 10.490 mm diameter. (Table 1)

Table 1

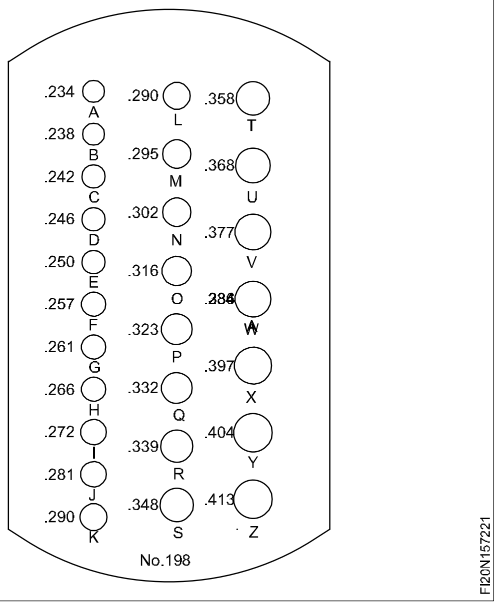
Letter drill sizes

Letter	Diameter	
	Inches	**mm**
A	.234	5.944
B	.238	6.045
C	.242	6.147
D	.246	6.248
E	.250	6.35
F	.257	6.528
G	.261	6.629
H	.266	6.756
I	.272	6.909
J	.277	7.036
K	.281	7.137
L	.290	7.366

Letter	Diameter	
	Inches	**mm**
H	.266	6.756
I	.272	6.909
J	.277	7.036
K	.281	7.137
L	.290	7.366
M	.295	7.493
N	.302	7.671
O	.316	8.026
P	.323	8.204
Q	.332	8.433
R	.339	8.611
S	.348	8.839
T	.358	9.093
U	.368	9.347
V	.377	9.576
W	.386	9.804
X	.397	10.084
Y	.404	10.262
Z	.413	10.490

In the number drill and the letter drill series, the correct diameter of the drill is gauged with the help of the respective drill gauges. A drill gauge is a rectangular or square shaped metal piece containing a number of different diameter holes. The size of the hole is stamped against each hole. (Fig 1)

Fig 1



Number drills:

The number drill series consists of drills numbered from 1 to 80. The No.1 drill is the largest, with 5.791 mm diameter, and the No.80 drill is the smallest, with 0.35 mm diameter. (Table 2). There is no uniform variation in the drill diameters from number to number. To find the correct diameter of a number drill, refer to a drill Size Chart or a Hand-book. Number drill series are also known as 'wire gauge' series.

Table 2

Number drill sizes

No.	Diameter	
	Inches	mm
1	228	5.791
2	.221	5.613
3	.213	5.410
4	.209	5.309
5	.2055	5.220
6	.204	5.182
7	.201	5.105
8	.199	5.055
9	.196	4.978
10	.1935	4.915
11	.191	4.851
12	.189	4.801
13	.185	4.699
14	.182	4.623
15	.180	4.572
16	.177	4.496
17	.173	4.394
18	.1695	4.305
19	.166	4.216
20	.161	4.089
21	.159	4.039
22	.157	3.988
23	.154	3.912
24	.152	3.861
25	.1495	3.797
26	.147	3.734
27	.144	3.658
28	.1405	3.569
29	.136	3.454
30	.1285	3.264
31	.120	3.048
32	.116	2.946
33	.113	2.870
34	.111	2.819
35	.110	2.794
36	.1065	2.705
37	.104	2.642
38	.1015	2.578
39	.0995	2.527
40	.098	2.489
41	.096	2.438
42	.0935	2.375
43	.089	2.261
44	.086	2.184
45	.082	2.083
46	.081	2.057
47	.0785	1.994
48	.076	1.930
49	.073	1.854
50	.070	1.778
51	.067	1.702
52	.0635	1.613
53	.0595	1.511
54	.055	1.395

No.	Diameter	
	Inches	mm
55	.052	1.321
56	.0465	1.181
57	.043	1.092
58	.042	1.067
59	0.41	1.041
60	.040	1.016
61	0.0390	1.00
62	0.0380	0.98
63	0.0370	0.95
64	0.0360	0.92
65	0.0350	0.90
66	0.033	0.85
67	0.032	0.82

No.	Diameter	
	Inches	mm
68	0.031	0.79
69	0.0292	0.75
70	0.0280	0.70
71	0.0260	0.65
72	0.0240	0.65
73	0.0240	0.60
74	0.0225	0.58
75	0.0210	0.52
76	0.0200	0.50
77	0.0180	0.45
78	0.0160	0.40
79	0.0145	0.38
80	0.0135	0.35

Fraction & Metric sizes of drills conversion table

Inches and millimeteres

(a) Inches to millimteres   Basic: 1 inch = 25.4 millimetres

Inch	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16
0		1.59	3.18	4.76	6.35	7.94	9.53	11.11
1	25.40	26.98	25.58	30.16	31.75	33.34	34.93	36.51
2	50.80	52.39	53.97	55.56	57.15	58.74	60.33	61.91
3	76.20	77.79	79.38	80.96	82.55	84.14	85.73	87.31
4	101.60	103.19	104.78	106.36	107.95	109.54	111.13	112.71
5	127.00	128.59	130.18	131.76	133.35	134.94	136.53	138.11
6	152.40	153.99	155.58	157.16	158.75	160.34	161.93	163.51
7	177.80	179.39	180.98	182.56	184.15	185.74	187.33	188.91
8	203.20	204.79	206.38	207.96	209.55	211.14	212.73	214.31
9	228.60	230.19	231.78	233.36	234.95	236.54	238.13	239.71
10	254.00	255.59	257.18	258.76	260.35	261.94	263.53	265.11
Inch	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
0	12.70	14.29	15.88	17.46	19.05	20.64	22.23	23.81
1	38.10	39.69	41.28	42.86	44.45	46.04	47.63	49.21
2	63.50	65.09	66.68	68.26	69.85	71.44	73.03	74.61
3	88.90	90.49	92.08	93.66	95.25	96.84	98.43	100.01
4	114.30	115.89	117.48	119.06	120.65	122.24	123.83	125.41
5	139.70	141.29	142.88	144.46	146.05	147.64	149.23	150.81
6	165.10	166.69	168.28	169.86	171.45	173.04	174.63	176.21
7	190.50	192.09	193.68	195.26	196.85	198.44	200.03	201.61
8	215.90	217.49	219.08	220.66	222.25	223.84	225.43	227.01
9	241.30	242.89	244.48	246.06	247.65	249.24	250.83	252.41
10	266.70	268.29	269.88	271.46	273.05	274.64	276.23	277.81

Example: 25 3/4" = $\left\{ \begin{array}{ll} \text{20' = (10 x 2" = 10 x 50.8 =)} & 508.00 \\ \text{5 3/4" =} & 146.05 \end{array} \right\}$ = 654.05 mm

(b) Millimteres to Inches   Basic: 1 Millimetre = 0.039369 inch

mm	0	1	2	3	4	5	6	7	8	9
0		0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.700	0.748
20	0.787	0.827	0.866	0.905	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.259	1.299	1.338	1.378	1.417	1.457	1.496	1.535
40	1.575	1.614	1.653	1.693	1.732	1.772	1.811	1.850	1.890	1.929
50	1.968	2.007	2.047	20.87	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.401	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.716
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.031	3.074	3.110
80	3.149	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.464	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.779	3.819	3.858	3.897
mm	0	100	200	300	400	500	600	700	800	900
0		3.94	7.87	11.81	15.75	19.68	23.62	27.56	31.49	35.43
1000	39.37	43.30	47.24	51.18	55.12	59.05	62.99	66.93	70.86	74.80
2000	78.74	82.67	86.61	90.55	94.48	98.42	102.36	106.30	110.23	114.17
3000	118.11	122.04	125.98	129.92	133.85	137.79	141.73	145.66	149.60	153.54
4000	157.47	161.41	165.35	169.20	173.22	177.16	181.10	185.03	188.97	192.91
5000	196.84	204.71	212.59	220.38	228.34	236.21	244.09	251.96	259.83	267.71

Example: 2256 mm = $\left\{ \begin{array}{l} \text{2200 mm = 86.61'} \\ \text{56 mm = 2.204"} \end{array} \right\}$ =88.814"

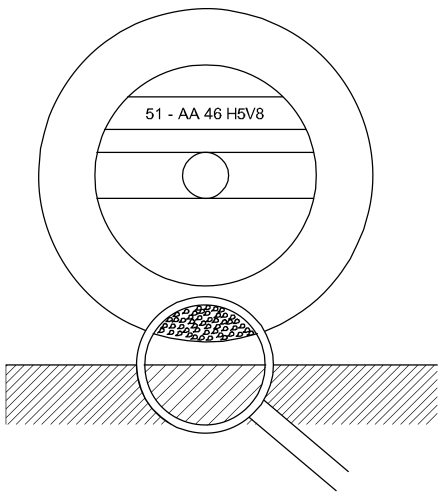
Standard marking system for grinding wheels

Objectives: At the end of this lesson you shall be able to
- **interpret the marking on a grinding wheel**
- **specify a grinding wheel.**

Introduction

Standard wheel - markings specify all the important wheel characteristics. The marking system comprises of seven symbols which are arranged in the following order. (Fig 1)

Fig 1



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Example (Marking system)

51 - A 46

Specification of grinding wheels

A grinding wheel is specified by the standard wheel markings like diameter of th

e wheel, bore diameter of the wheel, thickness of the wheel type (Shape) of the wheel.

Example

32 A 46 H8V

250X20X32-

Straight wheel

Table 1 shows the relative position measuring of the marking system

Table 1

Position 0	**Position 1**	**Position 2**	**Position 3**	**Position 4**	**Position 5**	**Position 6**
Manufac-turer's symbol for abrasive (Optional)	Type of abra-sive grit size	Grain size	Grade	Structure (Optional)	Type of bond	Manufac-turer's own mark (Optional)
51	A	46	H	5	V	8

Chart illustrating the standard marking system is : 551-1966 (Table - 2)

Table 2

ORDER OF MARKING

3	1	2	3	4	5	6
Nature of Wheel	Type of Abrasive	Grain Size	Grade	Structure	Type of bond	Manufacturer's Reference
51	A	36	L	5	V	23

Manufacturer's symbol indicating the exact nature of Abrasive (optional)

Manufacturer's own identification mark for the wheel (optional)

ALUMINIUM OXIDE – A
SILICON CARBIDES – C

V – VITRIFIED
S – SILICATE
R – RUBBER
RF – RUBBER REINFORCED
B – RESINOID (SYNTHETIC RESINS)
BF – RESINOID REINFORCED
E – SHELLAC
Mg – MAGNESIA

COARSE	MEDIUM	FINE	VERY FINE
10	30		220
12	36	80	240
14	46		280
16	54	100	320
20	60	120	400
24		150	500
		180	600

SPACING FROM THE CLOSEST TO THE MOST OPEN

	0	8
1	9	
2	10	
3	11	
4	12	
5	13	
6	14	
7		

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

SOFT (A–F) — MEDIUM (G–V) — HARD (W–Z)

CHART ILLUSTRATING STANDARD MARKING SYSTEM IS : 551 – 1966

Construction of the grinding wheel

Objectives: At the end of this lesson you shall be able to
- **state the different types of abrasives and their uses**
- **state the different grain sizes and their uses**
- **state the different grades of grinding wheels**
- **state the structure of a grinding wheel**
- **name the bonding materials used for grinding wheels.**

In order to suit the grinding wheel for different work situations, the features such as abrasive, grainsize, grade, structure and bonding materials can be varied.

A grinding wheel consists of the abrasive that does the cutting, and the bond that holds the abrasive particles together.

Abrasives

There are two types of abrasives.

- Natural abrasive
- Artificial abrasive

The natural abrasives are emery and corrundum,These are impure forms of aluminium oxide.

Artificial abrasives are silicon carbide and aluminium oxide.

The abrasives are selected depending upon the material being ground.

'Brown' aluminium oxide is used for general purpose grinding of tough materials.

'White aluminium oxide is used for grinding ferrous and ferrous alloys.

'Green' silicon carbide is used for very hard materials with low tensile strength such as cemented carbides.

Grain size (Grit size): The number indicating the size of the grit represents the number of openings in the sieve used to size the grain. The larger the grit size number, the finer the grit.

Grade: Grade indicates the strength of the bond and, therefore, the 'hardness' of the wheel. In a hard wheel the bond is strong, and securely anchors the grit in place and, therefore, reduces the rate of wear. In a soft wheel, the bond is weak and the grit is easily detached resulting in a high rate of wear.

Structure: This indicates the amount of bond present between the individual abrasive grains and the closeness of the individual grains to each other. An open structure wheel will cut more freely. That is, it will remove more metal in a given time and produce less heat. It will not produce such a good finish as a closely structured wheel.

Bond: The bond is the substance which, when mixed with abrasive grains, hold them together, enabling the mixture to be shaped to the form of the wheel, and after suitale treatment to take on the necessary mechanical strength for its work. The degree of hardness possessed by the bond is called the 'grade' of the wheel, and indicates the ability of the bond to hold the abrasive grains in the wheel. There are several types of bonding materials used for making wheels.

Vitrified bond: This is the most widely used bond. It has high porosity and strength which makes this type of wheel suitable for high rate of stock removal. It is not adversely affected by water, acid, oils or ordinary temperature conditions.

Silicate bond: Silicate wheels have a milder action and cut with less harshness than vitrified wheels. For this reason they are suitable for grinding fine edge tools, cutters etc.

Shellac bond: This is used for heavy duty, large diameter wheels where a fine finish is required. For example, the grinding of mill rolls.

Rubber bond: This is used where a small degree of flexibility is required on the wheel as in the cutting off wheels.

Retinoid bond: This is used for speed wheels. Such wheels are used in foundries for dressing castings. Retinoid bond wheels are also used for cutting off. They are strong enough to withstand considerable abuse.

Wheel inspection and wheel mounting

Objectives: At the end of this lesson you shall be able to
- **brief steps involved in grinding wheel inspection**
- **state the procedure for mounting of grinding wheel.**

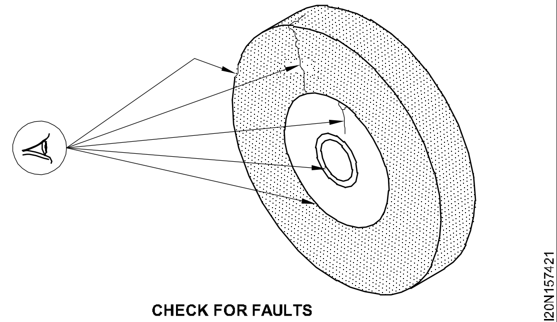
Wheel inspection: The wheel selected may have been damaged during transport or storage and must be carefully inspected before use.

Visual inspection (Fig 1)

Look for

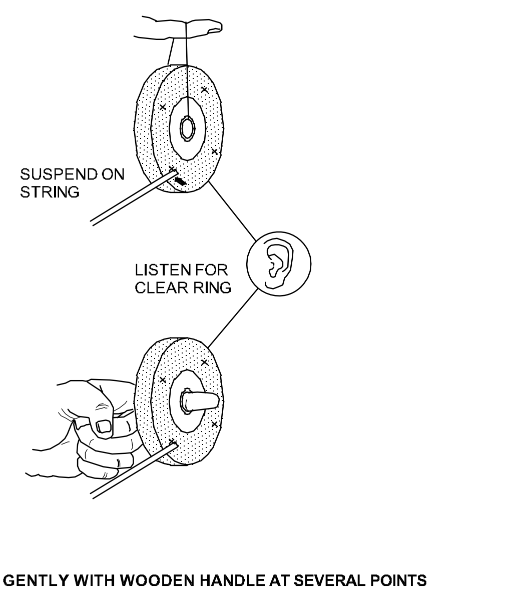
- Broken or chipped edges.
- Cracks
- Damaged mounting bushing
- Damaged paper washers

Fig 1



Testing for cracks (Fig 2)

Fig 2



TAP GENTLY WITH WOODEN HANDLE AT SEVERAL POINTS

Test a wheel for cracks by the following method

- Suspend the wheel on a piece of string or support it with one finger through the bushing.
- Allow the wheel to hang free.
- Tap the wheel with a non-metallic object such as a small wooden mallet or tool handle.
- A clear ringing sound indicates that the wheel is not cracked.
- A dull sound means that the wheel is cracked and must not be used.

> **Warning**
>
> **Discard any wheel that:**
>
> **- Shows any sign of damage.**
>
> **- Does not ring clearly when struck.**
>
> **If you are in doubt, do not use the wheel. Clearly mark it and seek advice from your supervisor. (Fig 3)**

Mounting the grinding wheel (Fig 4)**:** For correct and safe operation of a grinding machine it is essential to mount the grinding wheel correctly on the spindle.

Before fitting a new wheel, make sure that the spindle is completely clean and free from surface irregularities.

The spindle of the grinding machine includes an inner flange, an outer flange and a nut threaded on the spindle to hold the grinding wheel in position.

The inner flange must be fixed to rotate with the spindle.

Each flange has a dished face towards the surface of the wheel and has a true bearing surface at its area of contact.

Suitable paper discs are normally fitted to the wheel by the manufacturer.

Fig 3

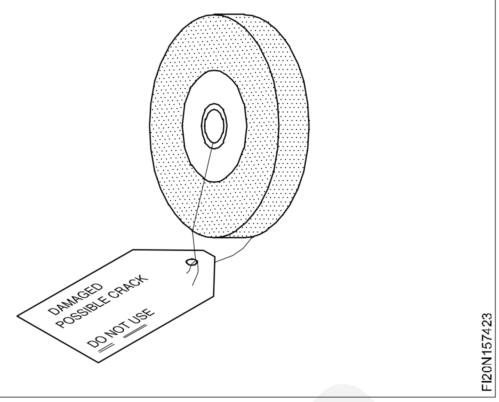
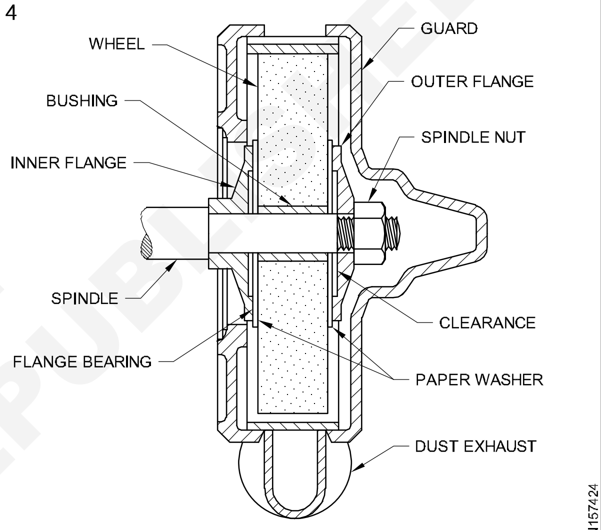


Fig 4



GRINDING WHEEL CORRECTLY MOUNTED

Mounting procedure (Fig 5)

Mount the wheel on the spindle of the grinding machine as follows:

Check that the spindle surface is clean and free of irregularities. Clean with a dry cloth, if necessary.

Check that the inner flange is fixed to the spindle and that its bearing surface is clean and true.

Check that the wheel bush surface is clean and that it can fits easily, but not loosely, onto the spindle. Clean the bush before fitting the wheel on the spindle, if necessary.

Check that each side of the grinding wheel is fitted with a soft paper disc of slightly larger diameter than the spindle flanges.

Check that the diameter of each spindle flange is at least one third the diameter of the grinding wheel.

Fit the grinding wheel to the spindle and place the outer spindle flange in position.

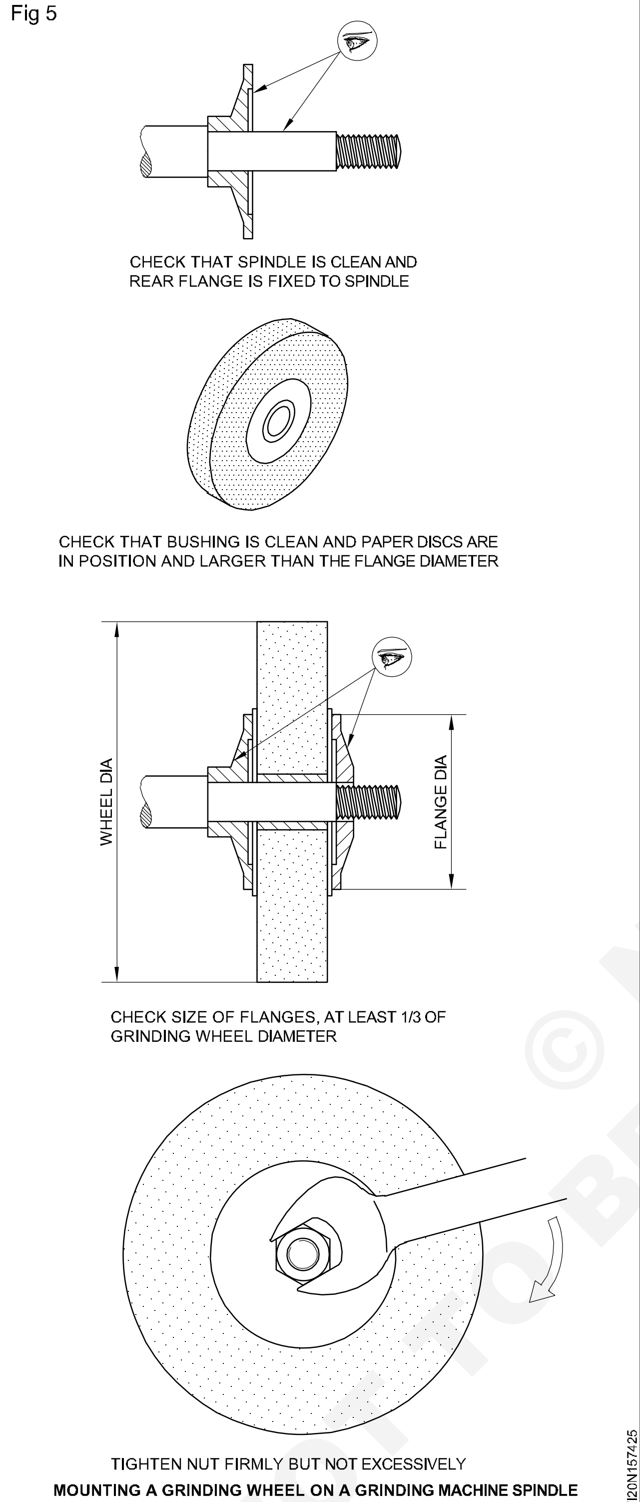


Fig 5 MOUNTING A GRINDING WHEEL ON A GRINDING MACHINE SPINDLE

Tighten the spindle nut against the outer spindle flange with a spanner of the correct size.

Replace the wheel guard correctly

Caution

The nut should only be tightened sufficiently to hold the wheel firmly. If it is tightened excessively, the wheel may break.

The nut is threaded onto the spindle in a direction opposite to the direction of rotation of the spindle.

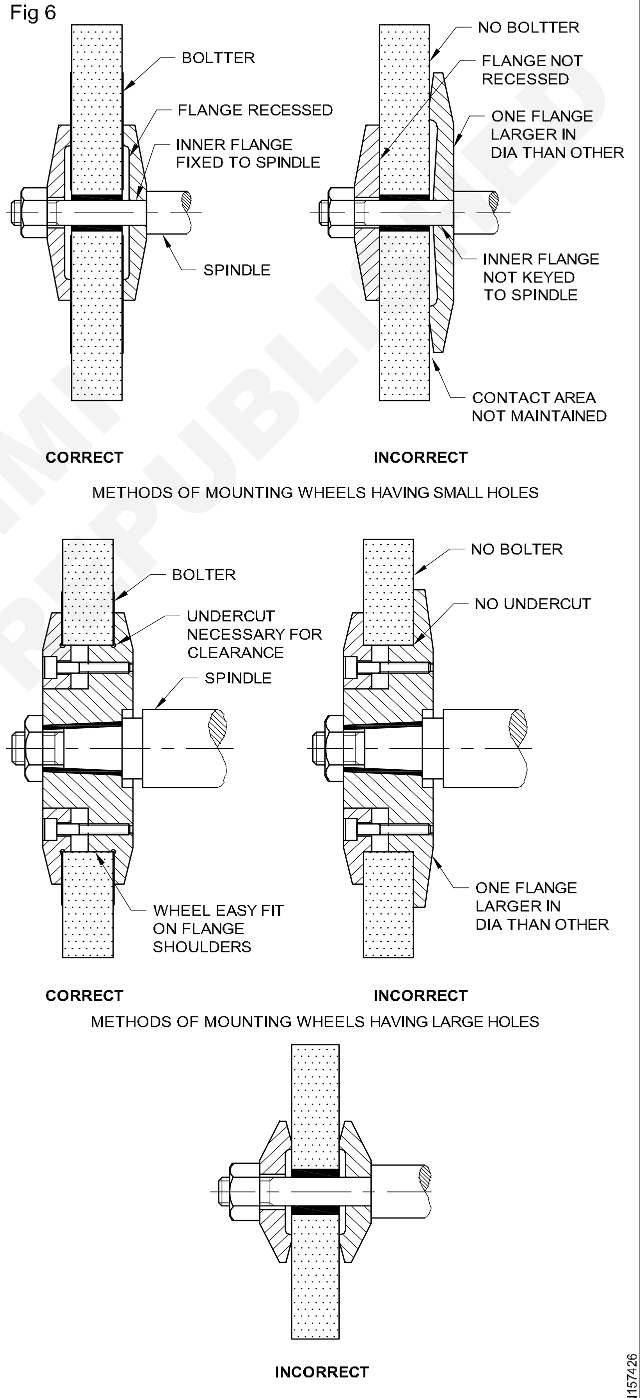
- Run the wheel at its recommended speed in the grinding machine for at least a minute. Do not use the wheel during this period.

Points to note

Study these illustrations carefully and note the points to watch when mounting grinding wheels. (Fig 6)

Washer of compressible material such as card board, leather, rubber etc, not more than 1.5mm thick should be fitted between the wheel and flanges. This prevents any unevenness of the wheel surface is balanced and the tight joint is obtained.

Fig 6



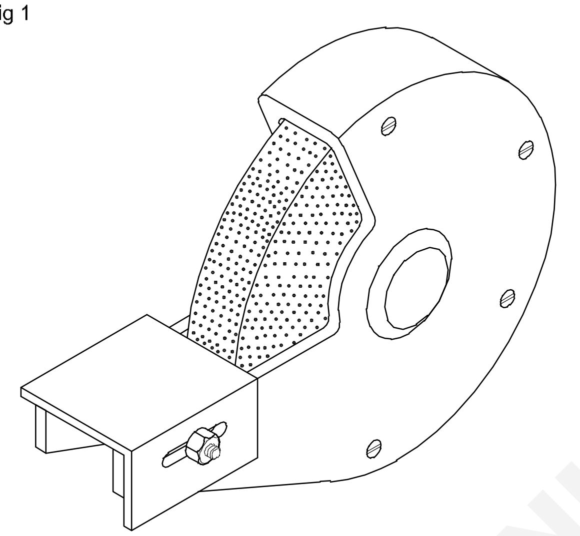
Grinding wheel dressing

Objectives : At the end of this lesson you shall be able to
- **differentiate between loading and glazing**
- **state the effects of loading and glazing**
- **differentiate between dressing and truing.**

Grinding wheels become inefficient due to two main causes known as loading and glazing.

Loading: When soft materials such as aluminium, copper, lead etc. are ground, the metal particles get clogged in the pores of the wheel. This condition is called loading. (Fig 1)

Fig 1



Glazing: When a surface of the wheel develops a smooth and shining appearance, it is said to be glazed. This indicates that the wheel is blunt, i.e. the abrasive grains are not sharp.

When such grinding wheels are used, there is a tendency to exert extra pressure in order to make the wheels cut. Excessive pressure on the grinding wheel will lead to the fracture of the wheel, excessive heating of the wheel, weakening of bonding of the wheel and bursting of the wheel.

Dressing: The purpose of dressing is to restore the correct cutting action of the wheel. Dressing removes the clogs on the surface of the wheel and the blunt grains of the abrasive, exposing the new sharp abrasive grains of the wheel which can be cut and brought to shape efficiently.

Truing: Truing refers to the shaping of the wheel to make it run concentric with the axis. When a new grinding wheel is mounted, it must be trued before use. The cutting surface of a new wheel may run out slightly due to the clearance between the bore and the machine spindle. Grinding wheels, which are in use, also can run out of true, due to uneven loading while grinding.

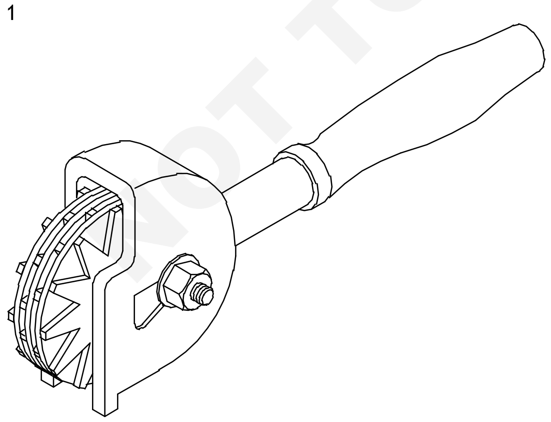
Dressing and truing are done at the same time.

Grinding wheel dressers

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

The wheel dressers used for off-hand grinders are star wheel dressers (Fig 1) (Huntington type wheel dresser) and diamond dressers.

Fig 1



The star wheel dresser consists of a number of hardened star-shaped wheels mounted on a spindle at one end and a handle at the other end.

While dressing, the star wheel is pressed against the face of the revolving grinding wheel. The star wheel revolves and digs into the surface of the grinding wheel. This releases the wheel loading and dull grains, exposing sharp new abrasive grains.

Star wheels are useful for pedestal grinders in which a precision finish is not expected.

Star wheel dressers should be used only on wheels which are large enough to take the load.

Diamond Dressers (Fig 2)

Bench type off-hand grinders used for sharpening cutting tools are usually fitted with smaller and rather delicate wheels.

These wheels are dressed and trued with diamond dressers.

Diamond dressers consist of a small diamond mounted on a holder which can be held rigidly on the work-rest.

Fig 2

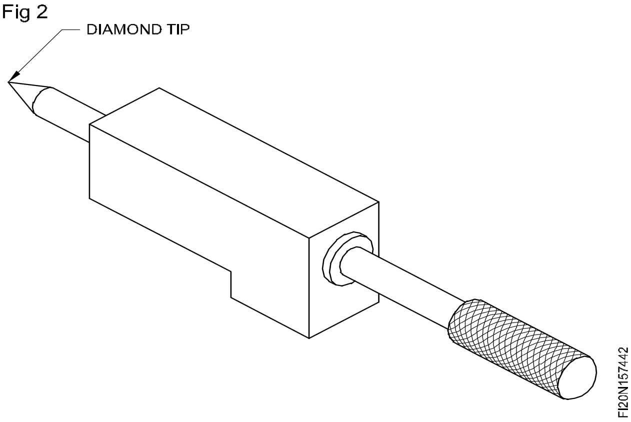
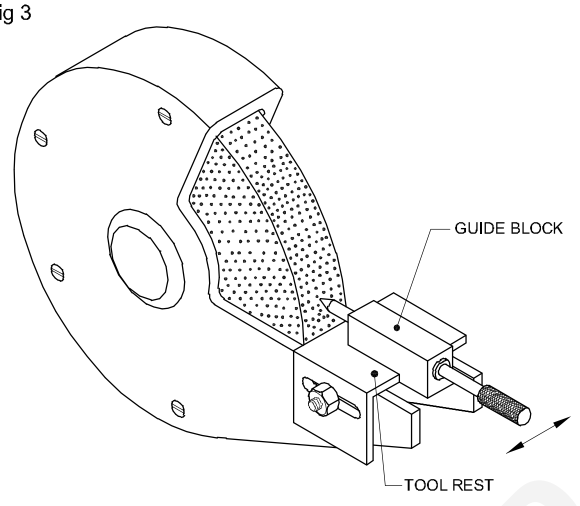


Fig 3



How to use a wheel dresser (Fig 3)

For dressing and truing, the dresser is slowly brought in to contact with the wheel face and moved across.

The finish obtained depends on the rate at which the dresser is moved across the face.

For roughing, the dresser is moved faster.

For fine finish, the dresser is moved slowly.

Roughing will be efficient with a dresser that has a sharp point, while, for fine finishing, a blunt diamond dresser is more suitable.

Abrasive stick: When only a light dressing is required, abrasive sticks can also be used. There are abrasive materials made in the form of sticks for the convenience of handling.

Diamond dressers, if moved too slowly, can glaze the wheel.

Off-hand grinding with bench and pedestal grinders

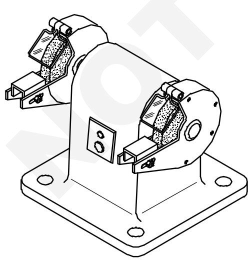
Objectives: At the end of this lesson you shall be able to
- **state the purposes of off-hand grinding**
- **name the machines with which off-hand grinding is done**
- **state the features of bench and pedestal grinders.**

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 rotating 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 grinders are fitted to a bench and pedestal (Figs 1 and 2)

Fig 1

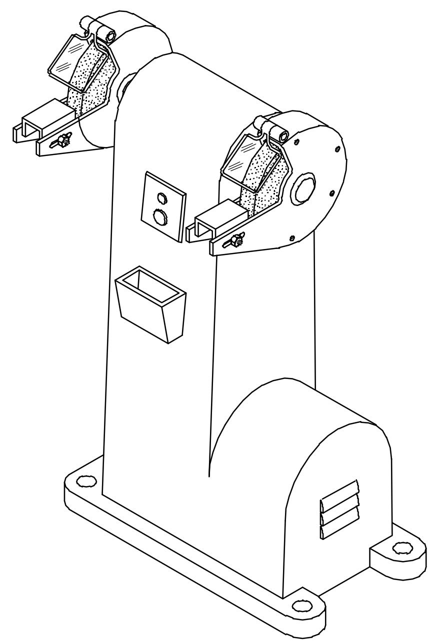


BENCH GRINDER

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

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

Fig 2

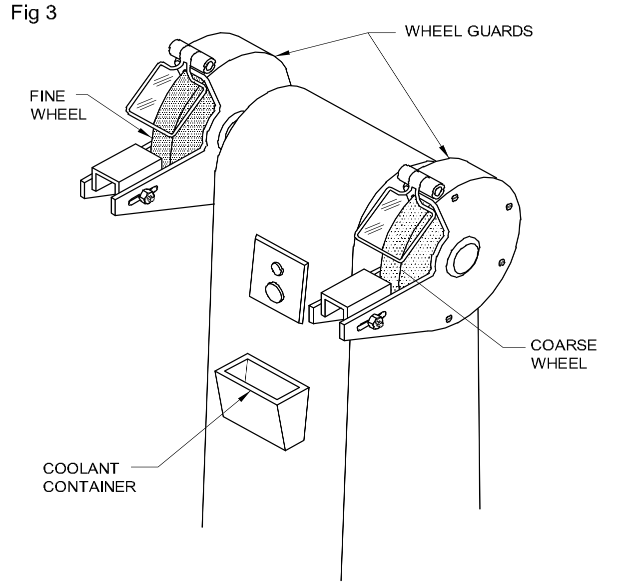


PEDESTAL GRINDER

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

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

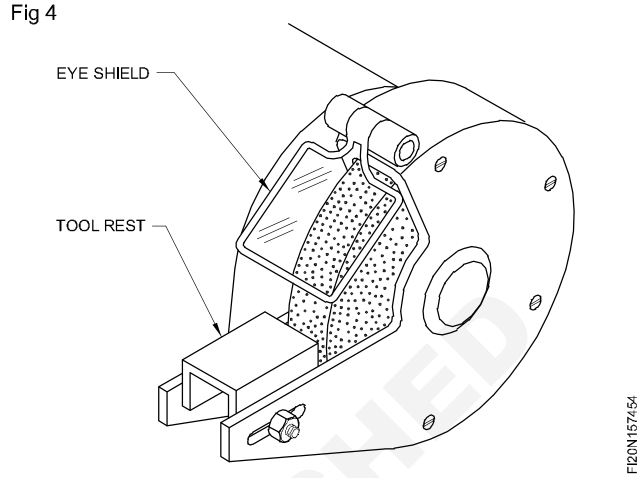
Fig 3



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

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

Fig 4



Gauges and types of gauges

Objectives: At the end of this lesson you shall be able to
- **define template with its uses and advantages**
- **define gauges their necessity and types.**

Gauge: Gauge is an inspection tool used to check product dimension with reference to its maximum and minimum acceptable limits. It is, generally, used to segregate acceptable and non-acceptable products in mass production, without the exact dimensions. It is made of tool steel and is heat treated.

Advantages of gauging

Faster checking of the product is within the specified limits.

Less dependence on operator skill and getting affected by operator judgement.

Gauges are economical when compared to measuring instruments.

Instrument used for gauging

1 Snap and ring gauge
2 Combined gauge
3 Plug gauge
4 Screw pitch gauge
5 Template and form gauge
6 Taper gauge

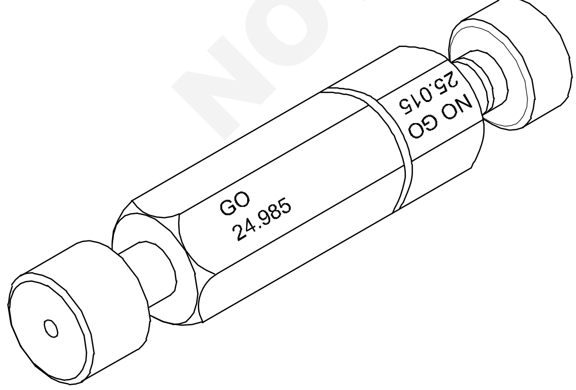
Types of cylindrical plug gauges

Double-ended plug gauge (Fig 1 and 2)

Progressive plug gauge (Fig 3)

Plain cylindrical gauges are used for checking the inside diameter of a straight hole. The ‘Go’ gauge checks the lower limit of the hole and the ‘No- Go’ gauge checks the upper limit. The plugs are ground and lapped. (Fig 3)

Fig 1



DOUBLE ENDED PLUG GAUGE

Fig 2

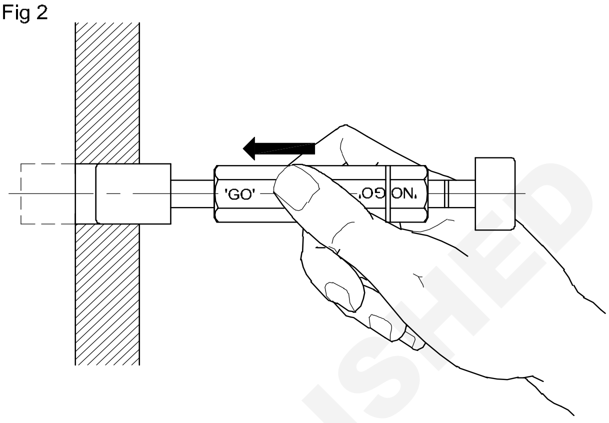
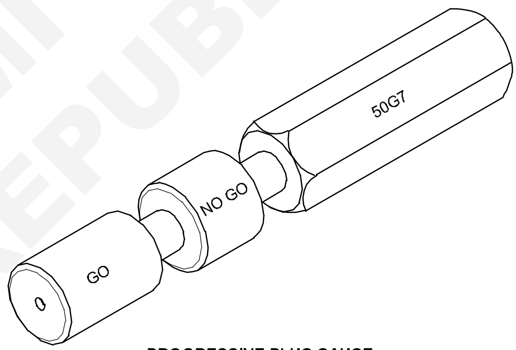


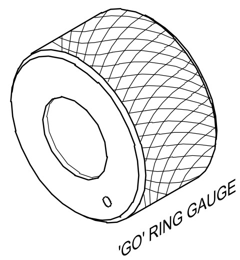
Fig 3



PROGRESSIVE PLUG GAUGE

Plain ring gauge (Fig 4)

Fig 4

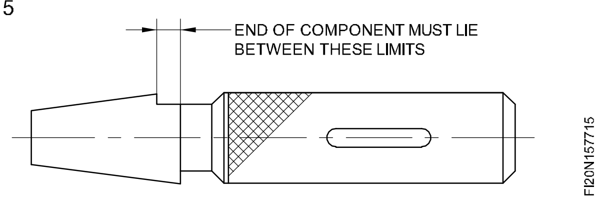


Plain ring gauges are used to check the outside diameter of pieces. Separate gauges are used for checking ‘Go’ and ‘No- Go’ sizes. A `No-Go’ gauge is identified by an annular groove on the knurled surface.

Taper plug gauges (Fig 5)

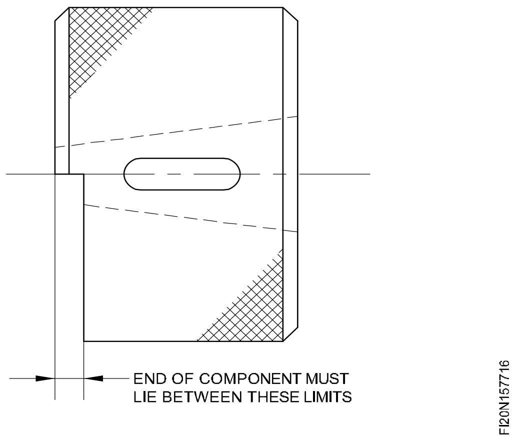
These gauges made with standard or special tapers are used to check the size of the hole and the accuracy of the taper. The gauge must slide into the hole for a prescribed depth and fit perfectly. An incorrect taper is evidenced by a wobble between the plug gauge and the hole.

Fig 5



Taper ring gauges (Fig 6)

Fig 6



They are used to check both the accuracy and the outside diameter of a taper. Ring gauges often have scribed lines or a step ground on the small end to indicate the 'Go' and 'No-Go' dimensions.

Thread plug gauges (Figs 7 and 8)

Fig 7

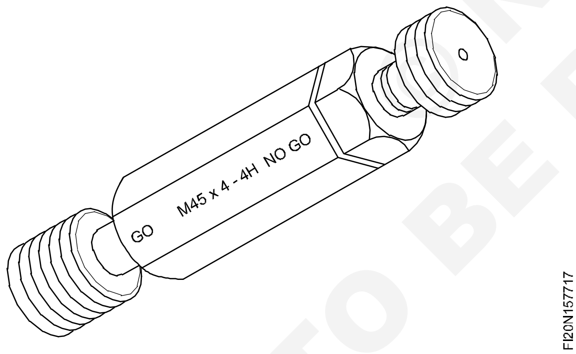
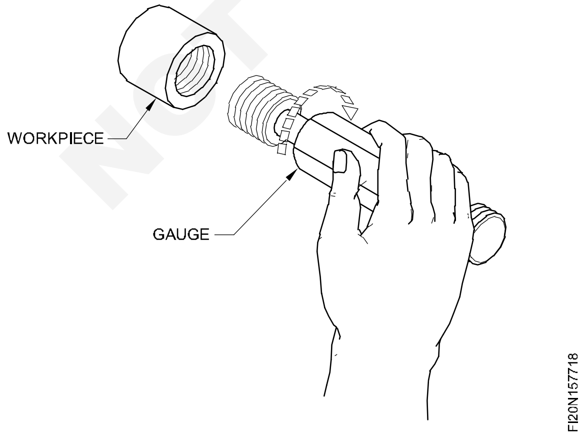


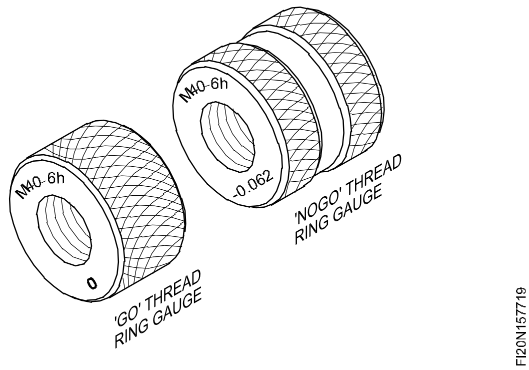
Fig 8



Internal threads are checked with thread plug gauges of 'Go' and `No-Go' variety which employ the same principle as cylindrical plug gauges.

Thread ring gauges (Fig 9)

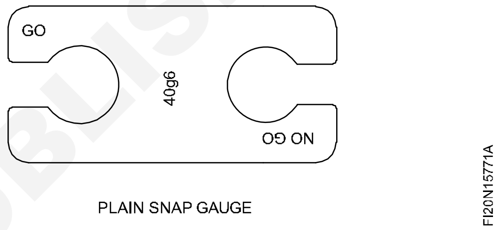
Fig 9



These gauges are used to check the accuracy of an external thread. They have a threaded hole in the centre with three radial slots and a set screw to permit small adjustments.

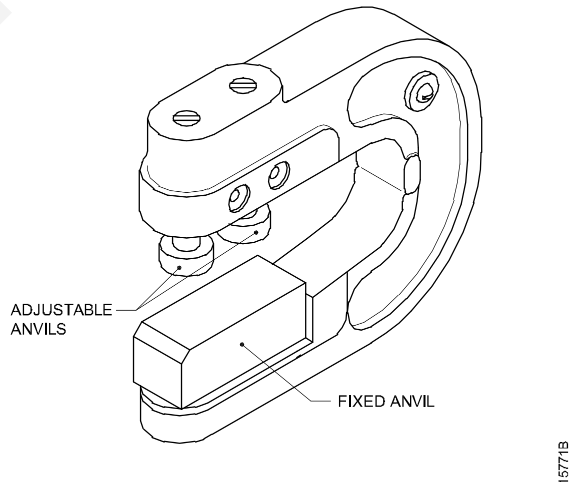
Snap gauges (Figs 10, 11, 12 and 13)

Fig 10



PLAIN SNAP GAUGE

Fig 11



ADJUSTABLE SNAP GAUGE

Snap gauges are a quick means of checking diameters and threads to within certain limits by comparing the part's size to the present dimension of the snap gauge.

Snap gauges are generally C-shaped and are adjustable to the maximum and minimum limits of the part being checked. When in use, the work should slide into the 'Go' gauge but not into the 'No-Go' gauging end.

Fig 12

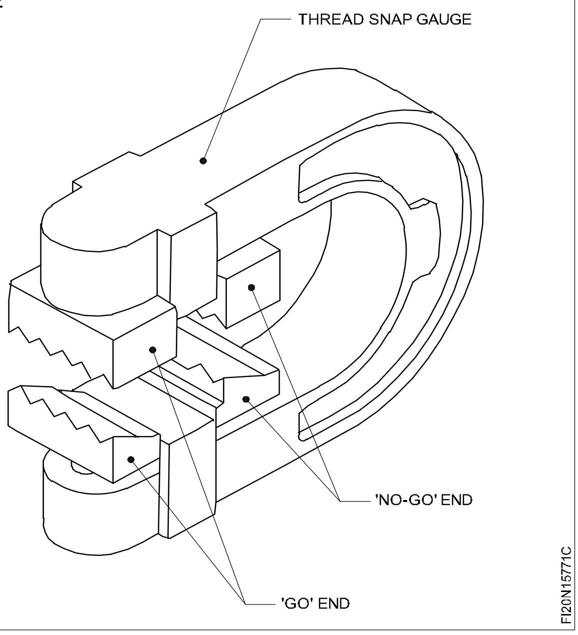
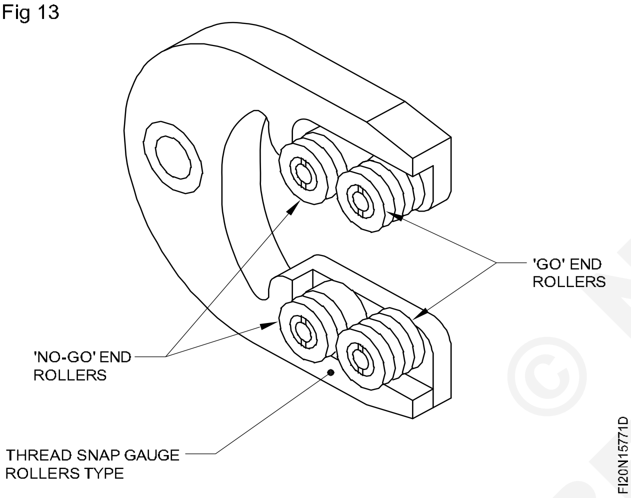


Fig 13



Screw pitch gauge

Purpose

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

It is also used to compare the profile of threads.

Constructional features

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

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

The thread profile on each blade is cut for about 25 mm to 30 mm. The pitch of the blade is stamped on each blade. The standard and range of the pitches are marked on the case. (Fig 14)

For obtaining accurate results while using the screw pitch gauge, the full length of the blade should be placed on the threads. (Fig 15)

Fig 14

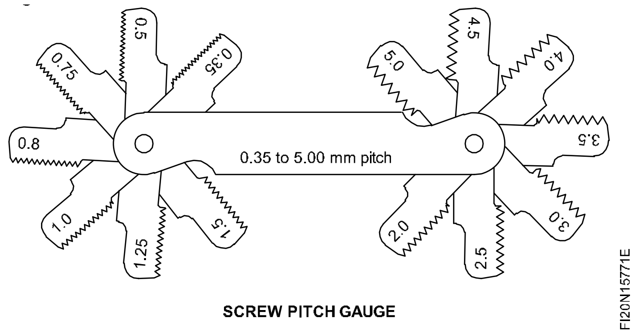
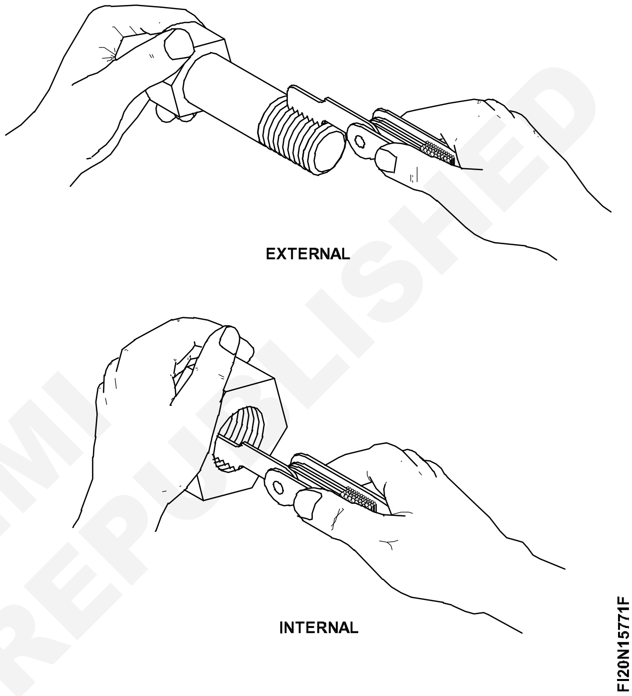


Fig 15



Simple and standard workshop gauges

Radius and fillet gauges: Components are machined to have curved formation on the edges or at the junction of two steps. Accordingly they are called radius and fillets. The size of the radius and radius is normally provided on a drawing. The gauges used to check the radius formed on the edges of diameters are fillet and the gauges used to check the fillets are called fillets gauges.

They are made of hardened sheet metal each to a precise radius. They are used to check the radii by comparing the radius on a part with the radius of the gauges.

Fig 16 shows the application of radius gauge to check the radius formed externally. Fig 17 shows the application of a fillet gauge to check the fillet formed on a turned component. The other typical applications are:

Some sets have provisions to check the radius and fillet on each blade. (Fig 18)

And some sets have separate sets of blades to check the radius and fillet. (Fig 19)

Each blade can be swung out of the holder separately, and has its size engraved on it. (Fig 20)

Fig 16

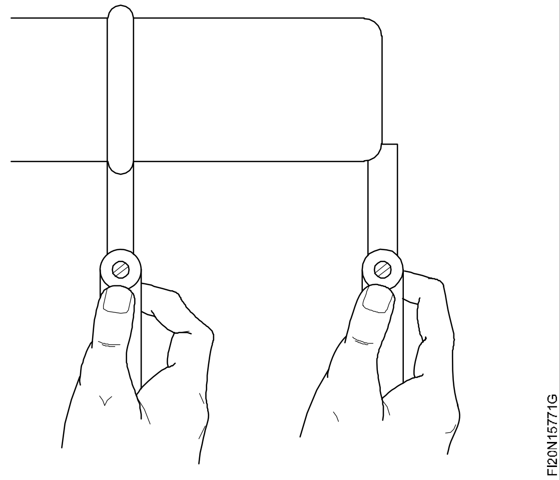


Fig 17

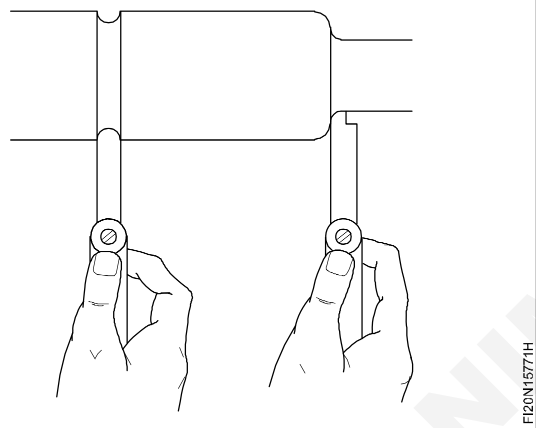


Fig 18

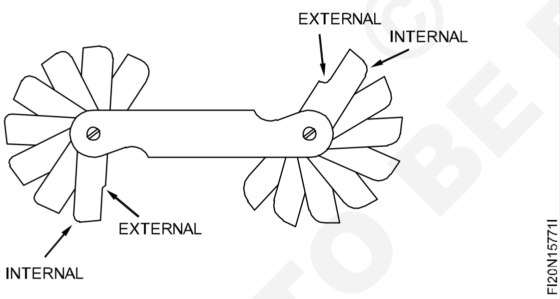


Fig 19

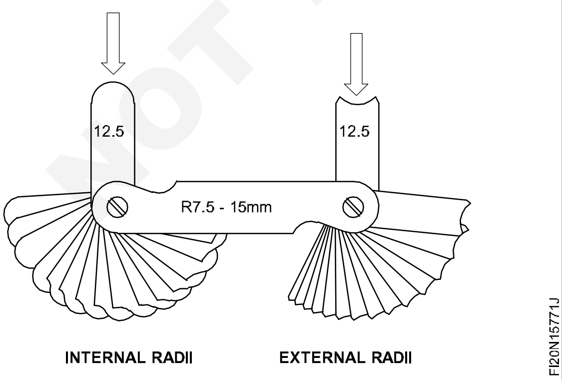
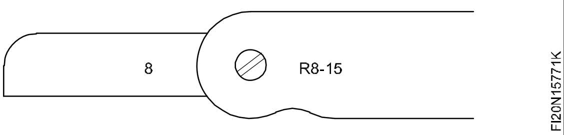


Fig 20



Fillet gauges are available in sets to check the radii and fillets from:

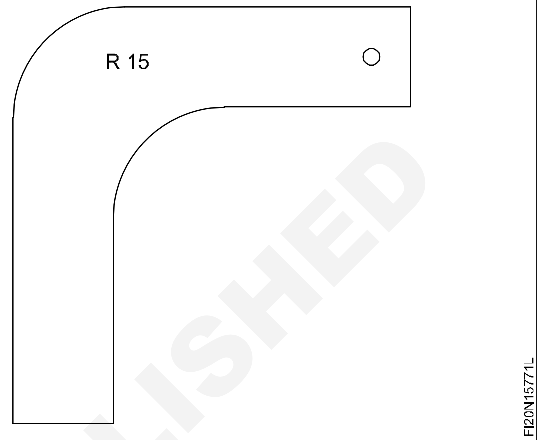
1 to 7 mm in steps of 0.5 mm

7.5 to 15 mm in steps of 0.5 mm

15.5 to 25 mm in steps 0.5 mm.

Individual gauges are also available. They usually have internal and external radii on each gauge and are made in sizes from 1 to 100 mm in steps of 1 mm. (Fig 21)

Fig 21



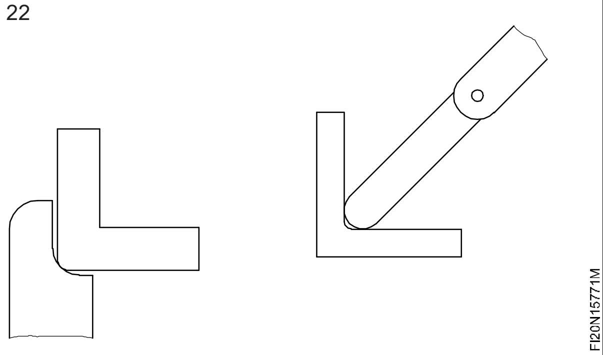
Before using the radius gauge, check that it is clean and undamaged.

Remove burrs from the workpiece.

Select the leaf of the gauge from the set corresponding to the radius to be checked.

Fig 22 shows that the radius of the fillet and that of the external radius are smaller than the gauge.

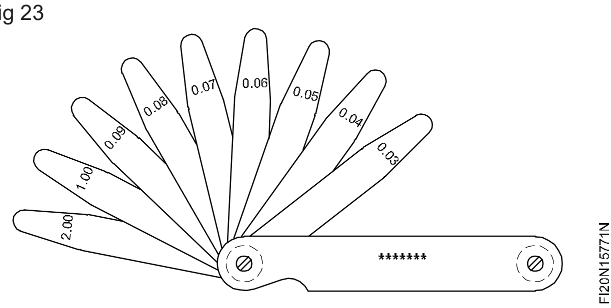
Fig 22



Feeler gauge and uses

Features: A feeler gauge consists of a number of hardened and tempered steel blades of various thicknesses mounted in a steel case. (Fig 23)

Fig 23



The thickness of individual leaves is marked on it. (Fig 23)

B.I.S. Set: The Indian Standard establishes four sets of feeler gauges Nos.1,2,3 and 4 which differ by the number of blades in each and by the range of thickness (minimum is 0.03 mm to 1 mm in steps of 0.01 mm). The length of the blade is usually 100 mm.

Example

Set No.4 of Indian Standard consist of 13 blades of different thicknesses.

0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.15, 0.20, 0.30, 0.40, 0.50.

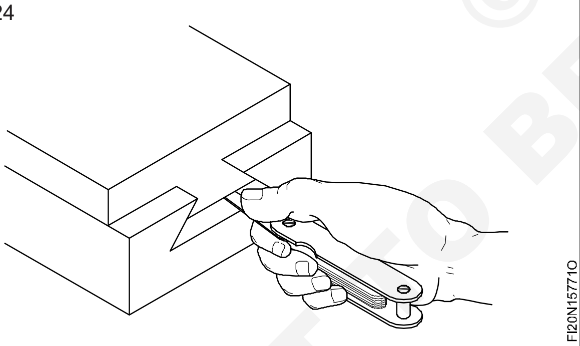
The sizes of the feeler gauges in a set are carefully chosen in order that a maximum number of dimensions can be formed by building up from a minimum number of leaves.

The dimension being tested is judged to be equal to the thickness of the leaves used, when a slight pull is felt while withdrawing them. Accuracy in using these gauge requires a good sense of feel.

Feeler gauges are used:

- To check the gap between the mating parts
- To check and set the spark plug gaps
- To set the clearance between the fixture (setting block) and the cutter/tool for machining the jobs
- To check and measure the bearing clearance, and for many other purposes where a specified clearance must be maintained. (Fig 24)

Fig 24



Drill gauge: A drill gauge is a rectangular or square shaped metal piece containing a number of different diameter holes. The size of the hole is stamped against each hole. (Fig 25)

In the number drill and letter drill series, the diameter of the drill is gauged with the help of the respective drill gauge.

Standard Wire Gauge (SWG): It is used to measure the size of a wire and thickness of sheet shown in Fig.26

Fig 25

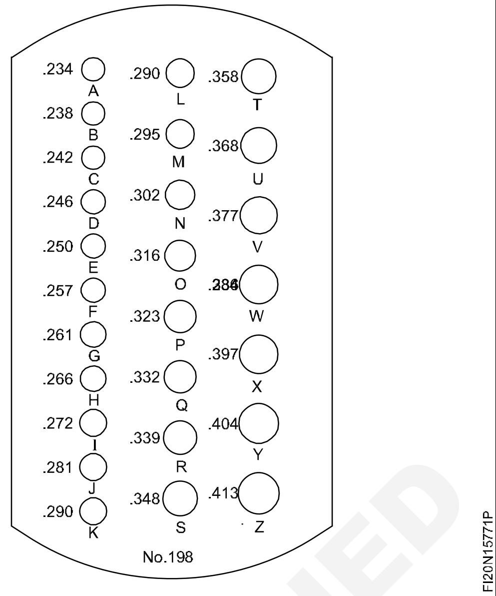
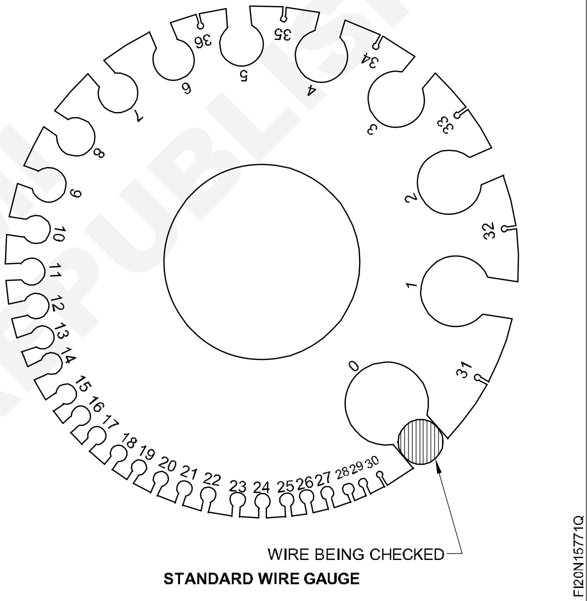


Fig 26



The standard wire gauge is a circular metal disc with varying hole and slot size on its circumference. Each slot size corresponds to a gauge number which is written just below the hole.

The gauge numbers specify the size of a round wire in terms of its diameter.

As the gauge number increase from 0 to 36, the dia size decrease.

The thickness of sheet metal and the diameter of wires confirm to various gauging numbers and the following Table 1 give the decimal equivalents of the different gauge numbers for the diameter of wires, and the thickness of sheets.

Table 1

Standard wire gauge number and equivalent value in mm as per IS 5049-1969

Wire No. according to SWG	Wire Dia according to IS:280-1962 in mm
0	8.00
2	7.10
3	6.30
4	6.00
5	5.60
6	5.00
7	4.50
8	4.00
9	3.55
10	3.15
11	2.80
12	2.50
13	2.24
14	2.00
15	1.80
16	1.60
17	1.40
18	1.25
-	1.12
19	1.00
20	0.90
21	0.80
22	0.710
23	0.630
24	0.560
25	0.500
26	0.450
27	0.400
29	0.355
30	0.315
32	0.280
33	0.250
34	0.224
36	0.200
37	0.180
38	0.160
39	0.140
40	0.125

Necessity of Interchangeability in engineering field

Objectives: At the end of this lesson you shall be able to
- **state the advantages and disadvantages of mass production**
- **outline the meaning of the term,'interchangeability'**
- **state the necessity for the limit system**
- **name the different standards of system of limits and fits.**

Mass production

Mass production means production of a unit, component or part in large numbers.

Advantages of mass production

Time for the manufacture of components is reduced.

The cost of a piece is reduced.

Spare parts can be quickly made available.

Disadvantages of mass production

Special purpose machines are necessary.

Jigs and fixtures are needed.

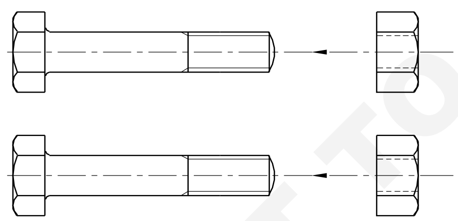
Gauges are to be used instead of conventional precision instruments.

Initial expenditure will be very high.

Selective assembly

The figures illustrate the difference between a selective assembly and a non-selective assembly. It will be seen in (Fig 1) that each nut fits only one bolt. Such an assembly is slow and costly, and maintenance is difficult because spares must be individually manufactured.

Fig 1



SELECTIVE ASSEMBLY

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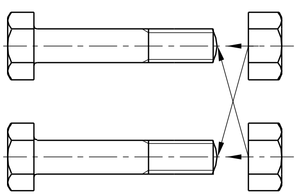
Non-selective assembly

Any nut fits any bolt of the same size and thread type. Such an assembly is rapid, and costs are reduced. Maintenance is simpler because spares are easily available. (Fig 2)

Fig 2



NON-SELECTIVE ASSEMBLY INTERCHANGEAB ILITY

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Non-selective assembly provides interchange-ability between the components.

In modern engineering production, i.e. mass production, there is no room for selective assembly. However, under some special circumstances, selective assembly is still justified.

Interchangeability: When components are mass-produced, unless they are interchangeable, the purpose of mass production is not fulfilled. By interchangeability, we mean that identical components, manufactured by different personnel under different environments, can be assembled and replaced without any further rectification during the assembly stage, without affecting the functioning of the component when assembled.

Necessity of the limit system: If components are to be interchangeable, they need to be manufactured to the same size which is not possible, when they are mass-produced. Hence, it becomes necessary to permit the operator to deviate by a small margin from the exact size which he is not able to maintain for all the components. At the same time, the deviated size should not affect the quality of the assembly. This sort of dimensioning is known as limit dimensioning.

A system of limits is to be followed as a standard for the limit dimensioning of components.

Various standard systems of limits and fits are followed by different countries based on the ISO (International Standards Organisation) specifications.

The system of limits and fits followed in our country is stipulated by the BIS. (Bureau of Indian Standards)

Other systems of limits and fits

International Standards Organisation (ISO)

British Standard System (BSS)

German Standard (DIN)

The indian standard system of limits & fits - terminology

Objectives: At the end of this lesson you shall be able to
- **state the terms under the BIS system of limits and fits**
- **define each term under the BIS system of limits and fits**.

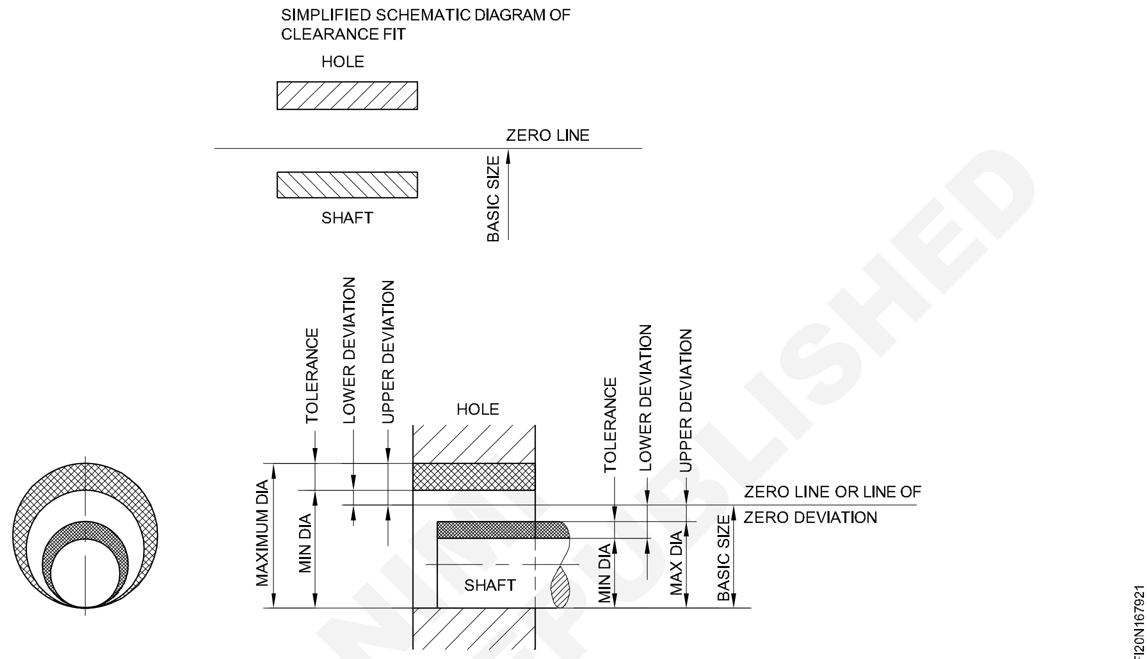
Size

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

Basic size

It is the size based on which the dimensional deviations are given. (Fig 1)

Fig 1



Actual size

It is the size of the component by actual measurement after it is manufactured. It should lie between the two limits of size if the component is to be accepted.

Limits of size

These are the extreme permissible sizes within which the operator is expected to make the component. (Fig 2) (Maximum and minimum limits)

Maximum limit of size

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

Minimum limit of size

It is the smaller of the two limits of size. (Fig 2) (Table 1)

Hole

In the BIS system of limits & fits, all internal features of a component including those which are not cylindrical are designated as ` hole'. (Fig 3)

Shaft

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

Fig 2

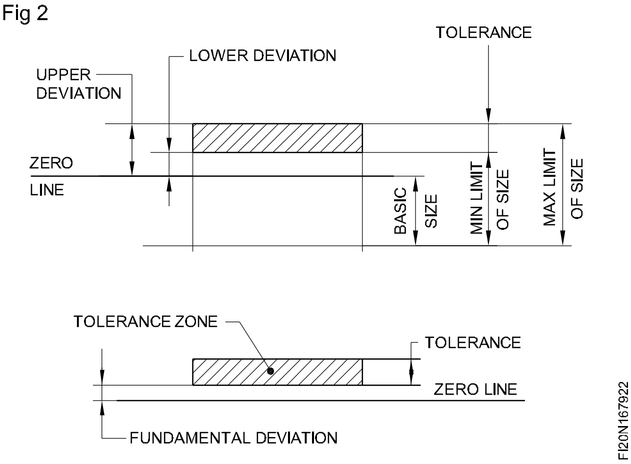


Fig 3

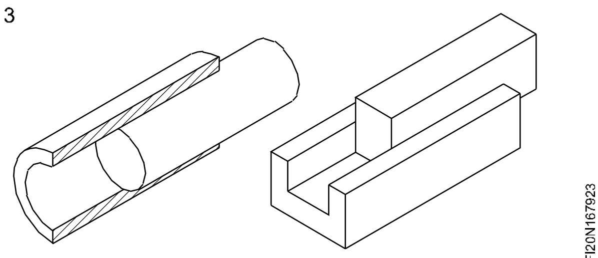


Table 1 (Examples)

SL. NO.	SIZE OF COMPONENT	UPPER DEVIATION	LOWER DEVIATION	MAX-LIMIT OF SIZE	MIN-LIMIT OF SIZE
1	$20^{+.008}_{-.005}$	+ 0.008	- 0.005	20.008	19.995
2	$20^{+.028}_{+.007}$	+ 0.028	+ 0.007	20.028	20.007
3	$20^{-.012}_{-.021}$	- 0.012	- 0.021	19.988	19.979

Deviation

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

Upper deviation

It is the algebraic difference between the maximum limit of size and its corresponding basic size. (Fig 2) (Table 1)

Lower deviation

It is the algebraic difference between the minimum limit of size and its corresponding basic size.(Fig 2) (Table 1)

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

Actual deviation

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

Tolerance

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

Zero line

In graphical representation of the above terms, the zero line represents the basic size. This line is also called as the line of zero deviation. (Figs 1 and 2)

Fundamental deviation

There are 25 fundamental deviations in the BIS system represented by letter symbols (capital letters for holes and small letters for shafts), i.e for holes - ABCD....Z excluding I,L,O,Q & W. (Fig 4)

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

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

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

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

Fig 4

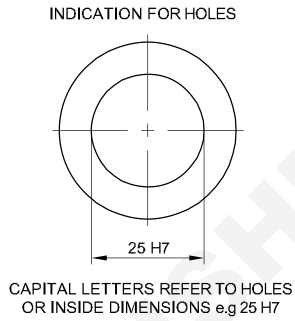


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Fig 5

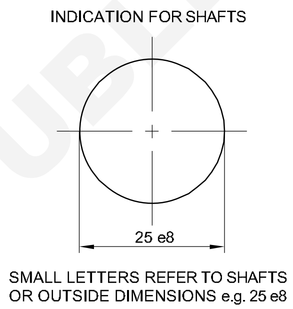

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Fig 6

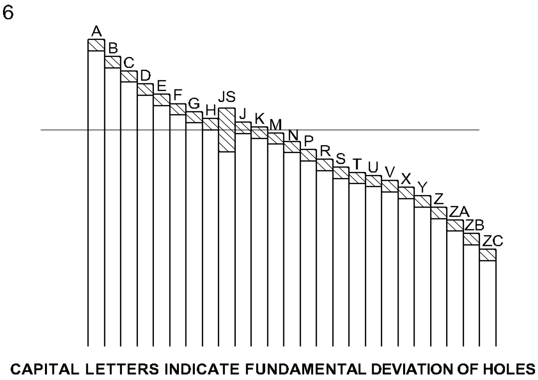

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Fig 7

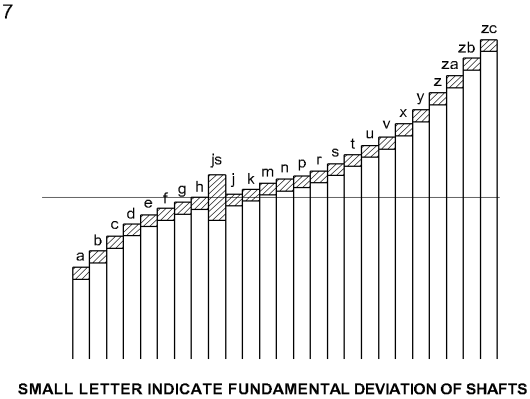

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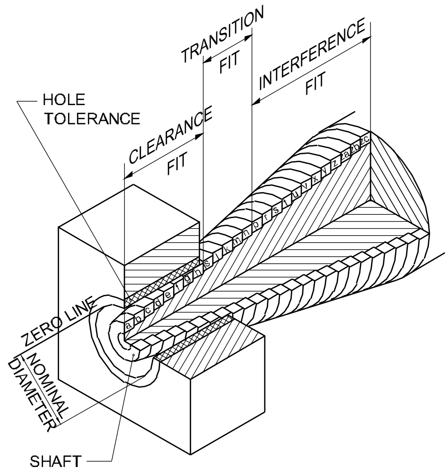
Fig 8



HOLE BASIS SYSTEM

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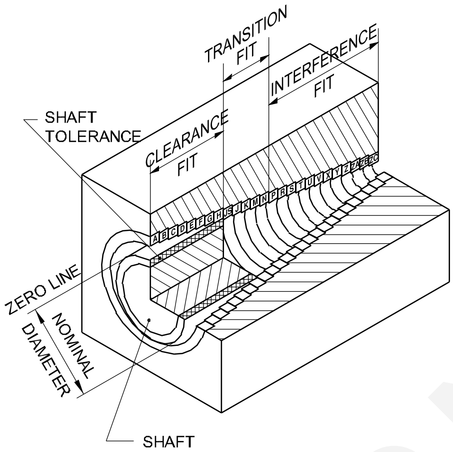
Fig 9



SHAFT BASIS SYSTEM

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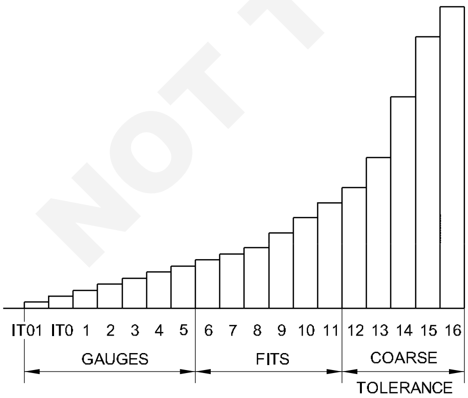
Fundamental tolerance

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

Fig 10



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The grade of tolerance refers to the accuracy of manufacture.

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

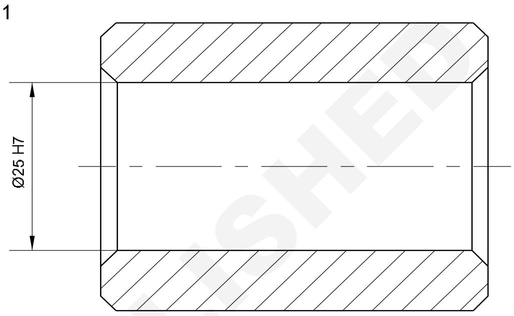
Toleranced size

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

Example

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

Fig 11



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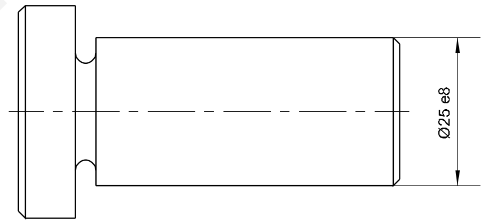
25 e8 - is the toleranced size of a shaft whose basic size is 25. The fundamental deviation is represented by the letter symbol e and the grade of tolerance is represented by the number 8. (Fig 12)

Fig 12



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

Example

In figure 13, a hole is shown as 25 ± 0.2 which means that 25 mm is the basic dimension and ± 0.2 is the deviation.

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

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

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

25 + 0.2 = 25.2 mm

or 25 - 0.2 = 24.8 mm.

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

24.8 mm is known as the minimum limit. (Fig 15)

Fig 13

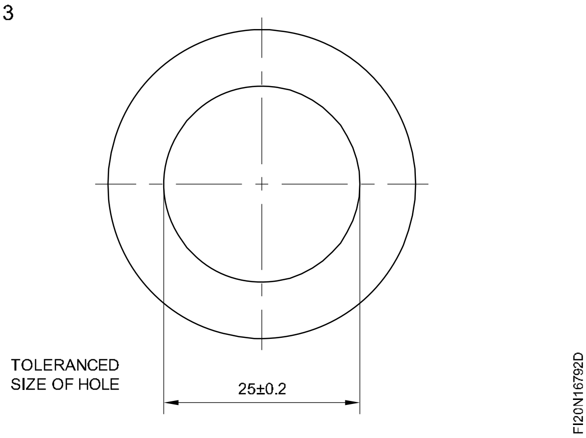
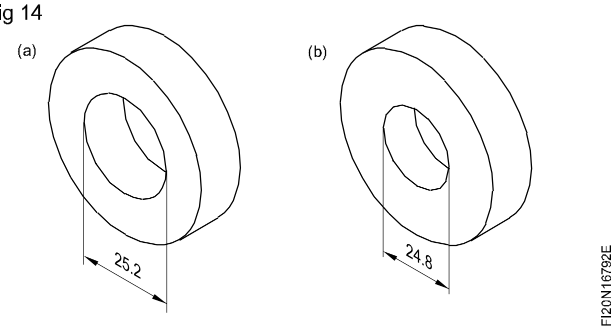
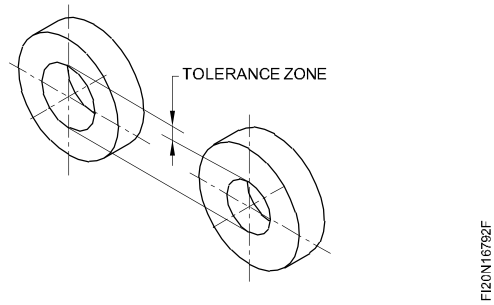


Fig 14



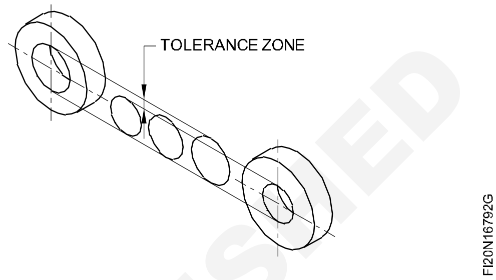
The difference between the maximum and minimum limits is the TOLERANCE. Tolerance here is 0.4 mm. (Fig 16)

Fig 15



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

Fig 16



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

Fits and their classification as per the Indian Standard

Objectives: At the end of this lesson you shall be able to
- **define 'Fit' as per the Indian Standard**
- **list out the terms used in limits and fits as per the Indian Standard**
- **state examples for each class of fit**
- **interpret the graphical representation of different classes of fits.**

Fit

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

Expression of a fit

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

Example

30 H7/g6 or 30 H7 - g6 or 30 $\frac{H7}{g6}$

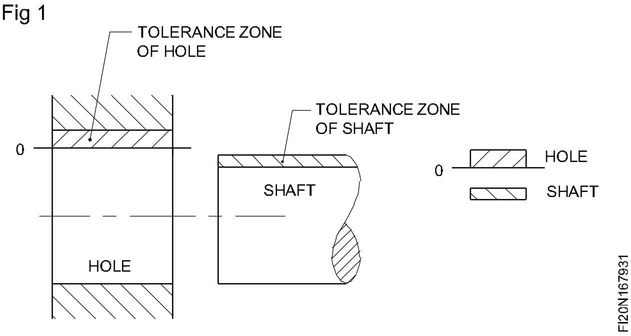
Clearance

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

Clearance fit

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

Fig 1



Example 20 H7/g6

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

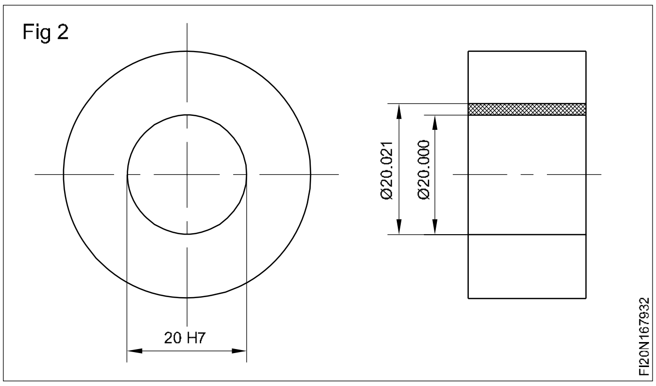
For a hole 20 H7 we find in the table + 21.

These numbers indicate the deviations in microns.

(1 micrometre = 0.001 mm)

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

Fig 2



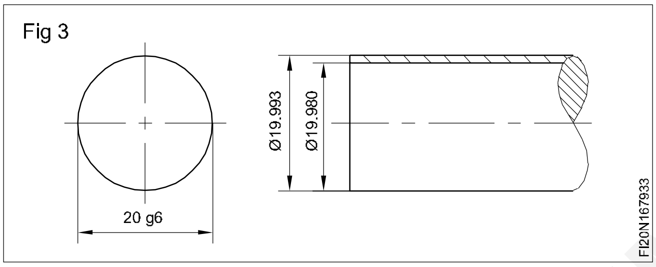
For a shaft 20 g6 we find in the table – 7
– 20.

So the limits of the shaft are

20 – 0.007 =19.993 mm

and 20 – 0.020 =19.980mm.(Fig .3)

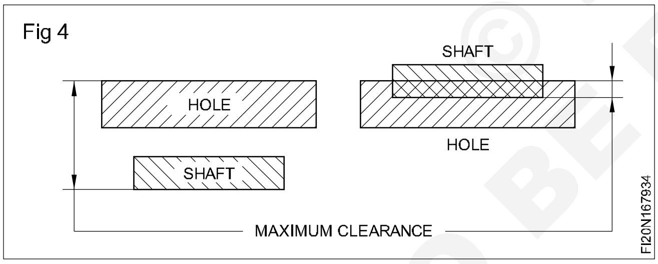
Fig 3



Maximum clearance

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

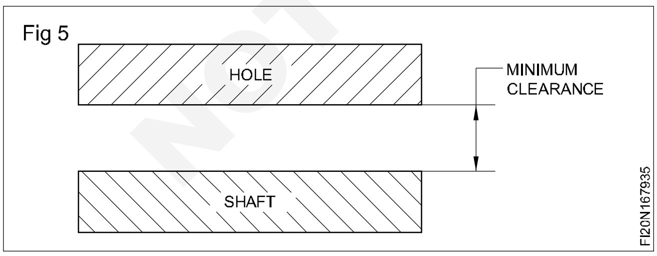
Fig 4



Minimum Clearance

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

Fig 5



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

The maximum clearance is 20.021 - 19.980 = 0.041 mm. (Fig 7)

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

Fig 6

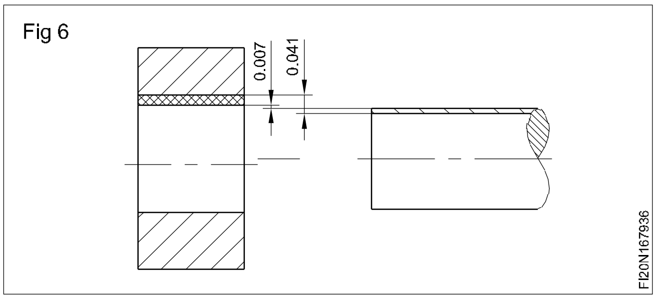
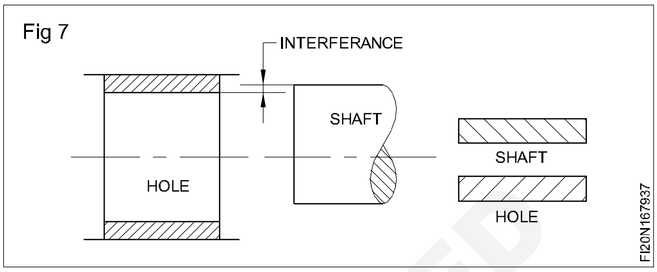


Fig 7



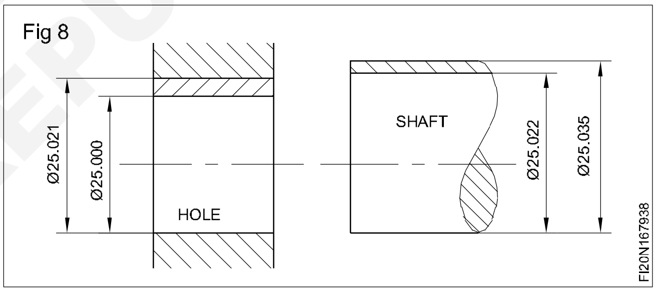
Interference

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

Interference Fit

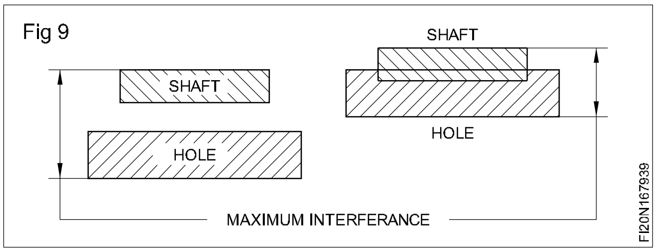
It is a fit which always provides interference. Here the tolerance zone of the hole will be below the tolerance zone of the shaft. (Fig 8)

Fig 8



Example: Fit 25 H7/p6 (Fig 9)

Fig 9



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

Maximum interference

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

Minimum interference

In an interference fit, it is the algebraic difference between the maximum hole and the minimum shaft. (Fig 11)

Fig 10

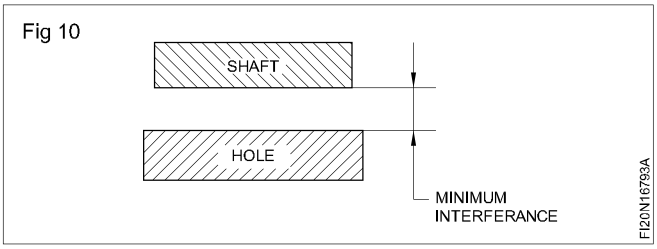
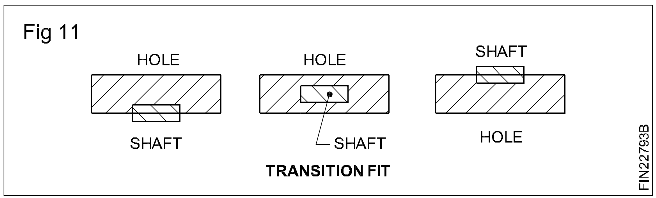


Fig 11



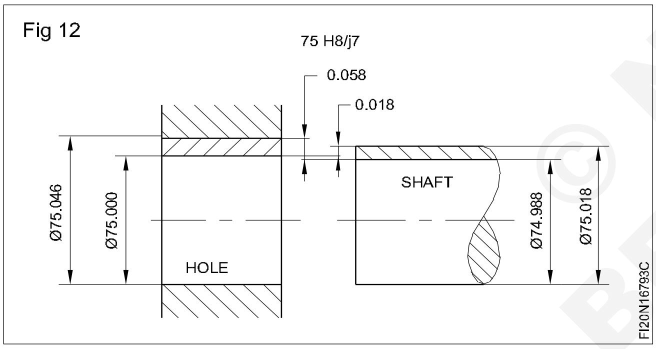
In the example shown in figure 9

The maximum interference is	= 25.035 – 25.000
	= **0.035**
The minimum interference is	= 25.022 – 25.021
	= 0.001

Transition fit

It is a fit which may sometimes provide clearance, and sometimes interference. When this class of fit is represented graphically, the tolerance zones of the hole and shaft will overlap each other. (Fig 12)

Fig 12

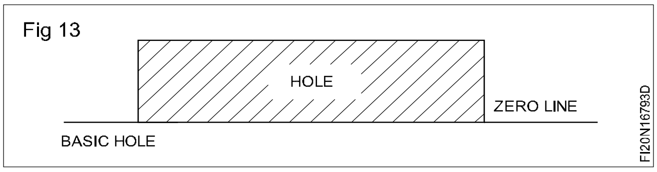


Example Fit 75 H8/j7 (Fig 13)

The limits of the hole are 75.000 and 75.046 mm and those of the shaft are 75.018 and 74.988 mm.

Maximum Clearance = 75.046 - 74.988 = 0.058 mm.

Fig 13



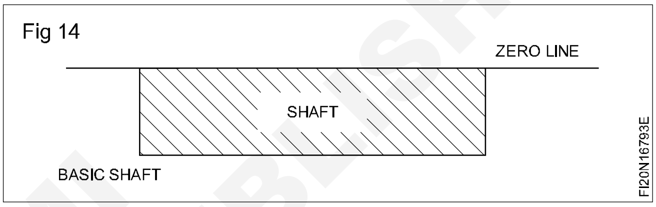
If the hole is 75.000 and the shaft 75.018 mm, the shaft is 0.018 mm, bigger than the hole. This results in interference. This is a transition fit because it can result in a clearance fit or an interference fit.

Hole basis system

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

The fundamental deviation symbol `H' is chosen for the holes, when the hole basis system is followed. This is because the lower deviation of the hole `H' is zero. It is known as `basic hole'. (Fig 14)

Fig 14



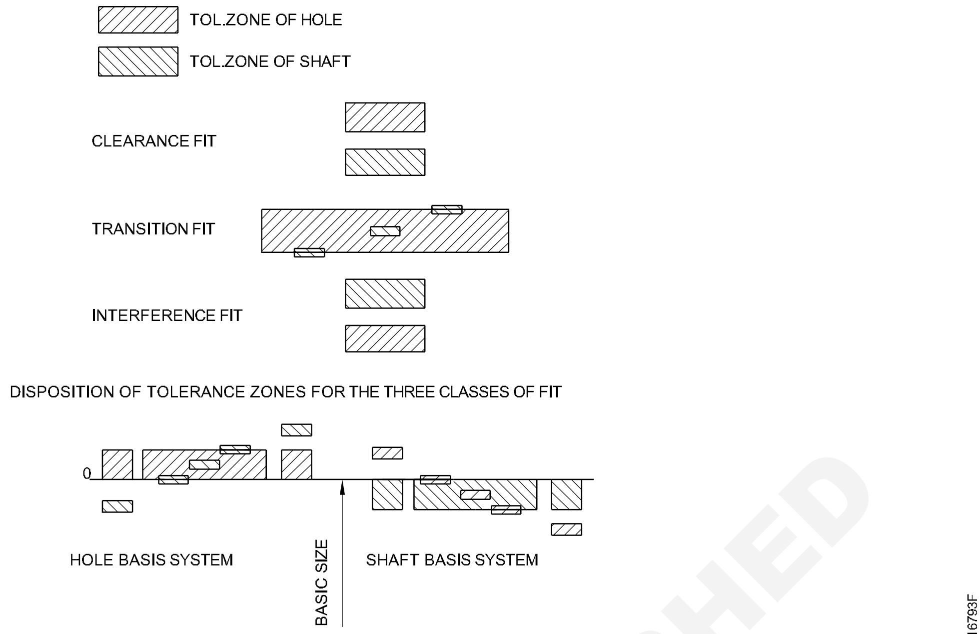
Shaft basis system

In a standard system of limits and fits, where the size of the shaft is kept constant and the variations are given to the hole for obtaining different class of fits, then it is known as shaft basis. The fundamental deviation symbol `h' is chosen for the shaft when the shaft basis is followed. This is because the upper deviation of the shaft `h' is zero. It is known as `basic shaft'. (Fig 15)

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

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

Fig 15



EXAMPLES ILLUSTRATING THE HOLE BASIS AND SHAFT BASIS SYSTEM

The BIS system of limits and fits- reading the standard chart

Objective: At the end of this lesson you shall be able to
- **refer to the standard limit system chart and determine the limits of sizes.**

The standard chart covers sizes upto 500 mm (I.S. 919 of 1963) for both holes and shafts. It specifies the upper and lower deviations for a certain range of sizes for all combinations of the 25 fundamental deviations, and 18 fundamental tolerances.

The upper deviation of the hole is denoted as ES and the lower deviation of the hole is denoted as E I. The upper deviation of the shaft is denoted as **es** and the lower deviation of the shaft is denoted as **ei.**

"ES is expanded as ECART SUPERIEUR and "EI" as ECART INFERIEUR.

Determining the limits from the chart

Note whether it is an internal measurement or an external measurement.

Note the basic size.

Note the combination of the fundamental deviation and the grade of tolerance.

Then refer to the chart and note the upper and lower deviations which are given in microns, with the sign. Accordingly add or subtract from the basic size and determine the limits of size of the components.

Example

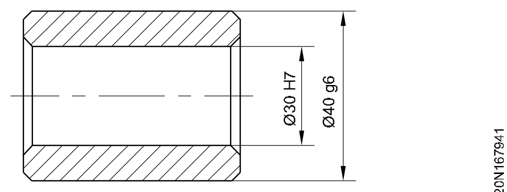
30 H7 (Fig 1)

It is an internal measurement. So we must refer to the chart for 'holes'.

The basic size is 30 mm. So see the range 30 to 40.

Look for ES, and EI values in microns for H7 combination

Fig 1



for 30 mm basic size.

It is given as

Therefore, the maximum limit of the hole is 30 + 0.025 = 30.025mm.

The minimum limit of the hole is 30 + 0.000 = 30.000mm.

Refer to the chart and note the values of 40 g6.

The table for tolerance zones and limits as per IS 2709 is attached.

British standard limits and fits BS 4500: 1969

International Tolerance Grades (IT)

The specific tolerance for a particular IT grade is calculated via the following formula:

$$T = 10^{0.2 \times (ITG - 1)} \cdot (0.45 \times \sqrt[3]{D} + 0.001 \times D)$$

T is the tolerance in micrometres [μ m]

D is the geometric mean dimension in millimeters [mm]

ITG is the IT Grade, a positive integer.

NOMINAL (BASIC) SIZES (INCHES)		INTERNATIONAL TOLERANCE GRADES OVER UP TO INCL.									
OVER	UP TO INCL	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13
0	0.12	0.12	0.15	0.25	0.4	0.6	1.0	1.6	2.5	4	6
0.12	0.24	0.15	0.20	0.3	0.5	0.7	1.2	1.8	3.0	5	7
0.24	0.40	0.15	0.25	0.4	0.6	0.9	1.4	2.2	3.5	6	9
0.40	0.71	0.2	0.3	0.4	0.7	1.0	1.6	2.8	4.0	7	10
0.71	1.19	0.25	0.4	0.5	0.8	1.2	2.0	3.5	5.0	8	12
1.19	1.97	0.3	0.4	0.6	1.0	1.6	2.5	4.0	6	10	16
1.97	3.15	0.3	0.5	0.7	1.2	1.8	3.0	4.5	7	12	18
3.15	4.73	0.4	0.6	0.9	1.4	2.2	3.5	5	9	14	22
4.73	7.09	0.5	0.7	1.0	1.6	2.5	4.0	6	10	16	25
7.09	9.85	0.6	0.8	1.2	1.8	2.8	4.5	7	12	18	28
9.85	12.41	0.6	0.9	1.2	2.0	3.0	5.0	8	12	20	30
12.41	15.75	0.7	1.0	1.4	2.2	3.5	6	9	14	22	35
15.75	19.69	0.8	1.0	1.63	2.5	4	6	10	16	25	40
19.69	30.09	0.9	1.2	2.0	3	5	8	12	20	30	50
30.09	41.49	1.0	1.6	2.5	4	6	10	16	25	40	60
41.49	56.19	1.2	2.0	3	5	8	12	20	30	50	80
56.19	76.39	1.6	2.5	4	6	10	16	25	40	60	100
76.39	100.9	2.0	3	5	8	12	20	30	50	80	125
100.9	131.9	2.5	4	6	10	16	25	40	60	100	160
131.9	171.9	3	5	8	12	20	30	50	80	125	200
171.9	200	4	6	10	16	25	40	60	100	160	250

Tolerances in Thousandths of an Inch (0.001)

Table 1 for Tolerance Zones & Limits (Dimensions in μm)

NOMINAL SIZE RANGE mm	s6	r6	p6	n6	k6	js6	h6	h7	h9	h11	g6	f7	e8	d9	c11	b11	a11	S7	R7	P7	N7	K7	JS7	H7	H8	H9	H11	G7	F8	E9	D10	C11	B11	A11
From 1 up to 3	+20 +14	+16 +10	+12 +6	+10 +4	+6 0	+3 −3	0 −6	0 −10	0 −25	0 −60	−2 −8	−6 −16	−14 −28	−20 −45	−60 −120	−140 −200	−270 −330	−14 −24	−10 −20	−6 −16	−4 −14	0 −10	+5 −5	+10 0	+14 0	+25 0	+60 0	+12 +2	+20 +6	+39 +14	+60 +20	+120 +60	+200 +140	+330 +270
Over 3 up to 6	+27 +19	+23 +15	+20 +12	+16 +8	+9 +1	+4 −4	0 −8	0 −12	0 −30	0 −75	−4 −12	−10 −22	−20 −38	−30 −60	−70 −145	−140 −215	−270 −345	−15 −27	−11 −23	−8 −20	−4 −16	+3 −9	+6 −6	+12 0	+18 0	+30 0	+75 0	+16 +4	+28 +10	+50 +20	+78 +30	+145 +70	+215 +140	+345 +270
Over 6 up to 10	+32 +23	+28 +19	+24 +15	+19 +10	+10 +1	+4.5 −4.5	0 −9	0 −15	0 −36	0 −90	−5 −14	−13 −28	−25 −47	−40 −76	−80 −170	−150 −240	−280 −370	−17 −32	−13 −28	−9 −24	−4 −19	+5 −10	+7.5 −7.5	+15 0	+22 0	+36 0	+90 0	+20 +5	+35 +13	+61 +25	+98 +40	+170 +80	+240 +150	+370 +280
Over 10 up to 14	+39	+34	+29	+23	+12	+5.5	0	0	0	0	−6	−16	−32	−50	−95	−150	−290	−21	−16	−11	−5	+6	+9	+18	+27	+43	+110	+24	+43	+75	+120	+205	+260	+400
Over 14 up to 18	+28	+23	+18	+12	+1	−5.5	−11	−18	−43	−110	−17	−34	−59	−93	−205	−260	−400	−39	−34	−29	−23	−12	−9	0	0	0	0	+6	+16	+32	+50	+95	+150	+290
Over 18 up to 24	+48	+41	+35	+28	+15	+6.5	0	0	0	0	−7	−20	−40	−65	−110	−160	−300	−27	−20	−14	−7	+6	+10.5	+21	+33	+52	+130	+28	+53	+92	+149	+240	+290	+430
Over 24 up to 30	+35	+28	+22	+15	+2	−6.5	−13	−21	−52	−130	−20	−41	−73	−117	−240	−290	−430	−48	−41	−35	−28	−15	−10.5	0	0	0	0	+7	+20	+40	+65	+110	+160	+300
Over 30 up to 40	+59	+50	+42	+33	+18	+8	0	0	0	0	−9	−25	−50	−80	−120 −280	−170 −330	−310 −470	−34	−25	−17	−8	+7	+12.5	+25	+39	+62	+160	+34	+64	+112	+180	+280 +120	+330 +170	+470 +310
Over 40 up to 50	+43	+34	+26	+17	+2	−8	−16	−25	−62	−160	−25	−50	−89	−142	−130 −290	−180 −340	−320 −480	−59	−50	−42	−33	−18	−12.5	0	0	0	0	+9	+25	+50	+80	+290 +130	+340 +180	+480 +320
Over 50 up to 65	+72 +53	+60 +41	+51	+39	+21	+9.5	0	0	0	0	−10	−30	−60	−100	−140 −330	−190 −380	−340 −530	−42 −72	−30 −60	−21	−9	+9	+15	+30	+46	+74	+190	+40	+76	+134	+220	+330 +140	+380 +190	+530 +340
Over 65 up to 80	+78 +59	+62 +43	+32	+20	+2	−9.5	−19	−30	−74	−190	−29	−60	−106	−174	−150 −340	−200 −390	−360 −550	−48 −78	−32 −62	−51	−39	−21	−15	0	0	0	0	+10	+30	+60	+100	+340 +150	+390 +200	+550 +360
Over 80 up to 100	+93 +71	+73 +51	+59	+45	+25	+11	0	0	0	0	−12	−36	−72	−120	−170 −390	−220 −440	−380 −600	−58 −93	−38 −73	−24	−10	+10	+17.5	+35	+54	+87	+220	+47	+90	+159	+260	+390 +170	+440 +220	+600 +380
Over 100 up to 120	+101 +79	+76 +54	+37	+23	+3	−11	−22	−35	−87	−220	−34	−71	−126	−207	−180 −400	−240 −460	−410 −630	−66 −101	−41 −76	−59	−45	−25	−17.5	0	0	0	0	+12	+36	+72	+120	+400 +180	+460 +240	+630 +410
Over 120 up to 140	+117 +92	+88 +63													−200 −450	−260 −510	−460 −710	−77 −117	−48 −88													+450 +200	+510 +260	+710 +460
Over 140 up to 160	+125 +100	+90 +65	+68 +43	+52 +27	+28 +3	+12.5 −12.5	0 −25	0 −40	0 −100	0 −250	−14 −39	−43 −83	−85 −148	−145 −245	−210 −460	−280 −530	−520 −770	−85 −125	−50 −90	−28 −68	−12 −52	+12 −28	+20 −20	+40 0	+63 0	+100 0	+250 0	+54 +14	+106 +43	+185 +85	+305 +145	+460 +210	+530 +280	+770 +520
Over 160 up to 180	+133 +108	+93 +68													−230 −480	−310 −560	−580 −830	−93 −133	−53 −93													+480 +230	+560 +310	+830 +580
Over 180 up to 200	+151 +122	+106 +77													−240 −530	−340 −630	−660 −950	−105 −151	−60 −106													+530 +240	+630 +340	+950 +660
Over 200 up to 225	+159 +130	+109 +80	+79 +50	+60 +31	+33 +4	+14.5 −14.5	0 −29	0 −46	0 −115	0 −290	−15 −44	−50 −96	−100 −172	−170 −285	−260 −550	−380 −670	−740 −1030	−113 −159	−63 −109	−33 −79	−14 −60	+13 −33	+23 −23	+46 0	+72 0	+115 0	+290 0	+61 +15	+122 +50	+215 +100	+355 +170	+550 +260	+670 +380	+1030 +740
Over 225 up to 250	+169 +140	+113 +84													−280 −570	−420 −710	−820 −1110	−123 −169	−67 −113													+570 +280	+710 +420	+1110 +820
Over 250 up to 280	+190 +158	+126 +94	+88	+66	+36	+16	0	0	0	0	−17	−56	−110	−190	−300 −620	−480 −800	−920 −1240	−138 −190	−74 −126	−36	−14	+16	+26	+52	+81	+130	+320	+69	+137	+240	+400	+620 +300	+800 +480	+1240 +920
Over 280 up to 315	+202 +170	+130 +98	+56	+34	+4	−16	−32	−52	−130	−320	−49	−108	−191	−320	−330 −650	−540 −860	−1050 −1370	−150 −202	−78 −130	−88	−66	−36	−26	0	0	0	0	+17	+56	+110	+190	+650 +330	+860 +540	+1370 +1050
Over 315 up to 355	+226 +190	+144 +108	+98	+73	+40	+18	0	0	0	0	−18	−62	−125	−210	−360 −720	−600 −960	−1200 −1560	−169 −226	−87 −144	−41	−16	+17	+28.5	+57	+89	+140	+360	+75	+151	+265	+440	+720 +360	+960 +600	+1500 +1200
Over 355 up to 400	+244 +208	+150 +114	+62	+37	+4	−18	−36	−57	−140	−360	−54	−119	−214	−350	−400 −760	−680 −1040	−1350 −1710	−187 −244	−93 −150	−98	−73	−40	−28.5	0	0	0	0	+18	+62	+125	+210	+760 +400	+1040 +680	+1710 +1350
Over 400 up to 450	+272 +232	+166 +126	+108	+80	+45	+20	0	0	0	0	−20	−68	−135	−230	−440 −840	−760 −1160	−1500 −1900	−209 −272	−103 −166	−45	−17	+18	+31.5	+63	+97	+155	+400	+83	+165	+290	+480	+840 +440	+1160 +760	+1900 +1500
Over 450 up to 500	+292 +252	+172 +132	+68	+40	+5	−20	−40	−63	−155	−400	−60	−131	−232	−385	−480 −880	−840 −1240	−1650 −2050	−229 −292	−109 −172	−108	−80	−45	−31.5	0	0	0	0	+20	+68	+135	+230	+880 +480	+1240 +840	+2050 +1650

Metals

Objectives: At the end of this lesson you shall be able to
- **name the commonly used ferrous metals and raw material used for producing pig iron**
- **describe the properties of pig iron and its deriving process**
- **explain the types and properties of cast iron, wrought iron and uses**
- **explain the alloys of copper, aluminium, tin lead, zinc**
- **state this properties and uses.**

Metals which contain iron as a major content are called ferrous metals. Ferrous metals of different properties are used for various purposes.

The ferrous metals and alloys used commonly are:

- Pig-iron
- Cast iron
- Wrought iron
- Steels and alloy steels.

Different processes are used to produce iron and steel.

Pig-iron is obtained by the chemical reduction of iron ore. This process of reduction of the iron ore to pig-iron is known as SMELTING.

The main raw materials required for producing pig-iron are:

- Iron ore
- Coke
- Flux.

Iron ore

The types of iron ores

- Magnetite
- Hematite
- Limonite
- Carbonate.

These ores contain iron in different proportions and are 'naturally' available.

Coke

Coke is the fuel used to give the necessary heat to carry on the reducing action. The carbon from the coke in the form of carbon monoxide combines with the iron ore to reduce it to iron.

Flux

This is the mineral substance charged into a blast furnace to lower the melting point of the ore, and it combines with the non-metallic portion of the ore to form a molten slag.

Limestone is the most commonly used flux in the blast furnace.

Blast furnace (Fig 1)

The furnace used for smelting iron ore is the blast furnace. The product obtained from smelting in the blast furnace is pig-iron. The main parts of the blast furnace are:

- Throat
- Stack
- Bosh
- Hearth
- Double bell charging mechanism
- Tuyeres.

Smelting in a blast furnace

The raw materials are charged in alternate layers of iron ore, coke and flux in the furnace by means of a double bell mechanism. (Figs 1 & 2)

Fig 1

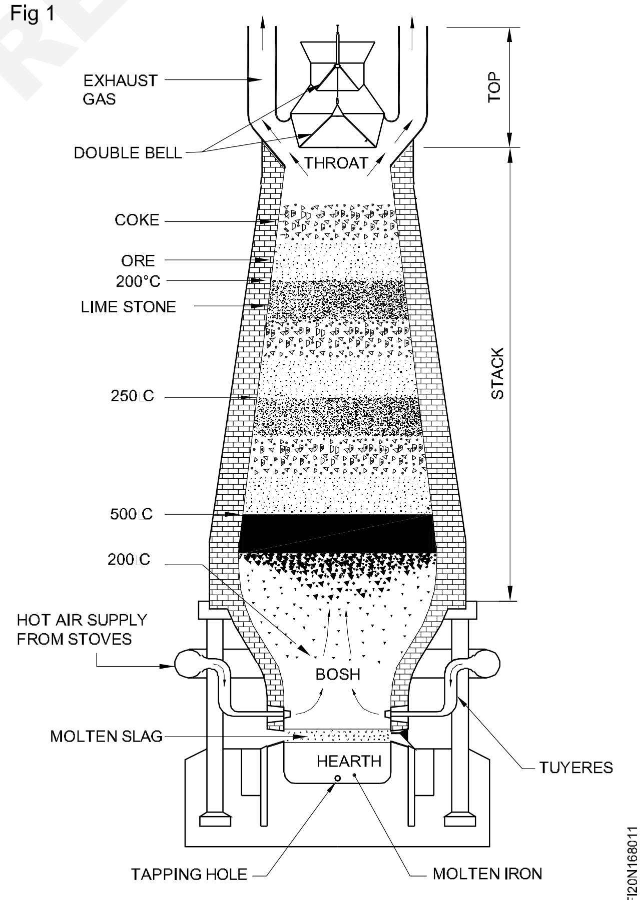
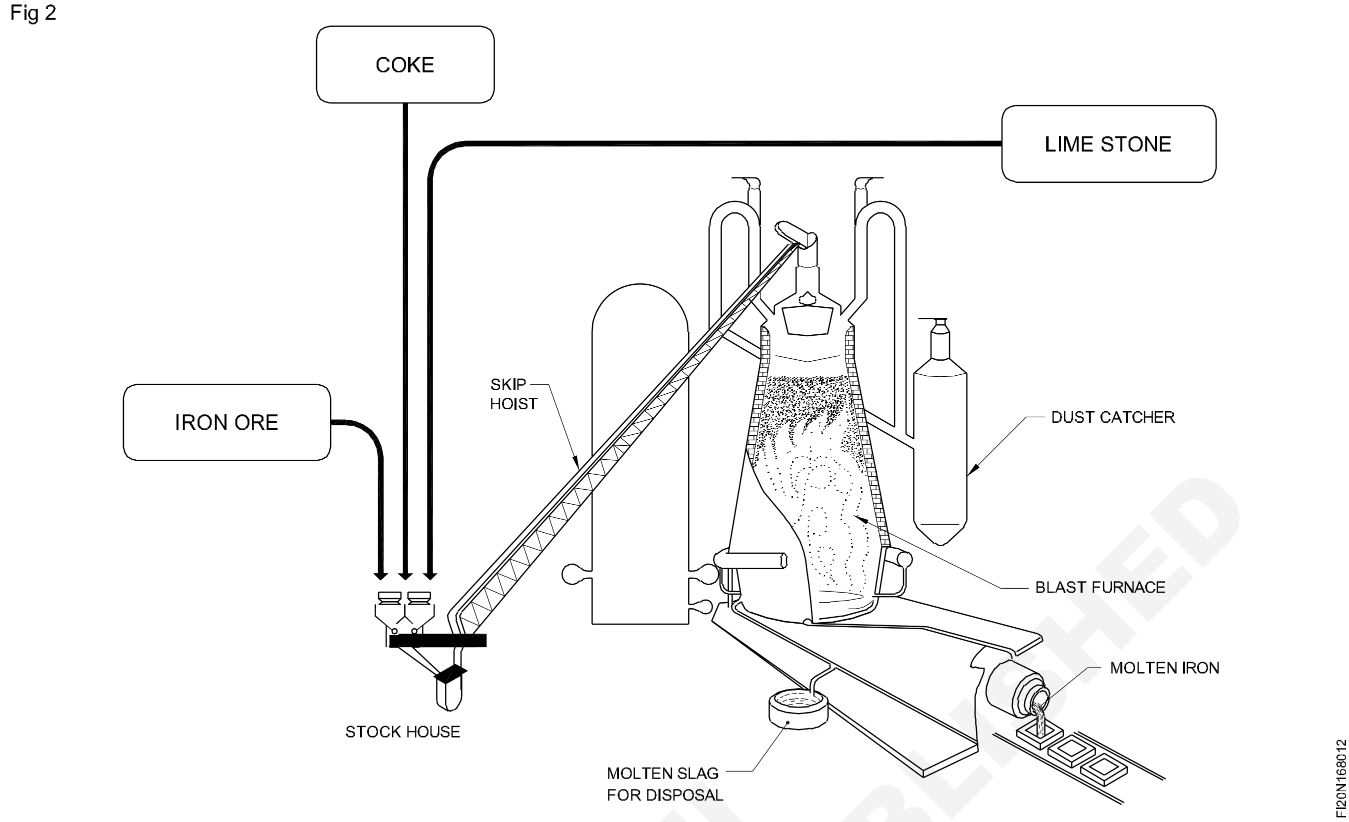


Fig 2



The hot blast is forced into the furnace through a number of nozzles (Fig1) called tuyeres.

The temperature of the furnace just above the level of the tuyeres (melting zone) is between 1000° C to 1700° C when all the substances start melting.

The limestone, which serves as a flux, combines with the non-metalic substances in the ore to form a molten slag which floats on the top of the molten iron. The slag is tapped off through the slag hole.

The molten iron is tapped at intervals through a separate tapping hole.

The molten iron may be cast in pig beds or used in other processing plants for steel making.

Properties and use of pig-iron: Pig-iron absorbs varying amounts of carbon, silicon, sulphur, phosphorus and manganese during the smelting process. A high amount of carbon makes the pig-iron very hard and brittle, and unsuitable for making any useful article.

Pig-iron is, therefore, refined and remeitted and used to produce other varieties of iron and steel.

Cast iron (types): Cast iron is an alloy of iron, carbon and silicon. The carbon content ranges from 2 to 4%.

Types of cast iron

The following are the types of cast iron.

- Grey cast iron
- White cast iron
- Malleable cast iron
- Nodular cast iron

Grey cast iron

This is widely used for the casting of machinery parts and can be machined easily.

Machine bases, tables, slide ways are made of cast iron because it is dimensionally stable after a period of aging.

Because of its graphite content, cast iron provides an excellent bearing and sliding surface.

The melting point is lower than that of steel and as grey cast iron possesses good fluidity, intricate casting can be made.

Grey cast iron is widely used for machine tools because of its ability to reduce vibration and minimize tool chatter.

Grey cast iron, when not alloyed, is quite brittle and has relatively low tensile strength. Due to this reason it is not used for making components subjected to high stress or impact loads.

Grey cast iron is often alloyed with nickel, chromium, vanadium or copper to make it tough.

Grey cast iron is weldable but the base metal needs pre-heating.

White cast iron: This is very hard and is very difficult to machine, and for this reason, it is used in components which should be abrasion-resistant.

White cast iron is produced by lowering the silicon content and by rapid cooling. When cooled in this manner, it is called chilled cast iron.

White cast iron cannot be welded.

Malleable cast iron: Malleable cast iron has increased ductility, tensile strength and toughness when compared with grey cast iron.

Malleable cast iron is produced from white cast iron by a prolonged heat-treatment process lasting for about 30 hours.

Nodular cast iron: This is very similar to malleable cast iron. But this is produced without any heat treatment. Nodular cast iron is also known as:

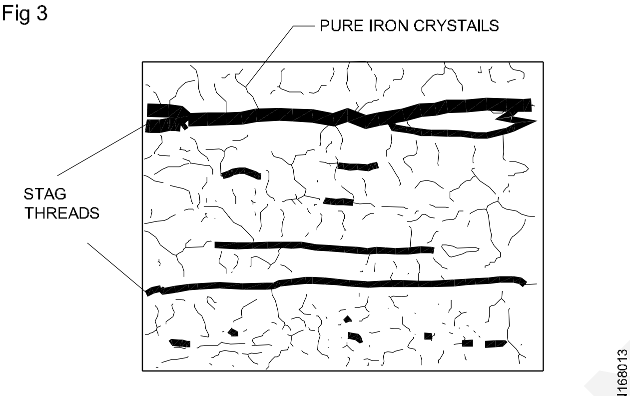
Nodular iron - ductile iron - spheroidal graphite iron

This has good machinability, castability, resistance to wear, low melting point and hardness.

Malleable and nodular castings are used for machine parts where there is a higher tensile stress and moderate impact loading. These castings are less expensive and are an alternative to steel casting.

Wrought iron and plain carbon steels: Wrought iron is the purest form of iron. The analysis of wrought iron shows as much as 99.9% of iron. (Fig 3)

Fig 3



MICROSTRUCTURE OF WROUGHT IRON

When heated, wrought iron does not melt, but only becomes pasty and in this form it can be forged to any shape.

Modern methods used to produce wrought iron in large quantities are the:

- Puddling process
- Aston or Byers process.

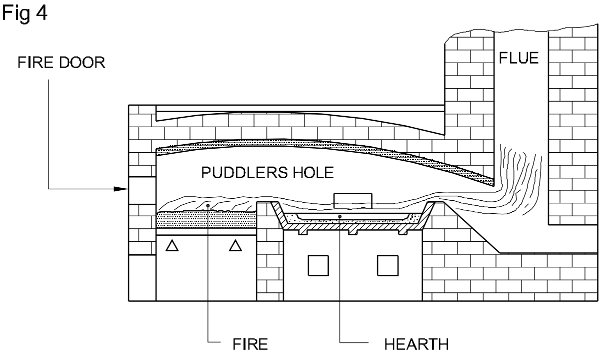
Puddling process

Wrought iron is manufactured by refining pig-iron.

By refining pig-iron silicon is removed completely, a greater amount of phosphorus is removed, and graphite is converted to combined carbon.

The above process is carried out in a puddling furnace.

Fig 4



Puddling furnace

This furnace is a coal-fired reverberator furnace. (Fig 4)

The term reverberator is applied because the charge is not in actual contact with the fire, but receives its heat by reflection from the dome shaped furnace roof.

The product obtained is taken out from the furnace in the form of balls (or blooms) having a mass of about 50 kgs.

The hot metal is then passed through grooved rollers which convert blooms into bars called Muck bars or Puddle bars.

These bars are cut into short lengths, fastened together in piles, reheated to welding temperatures and again rolled into bars.

Aston process: In this process molten pig-iron and steel scrap are refined in a Bessemer converter.

The refined molten metal is poured into an open hearth furnace in the iron silicate stage. This removes most of the carbon.

The slag cools the molten metal to a pasty mass which is later squeezed in a hydraulic press to remove most of the slag. Rectangular blocks known as blooms are formed from this mass.

The hot bloom is immediately passed through rolling mills to produce products of wrought iron of different shapes and sizes.

COMPOSITION OF WROUGHT IRON

Carbon	-	0.02 to 0.03%
Silicon	-	0.1 to 0.2%
Manganese	-	0.02 to 0.1%
Sulphur	-	0.02 to 0.04%
Phosphorous	-	0.05 to 0.2%
Iron forms of the rest of the content.		

Properties and uses of Wrought Iron

Properties	Uses
Malleable and ductile. It can neither be hardened nor tempered.	Architectural works.
Tough, shock-resistant fibrous structure; easy for forge welding. Ultimate tensile strength of about 350 newtons per sq. mm.	Crane hooks, chain links, bolts and nuts & railway couplings.
No effect in salt water.	Marine works.
Will not retain the magnetism.	Temporary magnets. Core of dynamos.
Corrosion resistant.	Agricultural equipment.
Easy to forge - wide temperature range 850°C to 1350°C.	Pipes, flanges etc.

Steel (plain carbon steel)

Steel is fundamentally an alloy of iron and carbon, with the carbon content varying up to 1.5%. The carbon present is in a combined state.

Plain carbon steels are classified according to their carbon content.

Classification and content of Plain Carbon Steel is given in Table 1.

Table 1
Classification and content of Plain Carbon Steel

Name of the plain carbon steel	Percentage of Carbon	Properties and uses
Dead mild	0.1 to 0.125 %	Highly ductile. Used for making wire steel rods, thin sheets & solid drawn tubes.
Mild steel	0.15 to 0.3%	Relatively soft and ductile. Used for general workshop purposes, boiler plates, bridge work, structural sections and drop forgings.
Medium carbon	0.3 to 0.5%	Used for making axles, drop forgings, high tensile tubes, wires and agricultural tools.
- do -	0.5 to 0.7%	Harder, tougher and less ductile. Used for making springs, locomotive tyres, large forging dies, wire ropes, hammers and snaps for riveters.
High carbon steel	0.7 to 0.9%	Harder,less ductile and slightly less tough. Used for making springs, small forging dies, shear blades and wood chisels.
- do -	0.9 to 1.1%	Used for making cold chisels, press dies, punches, wood-working tools, axes,etc.
- do -	1.1% to 1.4%	Used for making hand files, drills, gauges, metal-cutting tools & razors.

Non-ferrous metals - copper: Metals without iron are called non-ferrous metals. Eg. Copper, Aluminium, Zinc, Lead and Tin.

Copper: This is extracted from its ores 'MALACHITE' which contains about 55% copper and 'PYRITES' which contains about 32% copper.

Properties: Reddish in colour. Copper is easily distinguishable because of its colour.

The structure when fractured is granular, but when forged or rolled it is fibrous.

It is very malleable and ductile and can be made into sheets or wires.

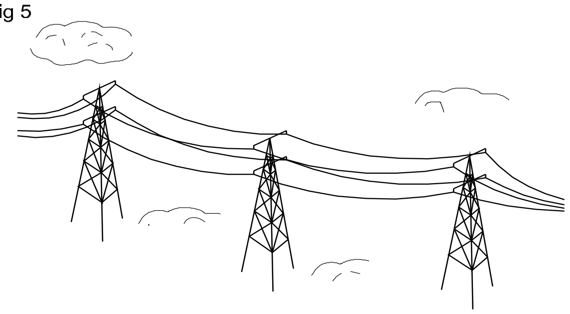
It is a conductor of electricity. Copper is extensively used as electrical cables and parts of electrical apparatus which conduct electric current. (Fig 5)

Copper is a good conductor of heat and also highly resistant to corrosion. For this reason it is used for boiler fire boxes, water heating apparatus, water pipes and vessels in brewery and chemical plants. Also used for making soldering iron.

The melting temperature of copper is 1083^o C.

The tensile strength of copper can be increased by hammering or rolling. (Fig 6)

Fig 5



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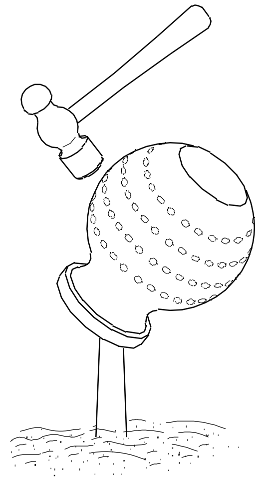
Copper alloys

Brass

It is an alloy of copper and zinc. For certain types of brass small quantities of tin or lead are added. The colour of brass depends on the percentage of the alloying elements. The colour is yellow or light yellow, or nearly white. It can be easily machined. Brass is also corrosion-resistant.

Brass is widely used for making motor car radiator core and water taps etc. It is also used in gas welding for hard soldering/brazing. The melting point of brass ranges from

Fig 6



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880 to 930^{o}C.

Brasses of different composition are made for various applications. The following Table-2 gives the commonly used brass alloy compositions and their application.

Bronze

Bronze is basically an alloy of copper and tin. Sometimes zinc is also added for achieving certain special properties. Its colour ranges from red to yellow. The melting point of bronze is about 1005^{o}C. It is harder than brass. It can be easily machined with sharp tools. The chip produced is granular. Special bronze alloys are used as brazing rods. Bronze of different compositions are available for various applications. Table-3 gives the type compositions and applications of different bronzes.

Table 2 - Composition of different types of Brass

Name	Composition (%)			Applications
	Copper	Zinc	Other elements	
Cartridge brass	70	30	-	Most ductile of the copper/zinc alloys. Widely used in sheet metal pressing for severe deep drawing operations. Originally developed for making cartridge cases, hence its name.
Standard brass	65	35	-	Cheaper than cartridge brass and less ductile. Suitable for most engineering processes.
Basic brass	63	37	-	The cheapest of the cold working brasses. It lacks ductility and is only capable of withstanding simple forming operations.
Muntz metal	60	40	-	Not suitable for cold working, but suitable for hot-working. Relatively cheap due to its high zinc content. It is widely used for extrusion and hot-stamping processes.
Free-cutting brass	58	39	3% lead	Not suitable for cold working but excellent for hot working and high speed machining of low strength components.
Admirality brass	70	29	1% tin	This is virtually cartridge brass plus a little tin to prevent corrosion in the presence of salt water.
Naval brass	62	37	1% tin	This is virtually Muntz metal plus a little tin to prevent corrosion in the presence of salt water.
Gilding metal	95	5	-	Used for jewellery.

Table 3 - Composition of different types of bronze

Name	Composition (%)				Applications
	Copper	Zinc	Phosphorus	Tin	
Low tin bronze	96	-	0.1 to 0.25	3.9 to 3.75	This alloy can be severely cold-worked to harden it so that it can be used for springs where good elastic properties must be combined with corrosion resistance,fatigue-resistance and electrical conductivity. Eg.Contact blades
Drawn phosphor/ bronze	94	-	0.1 to 0.5	5.9 to 5.5	This alloy is used for turned components requiring strength and corrosion resistance, such as valve spindles.
Cast phosphor/ bronze	89.75 to 89.97		0.03 to 0.25	10	Usually cast into rods and tubes for making bearing bushes and worm wheels. It has excellent anti-friction properties.
Admirality gun-metal	88	2	-	10	This alloy is suitable for sand casting where fine-grained, pressure-tight components such as pump and valve bodies are required.
Leaded gun-metal (free cutting)	85	5 (5%lead)	-	5	Also known as 'red brass' this alloy is used for the same purposes as standard, admiralty gun-metal. It is rather less strong but has improved toughness and machining properties.
Leaded (plastic) bronze	74	(24%lead)	-	2	This alloy is used for lightly loaded bearings where alignment is difficult. Due to its softness, bearings made from this alloy "bed in" easily.

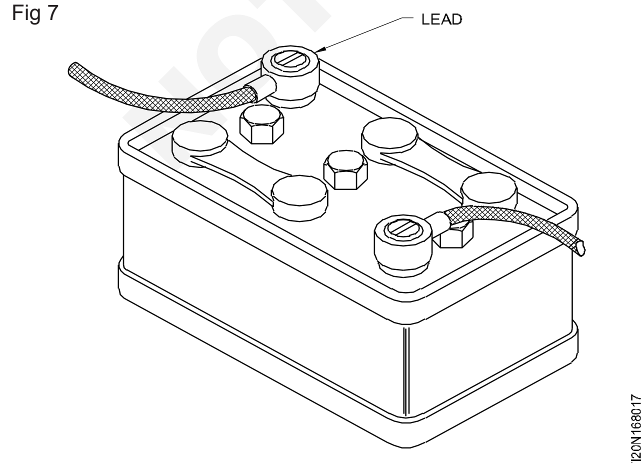
Lead

Lead is a very commonly used non-ferrous metal and has a variety of industrial applications.

Lead is produced from its ore 'GALENA'. Lead is a heavy metal that is silvery in colour when molten. It is soft and malleable and has good resistance to corrosion. It is a good insulator against nuclear radiation. Lead is resistant to many acids like sulphuric acid and hydrochloric acid.

It is used in car batteries, in the preparation of solders etc. It is also used in the preparation of paints. (Fig 7)

Fig 7



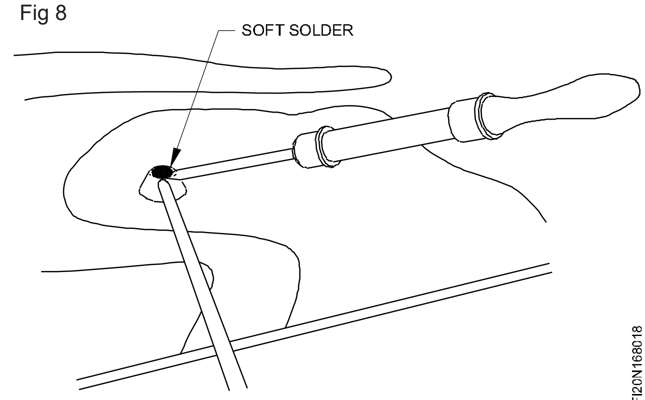
Lead Alloys

Babbit metal

Babbit metal is an alloy of lead, tin, copper and antimony. It is a soft, anti-friction alloy, often used as bearings.

An alloy of lead and tin is used as 'soft solder. (Fig 8)

Fig 8



Zinc

Zinc is a commonly used metal for coating on steel to prevent corrosion. Examples are steel buckets, galvanized roofing sheets, etc.

Zinc is obtained from the ore-calamine or blende.

Its melting point is 420° C.

It is brittle and softens on heating; it is also corrosion-resistant. Due to this reason it is used for battery containers and is coated on roofing sheets etc.

Galvanized iron sheets are coated with zinc.

Tin: Tin is produced from cassiterite or tinstone. It issilvery white in appearance, and the melting point is 231° C. It is soft and highly corrosion-resistant.

It is mainly used as a coating on steel sheets for the production of food containers. It is also used with other metals, to form alloys.

Example: Tin with copper to form bronze. Tin with lead to

Aluminium: Aluminium is a non-ferrous metal which is extracted from 'BAUXITE'. Aluminium is white or whitish grey in colour. It has a melting point of 660° C. Aluminium has high electrical and thermal conductivity. It is soft and ductile, and has low tensile strength. Aluminium is very widely used in aircraft industry and fabrication work because of its lightness. Its application in the electrical industry is also on the increase. It is also very much in use in household heating appliances. Some typical aluminium alloys, their composition and applications are given in the table that follows. (Table 4)

ALUMINIUM ALLOYS - COMPOSITION - USES

Composition(%) (Only the percentage of alloying elements is shown. The remaining is aluminium.)						**Category**	**Applications**
Copper	Silicon	Iron	Manganese	Magnesium	Other elements		
0.1 max.	0.5 max.	0.7 max.	0.1 max.	-	-	Wrought. Not heat treatable.	Fabricated assemblies, Electrical conductors. Food and brewing, processing plants. Architectural decorations.
0.15 max.	0.6 max.	0.75 max.	1.0 max.	4.5 to 5.5	0.5 Chromium	Wrought. Not heat treatable.	High strength ship building and engineering products. Good corrosion resistance.
1.6	10.0	-	-	-	-	Cast, not heat treatable.	General purpose alloy for moderately stressed pressure die-castings.
-	10.0 to 13.0	-	-	-	-	Cast, not heat treatable	One of the most widely used alloys. Suitable for sand,gravity and pressure die castings. Excellent foundry characteristics Used for large marine, automotive and general engineering castings.
4.2	0.7	0.7	0.7	0.7	0.3 Titanium (option)	Wrought. Heat treatable.	Traditional'Duralumin'. General machining alloy. Widely used for stressed components in aircraft.
-	0.5	-	-	0.6	-	Wrought. Heat treatable.	Corrosion-resistant alloy for lightly stressed components such as glazing bars, window sections and automotive body components.
1.8	2.5	1.0	-	0.2	0.15 Titanium 1.2 Nickel	Cast. Heat treatable.	Suitable for sand and gravity die casting. High rigidity with moderate strength and shock resistance. A general purpose alloy
-	-	-	-	10.5	0.2 Titanium	Cast. Heat treatable.	A strong, ductile and highly corrosion-resistant alloy used for air craft and marine castings, both large and small.

Simple scrapers and scraping

Objectives: At the end of this lesson you shall be able to
- **state the necessity of scraping surfaces**
- **state what is high spots**
- **state what is bearing surface**
- **list the types of scrapers used, material and size**
- **hold the scraper at correct angle/position.**

Necessity of scraping surface: Scrapers are used to correct slight errors on all flat or curved surfaces that must be finished more decorate.

Scraping is used to produce a high degree of fit between two flat or two curved surfaces particularly where the surfaces can rub together in use.

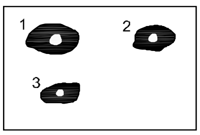
After a surface is filed or machined as accurately as possible, it can be further improved by rough scraping after which finish scraping is employed. Finish scraping is used to remove minute amount of material.

High spots and bearing surfaces: On the surface plate apply the coating of Prussian blue or red lead mixed with oil or apply used carbon. Placing the job to be scraped, move the job under light downward pressure keeping all edges of the job within the limits of surface. Carefully lift off the job in a perpendicular direction.

Study the patches of marking compound before you begin scraping.

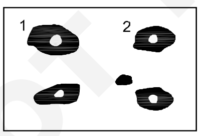
– First test having 3 shiny patches. Only patch 3 would be scraped (high spots) (Fig 1)

Fig 1



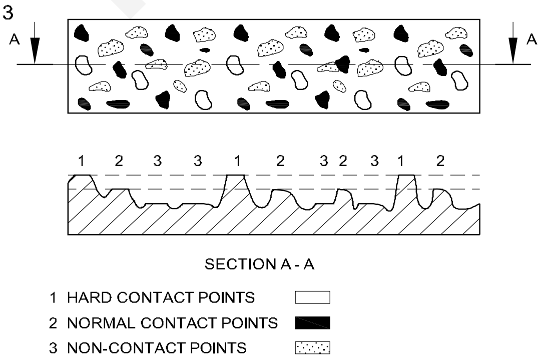
– Second test having even distribution of marking compound. (High spots) (Fig 2)

Fig 2



– Types of bearing contact obtained (Fig 3)

Fig 3



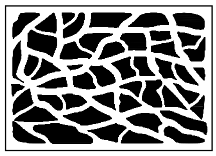
1 Metal contact with the surface plate. The points have been rubbed shiny.

2 They have been conduct with the marking compound and coloured by it. This portion is called normal contact point.

3 Non-contact point, have not been in contact with the marking compound.

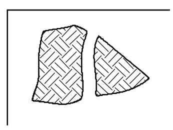
– After third scraping completed and testing the shining shows the shiny spots are more than those coloured with marking compound. The patches are greater in number in size more evenly distributed. (High spots) (Fig 4)

Fig 4



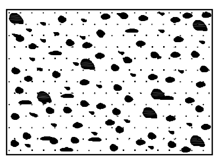
– The enlarged view of the pattern of scraping marks on the small patches shown in Fig 5.

Fig 5



– Further testing, scraping would produce a more even distribution of larger number of smaller sized patches (bearing spots). (Fig 6)

Fig 6

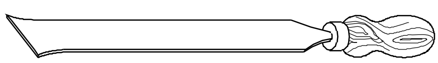


In 25 mm SQ = 25 bearing parts.

Types and uses of scraper: For scraping flat surfaces

– Flat scrapers with rectangular blades. (Fig 7)

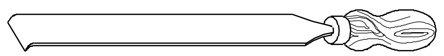
Fig 7



Used for scraping large flat surfaces. The working edge is not thicker than 3 mm.

– Hook scrapers with rectangular blades. (Fig 8)

Fig 8

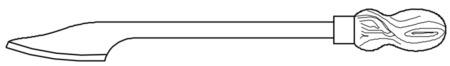


Hook scrapers are used for scraping the center portion of large flat surface where it is not convenient to use of flat scraper.

For scraping curved surfaces

– Half round scraper is curved slightly towards the curved surfaces. (Fig 9)

Fig 9

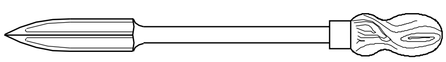


It is used to scrape bearing blocks or brasses, pressure is applied in radial direction and cutting edge moved at right angles to its length. So that scraping marks are circumferential.

– Three square or triangular scraper

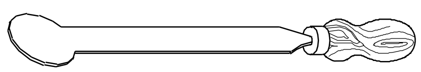
Each of the three faces are hallow ground Fig 10. It is used for scraping small diameter holes and deburring edges of accurate holes. The cutting edge is moved at right angles to its length.

Fig 10



– Bull-nose scraper is forged to a disc like end. (Fig 11) It is used for scraping large bearings. It can be used two ways either with the circumferential movement of a flat scraper or with the longitudinal movement of flat scraper.

Fig 11



Scraper material: High grade tool steel or special alloy steel and tungsten carbide tipped tool.

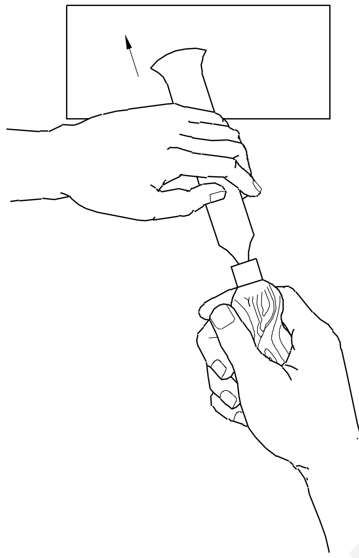
Specification: The overall length of blade and handle may range from 150 to about 500 mm.

Holding position of flat scraper: The handle of the scraper is held and pushed by right hand. Hold the right elbow out of from the body when beginning forward cutting stroke. As you finish the short cutting stroke bring the elbow into the body.

The blade is guided and pressed down by the left hand. Grasp the blade with the root of the little finger above the blade and about 40 mm to 50 mm from the cutting edge. (Fig 12)

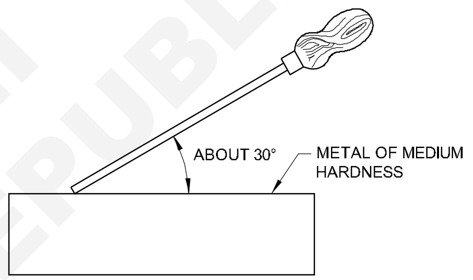
Curl the little finger and second finger lightly around the blade. The first finger lies loosely around the blade and thumb lies on top of the blade and at right angle to it.

Fig 12



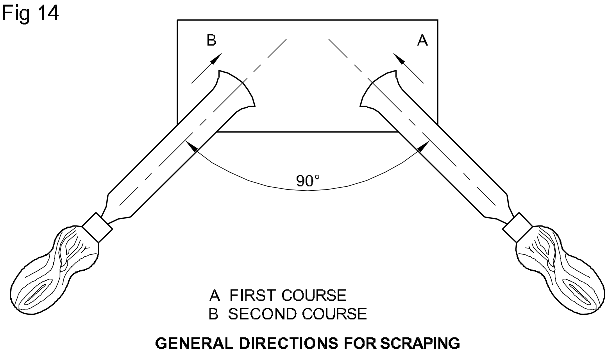
For work of average hardness blade of scraper is held at an angle about 30° to surface. For very hard work the angle may be greater, while for softer metals this angle may be decreased to about 20°. (Fig 13)

Fig 13



After scraping in one general direction and testing in the surface plate. Change the general direction of scraping by about 90°. (Fig 14)

Fig 14



Care and maintenance of scrapers

- Scrapers must be sharp and kept with good condition to handle.
- Cover the cutting edge with rubber or leather sheath.
- After use apply grease on cutting edge to avoid corroding.
- Scraper should not fall down from the bench.
- Don't mix with other tool.

Testing true flat surfaces by three-plate method (Whitworth principle)

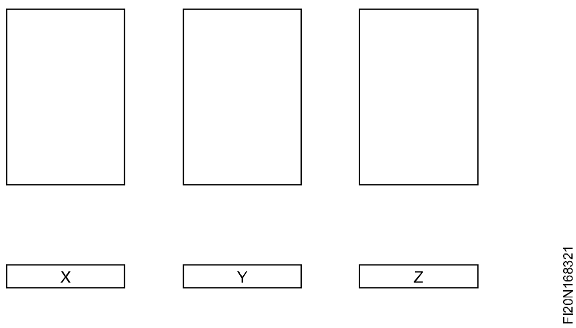
Objective: At the end of this lesson you shall be able to
- **originate flat scraped surfaces by the three-plate method.**

How does one obtain a flat surface?

It is easy to say that it is scraped but how does one know where to take off the high points.

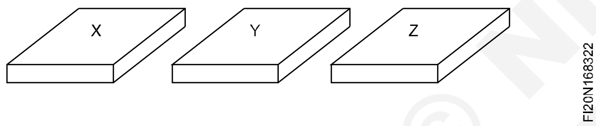
If three plates are compared with one another in alternate pairs, they will only mate perfectly in all positions when they are absolutely flat. (Fig 1)

Fig 1



File and ensure that all the three plates are finished to size and square. (Fig 2)

Fig 2

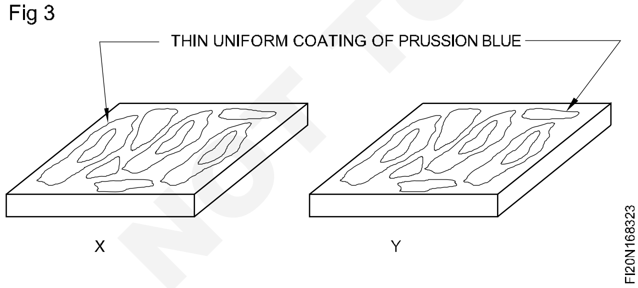


Check the level with the knife edge/straight edge

Stamp the plates X,Y and Z with a letter punch.

Apply a very thin uniform coating of Prussion blue on the feces of plates X and Y which are to be scrapped. (Fig 3)

Fig 3



Keep both the pieces together and rub the plates back and forth against each other. (Fig 4)

Observe the high spots on the plates X and Y remove by scraping. (Fig 5)

Clean the faces with knitted cotton cloth.

Rub with an oilstone gently to remove the burrs and again clean with knitted cotton cloth.

Repeat the same procedure till both the faces are mating with good bearing surfaces.

Fig 4

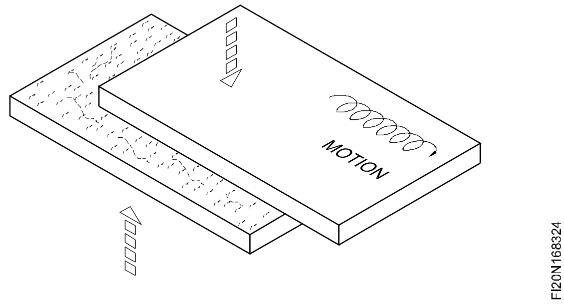
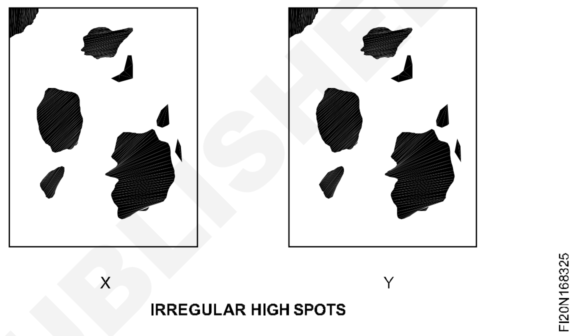


Fig 5



Apply a very thin uniform coating or Prussion blue on the face of the plate Z which is to be scraped.

Keep the faces of the plates X and Z together and rub the plates back and forth against each other.

Observe the high spots on the plate Z and remove by scraping (Figs 6 and 7)

Fig 6

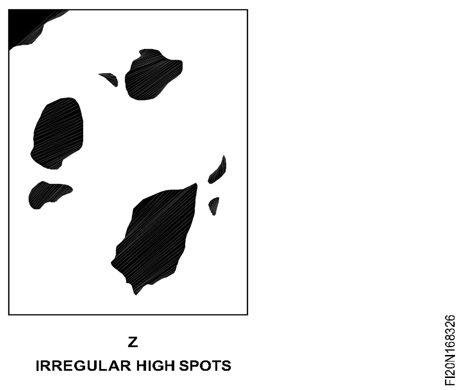
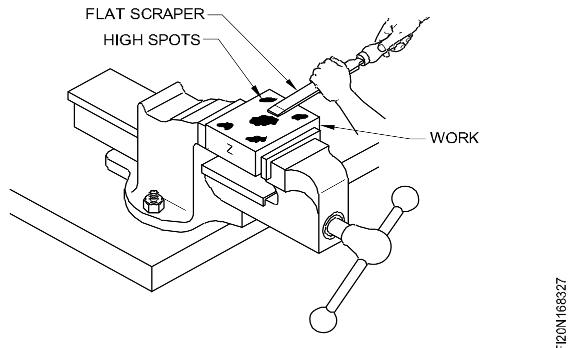


Fig 7



Do not scrape plate X. This is taken as a reference surface.

Repeat the same procedure till both the faces of the plates X and Z are mating with good

Repeat the procedure till the faces of plates Y and Z are mating with good bearing surfaces.

Now one cycle of operation is completed.

Note: Plate X will mate with plates Y and Z but Y and Z will not mate. All the three plates mate only when all the three are flat.

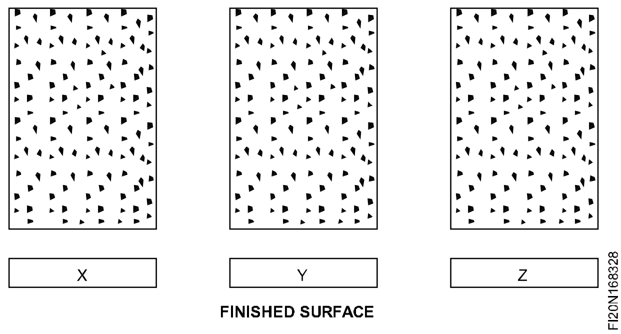
Repeat the cycle a number of times till interchangeable, flat, good bearing surfaces are achieved.

Clean all the plates with kerosene.

Use knitted cotton cloth for cleaning.

A good bearing surface is achieved when 5 to 10 points are visible and uniformy distribuited per cm^2 on the workpiece surfaces after finishing.(Fig 8)

Fig 8



Three trainees will work in a group for this exercise.

Each trainee will be given one plate for scraping.

Each trainee will compare his plate with those of the other trainees as per the above procedure and generate flat surfaces by the three-plate method.

Scraping curved surfaces

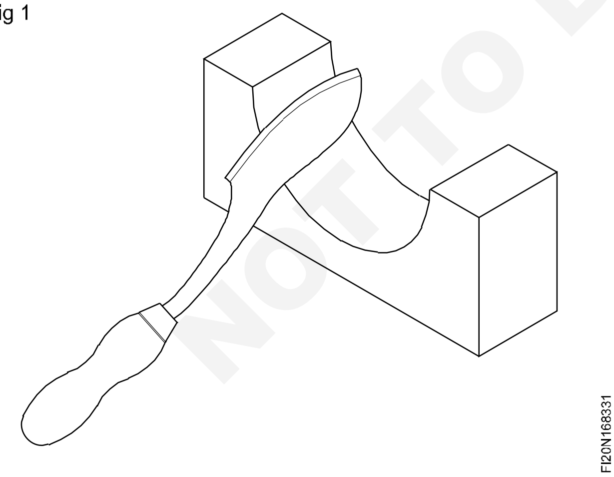
Objective: At the end of this lesson you shall be able to
- **scrape and test curved surfaces.**

A half round scraper is the most suitable scraper for scraping curved surfaces. This method of scrapping differs from that of flat scraping.

Method

For scraping curved surfaces the handle is held by hand in such a way as to facilitate the movement of the scraper in the required direction.(Fig 1)

Fig 1



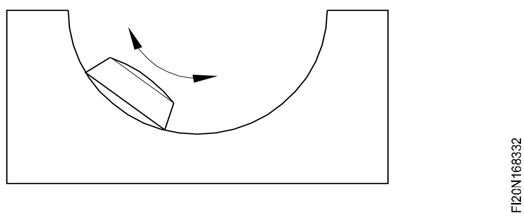
Pressure is exerted with other hand on the shank for cutting.

Rough scraping will need excessive pressure with longer strokes.

For fine scraping, pressure is reduced and the stroke length also becomes shorter.

Cutting action takes place both on forward and return strokes. (Fig 2)

Fig 2



During the forward movement one cutting edge acts, and on the return stroke, the other cutting edge acts.

After each pass, change the direction of cutting. This ensures a uniform surface. (Figs 3 & 4)

Fig 3

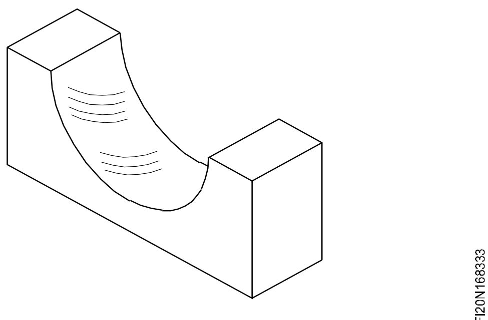
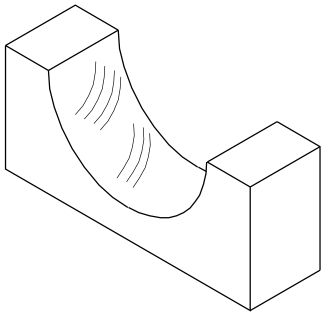


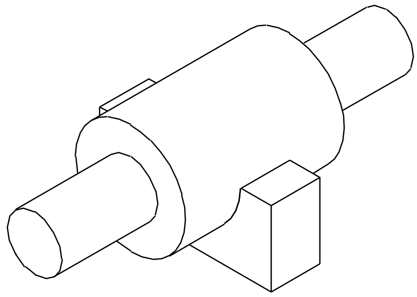
Fig 4



Use a master bar to check the correctness of the surface being scraped.(Fig 5)

Apply a thin coating of Prussian blue on the master bar to locate the high spots.

Fig 5



Vernier micrometer, screw thread micrometer, graduation & Measuring process

Objectives: At the end of this lesson you shall be able to
- **state the graduations of a vernier micrometer (metric)**
- **read a vernier micrometer**

Vernier micrometer

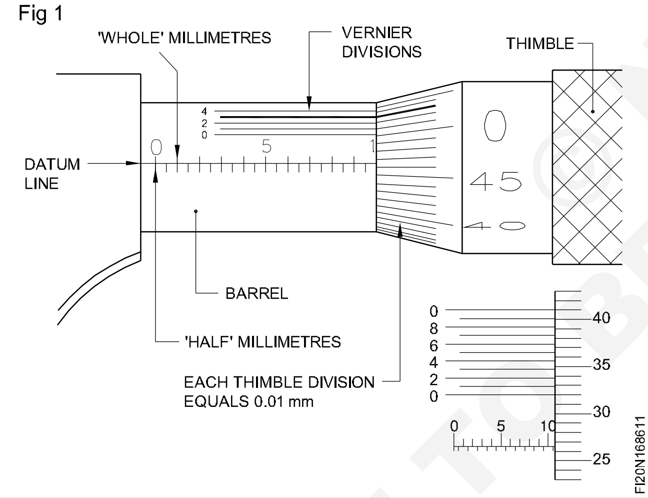
Ordinary metric micrometers can measure only to an accuracy of ±.01mm.

For taking more accurate measurements, vernier micrometers are useful. Vernier micrometers can measure to an accuracy of ±.001 mm.

Construction and graduation

Vernier micrometers are very similar to ordinary micrometers in construction. The difference is in the graduation. These micrometers have additional, equally spaced graduations (vernier graduations) given above the datum line. There are ten such vernier graduation lines marked parallel above the datum line. (Fig 1) The space between these 10 lines is equal to 9 divisions in the thimble. (Fig 1)

Fig 1



The value of 10 vernier divisions is

.0 1 mm X 9

=.09 mm.

The value of a vernier division

$$\frac{0.09}{10} = .009mm$$

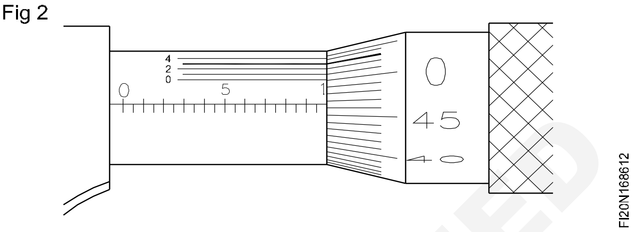
The least count = 1 thimble division – 1 Vernier division
= 0.01 – 0.009mm = .001 mm

Reading a vernier micrometer (Fig 2)

Example

After measuring, read the full mm divisions visible on the barrel.

Fig 2



full divisions in mm. 9 mm

Note the half divisions, if any, visible on the barrel.

1 half division

Read the thimble divisions below the datum line. (Fig 2)

46 divisions

Note the vernier division coinciding with the thimble division.

3rd division

Add up all the readings together

Calcuation

The range of micrometer is 0 to 25 mm

A	Full mm division visible before the thimble edge	= 1.00 x 9	= 9.00 mm
B	Half mm division visible after the full mm divsion on barrel.	= 0.5 x 1	= 0.50 mm
C	Thimble division below the index line	= 46 X 0.01	= 0.46 mm
D	Vernier division coinsiding with thimble division	= 3 X 0.001	= 0.003 mm
	Reading		= 9.963 mm

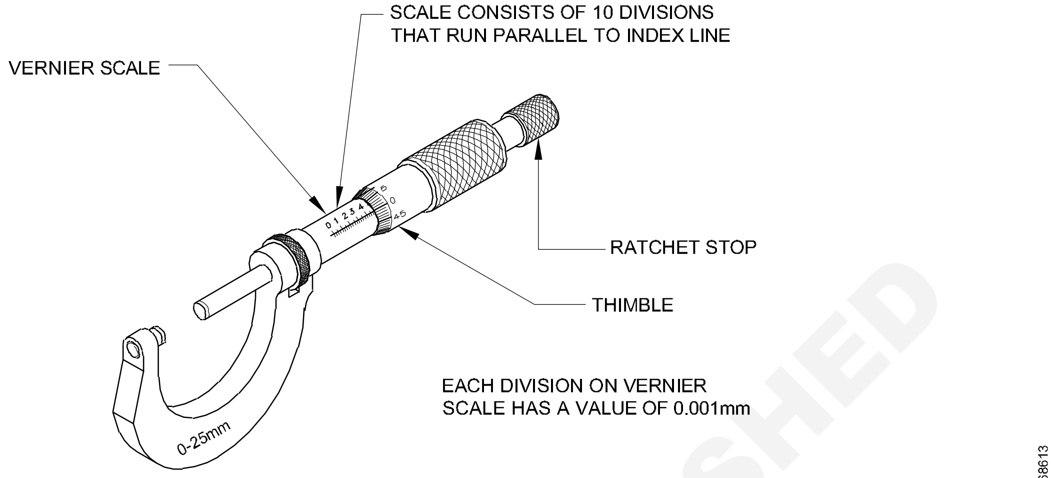
Vernier micrometers are made of invar steel. (Fig 3)

Care and maintenance

- Clean the circumference of the spindle and both measuring faces with dry linen cloth regularly before use.
- Clean and apply thin layer of oil on the spindle and measurring faces after the use.

- Care should be taken while handling the micrometer and not to drop on floor.
- Recalibrate the vernier micrometer if it is accidently dropped.
- Store vernier micrometer in a ventilated place with low humidity and ideally at room temperature.
- Ensure that there is a gap between measuring faces, when it is not in use.

Fig 3



VERNIER MICROMETER (METRIC)

Calibration of measuring instrument

Objectives: At the end of this lesson you shall be able to
- **state the importance of calibration**
- **state calibration and its procedure.**

Why calibration is important ?

The accuracy of all measuring devices degrade over time. This is typically caused by normal wear and tear. However, changes in accuracy can also be caused by electric or mechanical shock or a hazardous manufacturing environment in which it is being used, it may degrade very quickly or over a long period of time. The bottom line is that, calibration improves the accuracy of the measuring device. Accurate measuring devices improve product quality.

When should you calibrate your measuring device?

A measuring device should be calibrated:

- According to recommendation of the manufacturer.
- After any mechanical or electrical shock.
- Periodically (annually, quarterly, monthly).

What is calibration: Calibration is defined as a scientific and systematic method of identifying deviations (error) in a instrument by comparing with a master, having higher accuracy and rational traceability.

It is also referred as checking the integrity of an instrument, alternately ascertaining whether the instrument is fit enough to be used for measurement.

The instrument calibration is carried out as per (ISS) Indian Standard Specification published by the Bureau of Indian standards (BIS), which also gives the permissible error, that can be allowed in the relavant standard for each instrument.

Calibration is mandatory in most of the global quality standards and is covered under a special clause called measuring system analysis (MSA) for automobile industry standard ISO/TS 16949. Calibration should be carried out by an accredited laboratory or by following relevant documents of the certifying agency, NABL India (National Accreditation Board for calibration testing laboratories, the accrediting body in our country.

A part from following the standard specification for calibration of an instrument, the environmental condition of the lab is critical with respect to temperature, humidity, vibrations proper lighting, magnetic interference etc., which are specified in IS:199 or the NABL document, essential criteria for the calibration lab, which should adopt the quality system standard (QSS) as per ISO/IEC/170235 - 2015. The vital factor in calibration of an instrument is the frequency of calibration, which is determined based on the importance & criticality of the measurement process.

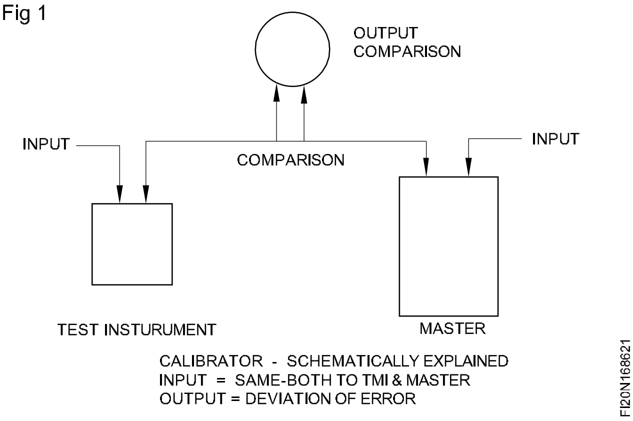
A good calibrated instrument will maintain both precision & accuracy, the essential requirement of any measuring system

Calibration of your measuring instruments has two objectives. It checks the accuracy of the instrument and it determines the traceability of the measurement. In practice, calibration also includes repair of the device if it is out of calibration. A report is provided by the calibration expert, which shows the error in measurements with the measuring device before and after the calibration.

To explain how calibration is performed we can use an external micrometer as an example. Here, accuracy of the scale is the main parameter for calibration. In addition,

these instruments are also calibrated for zero error in the fully closed position and flatness and parallelism of the measuring surfaces. For the calibration of the scale, a calibrated slip gauge is used. A calibrated optical flat is used to check the flatness and parallelism.

Fig 1



Mechanical fasteners

Objectives: At the end of this lesson you shall be able to
- **define mechanical fasteners**
- **classification of fasteners**
- **state the application of various fasteners & their uses.**

Definition

A mechanical fastener is a device that mechanically joins two (or) more components together easily and also can be dismantled without damaging any components using hand tools (or) power tools.

Classification

According to the need and usage they are classified into three categories.

- Temporary (or) removable fasteners
- Semi permanent fasteners
- Permanent fasteners

Temporary (or) removable fasteners

- The fasteners like bolts, nuts, screws, studs etc., enable us to join two (or) more components easily and also can be dismantled without damaging any component using hand tools (or) power tools.
- The most common types of male fasteners used in industry are hexagonal head, square head, flat (or) counters sunk head, round head, socket head (or) allen head, button head and socket set screws etc.
- The most common types of female fasteners (ie nuts) used in industry are regular hexagonal nut, square nut, round nut and nylon ring elastic stop nuts etc.

Uses: These types of fasteners are used for assembling two (or) more components together to make a sub-assembly (or) to make a full assembly.

Semi permanent fasteners: The fasteners like rivets are used to hold the plates (or) steel sections firmly. The rivets are placed through the pre drilled appropriate holes in parts to be joined (or) assembled. By using rivet sets, the tail part of the shank is formed into the head closing the hole.

The plates are held between the heads on cooling. Rivet is a cylindrical rod either carbon steel (or) wrought iron (or) non-ferrous metal. It consists of a head and shank tapering at the end facilitating easy placement in the rivet holes. During dismantling the rivets may be drilled to remove the plates already joined together without spoiling them. This process is a permanent as well as a semi-permanent in nature. According to the head type the rivets are called snap head, pan head, countersunk head, flat head etc.

Uses

Rivets are used in ship building, bridge girders, structural towers, goods wagons, boilers and heavy pressure vessels industry and also for small scale applications too.

Permanent fasteners

Arc welding, gas welding and brazing are the operations used in industry during permanent fastening of components and structures. Once the arc welding, gas welding and brazings has been done, the components (or) the structures cannot be separated without damage, hence these type of fastening is called permanent fastening.

Uses

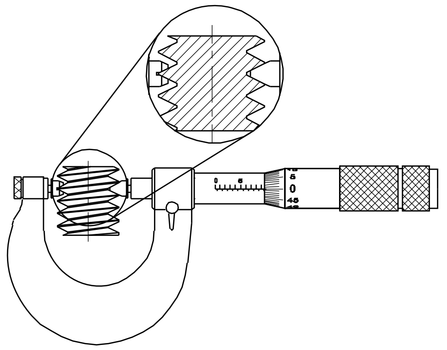
To hold steel plates (or) structures together like goods wagon building, ship building, bridge structures assembling etc. Sometimes before doing welding the components (or) the parts hold together with temporary fasteners like bolts, nuts, screws, rivets etc.

Screw thread micrometer - Thread measurement (effective diameter) using screw thread micrometer

Objectives: At the end of this lesson you shall be able to
- **state the features of a screw thread micrometer**
- **state the features of the three-wire system of measurement with the help of tables**
- **select the best wire with the help of tables for using in the three-wire method.**

The Screw thread micrometer: This micrometer (Fig 1) is used to measure the effective diameter of the screw threads. This dimension is important, because the area of the thread flanks in the vicinity of the pitch line is where the greatest transmission of force occurs between mating threads.

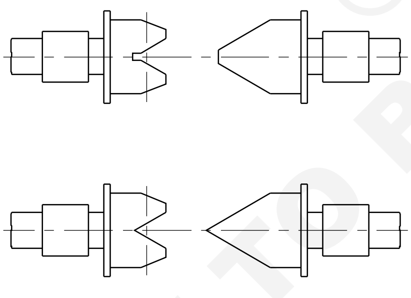
Fig 1



This is very similar to the ordinary micrometer in construction but has facilities to change the anvils.

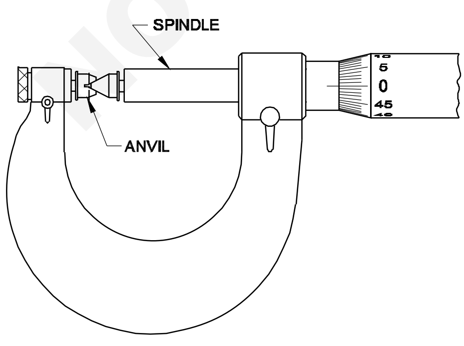
The anvils are replaceable and are changed according to the profile and pitch of the different systems of threads. (Figs 2 & 3)

Fig 2



INTERCHANGEABLE ANVILS

Fig 3



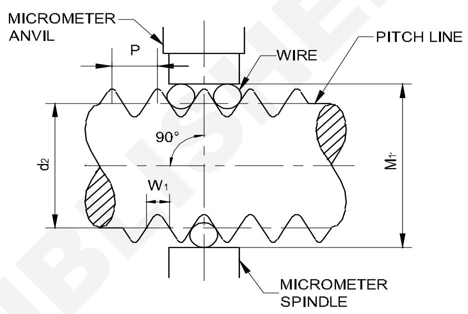
SPINDLE AND ANVIL OF MICROMETER AT ZERO SETTING

The three-wire method: This method uses three wires of the same diameter for checking the effective diameter and the flank form. The wires are finished with a high degree of accuracy.

The size of the wires used depends on the pitch of the thread to be measured.

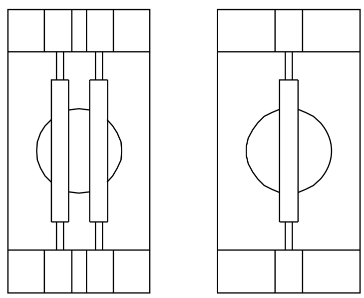
For measuring the effective diameter, three wires are suitable placed between the threads. (Fig 4)

Fig 4



The measuring wires are fitted in wire-holders which are supplied in pairs. One holder has provisions to fix one wire and the other for two wires. (Fig 5)

Fig 5



While measuring the screw thread, the holder with the one wire is placed on the spindle of the micrometer and the other holder with two wires is fixed on the anvil. (Fig 6)

Selection of 'best wire' (Fig 7)**:** The best wire is the one which, when placed in the thread groove, will make contact at the nearest to the effective diameter. The selection of the wire is based on the type of thread and pitch to be measured. The selection of the wire can be calculated and determined but readymade charts are available from which the selection can be made.

Fig 6

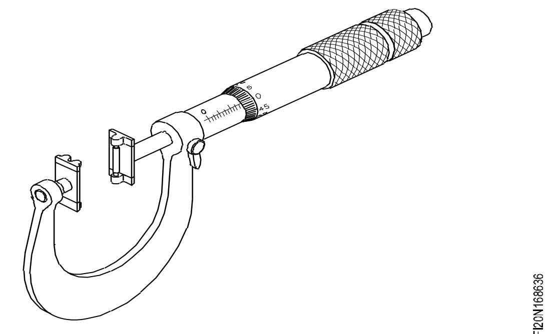


Fig 7

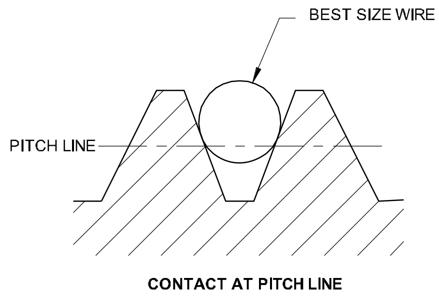


Table 1

Measurement with measuring wires. Metric threads with coarse pitch (M)

Thread designation	Pitch P (mm)	Basic measure-ment mean d_2(mm)	Measuring wire dia. W_1(mm)	Dimension over wire M_1(mm)
M1	0.25	0.838	0.15	1.072
M 1.2	0.25	1.038	0.15	1.272
M 1.4	0.3	1.205	0.17	1.456
M 1.6	0.35	1.373	0.2	1.671
M 1.8	0.35	1.573	0.2	1.870
M 2	0.4	1.740	0.22	2.055
M 2.2	0.45	1.908	0.25	2.270
M 2.5	0.45	2.208	0.25	2.569
M 3	0.5	2.675	0.3	3.143
M 3.5	0.6	3.110	0.35	3.642
M 4	0.7	3.545	0.4	4.140
M 4.5	0.75	4.013	0.45	4.715
M 5	0.8	4.480	0.45	5.139
M 6	1	5.350	0.6	6.285
M 8	1.25	7.188	0.7	8.207
M 10	1.5	9.026	0.85	10.279
M 12	1.75	10.863	1.0	12.350
M 14	2	12.701	1.15	14.421
M 16	2	14.701	1.15	16.420
M 18	2.5	16.376	1.45	18.464
M 20	2.5	18.376	1.45	20.563
M 22	2.5	20.376	1.45	22.563
M 24	3	22.051	1.75	24.706
M 27	3	25.051	1.75	27.705
M 30	3.5	27.727	2.05	30.848

Table 2

Measurement with measuring wires. Metric threads with fine pitch (M)

Thread designation	Basic measurement d_2(mm)	Measuring wire dia.mean W_1(mm)	Dimension over wire M_1(mm)
M 1 x 0.2	0.870	0.12	1.057
M 1.2 x 0.2	1.070	0.12	1.257
M 1.6 x 0.2	1.470	0.12	1.557
M 2 x 0.25	1.838	0.15	2.072
M 2.5 x 0.35	2.273	0.2	2.570
M 3 x 0.35	2.773	0.2	3.070
M 4 x 0.5	3.675	0.3	4.142
M 5 x 0.5	4.675	0.3	5.142
M 6 x 0.75	5.513	0.45	6.214
M 8 x 1	7.350	0.6	8.285
M 10 x 1.25	9.188	0.7	10.207
M 12 x 1.25	11.188	0.7	12.206
M 14 x 1.5	13.026	0.85	14.278
M 16 x 1.5	15.026	0.85	16.278
M 18 x 1.5	17.026	0.85	18.277
M 20 x 1.5	19.026	0.85	20.277
M 22 x 1.5	21.026	0.85	22.277
M 24 x 2	22.701	1.15	24.420
M 27 x 2	25.701	1.15	27.420
M 30 x 2	28.701	1.15	30.419

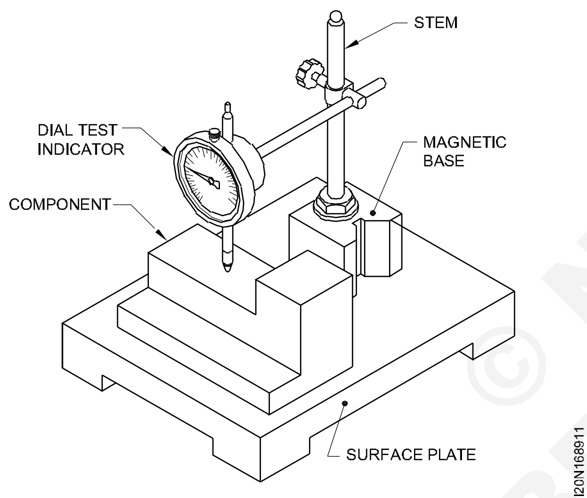
— — — — — —

Dial test indicator, comparators, digital dial indicator

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

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

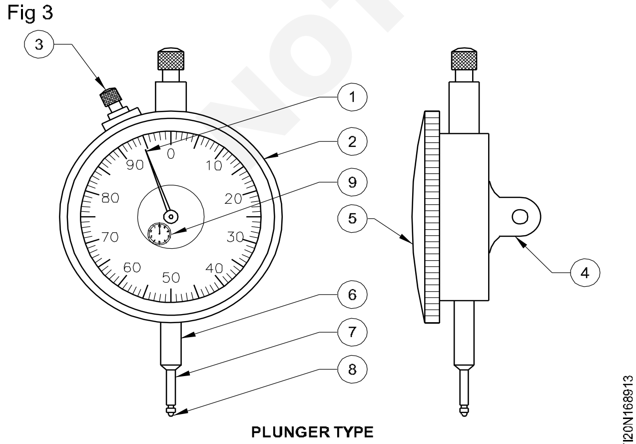
Fig 1



Principle of working: The magnification of the small movement of the plunger or stylus is converted into a rotary motion of the pointer on a circular scale. (Fig 2)

Types: Two types of dial test indicators are in use according to the method of magnification. They are

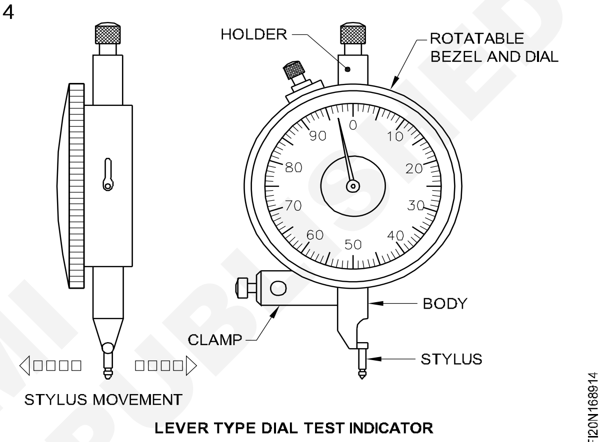
Fig 3



Plunger type (Fig 3)

Lever type (Fig 4)

Fig 4



The Plunger Type dial test indicator

The external parts and features of a dial test indicator are as shown in Fig 3.

> **Dial test indicators are made out of Inver steel material**

1 Pointer

2 Rotatable bezel

3 Bezel clamp

4 Back lug

5 Transparent dial cover

6 Stem

7 Plunger

8 Anvil

9 Revolution counter

For converting the linear motion of the plunger, a rack and pinion mechanism is used. (Fig 2)

The lever type dial test indicator (Fig 4)

In the case of this type of dial test indicators, the magnification of the movement is obtained by the mechanism of the lever and scroll. (Fig 5)

It has a stylus with a ball- type contact, operating in the horizontal plane.

Fig 2

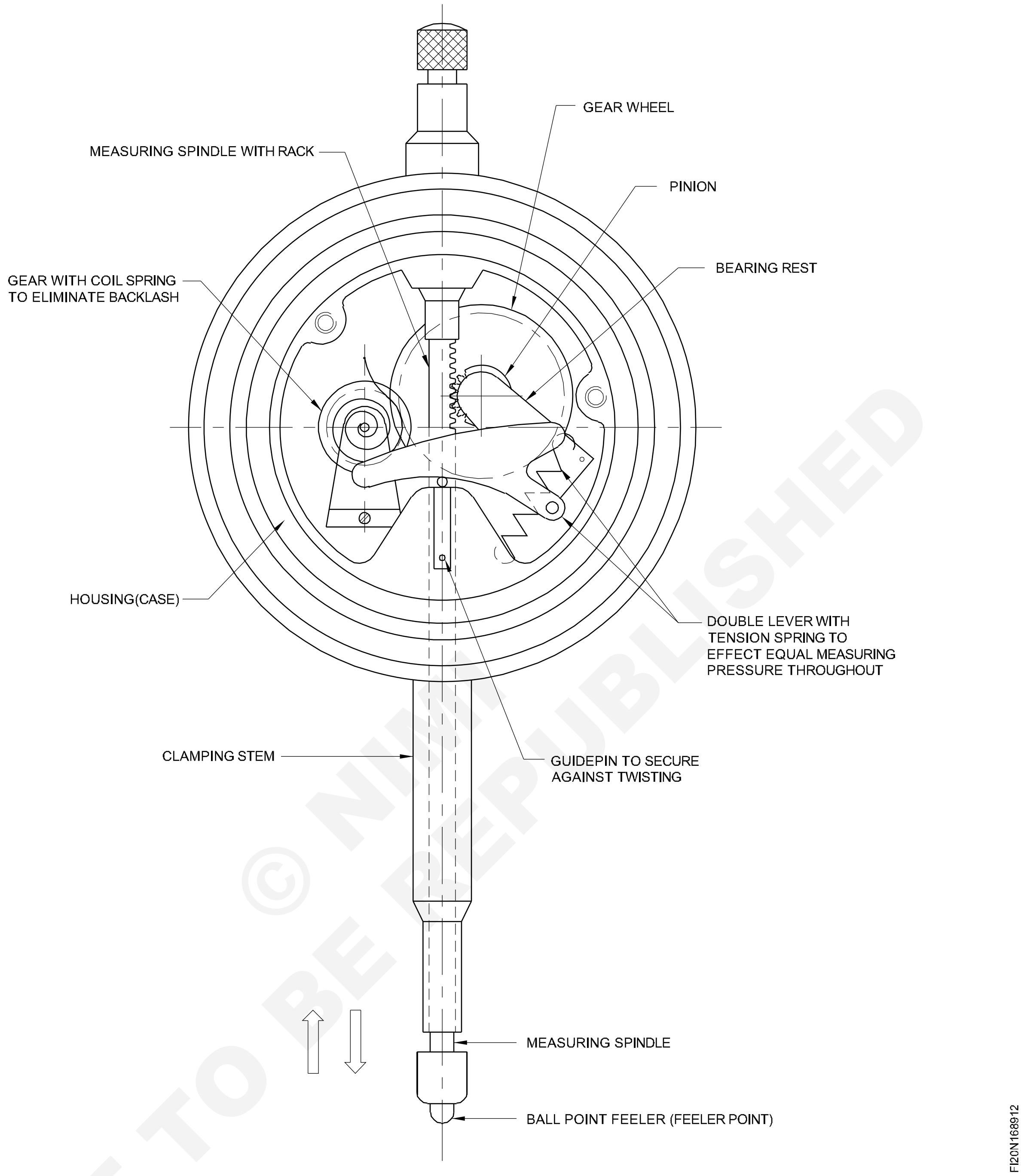
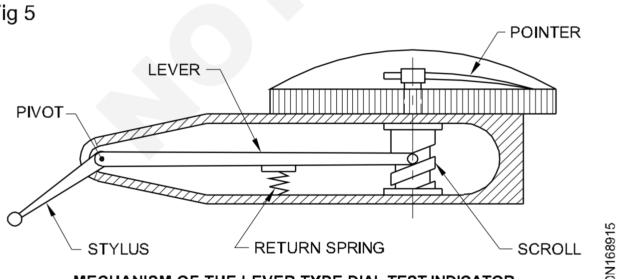


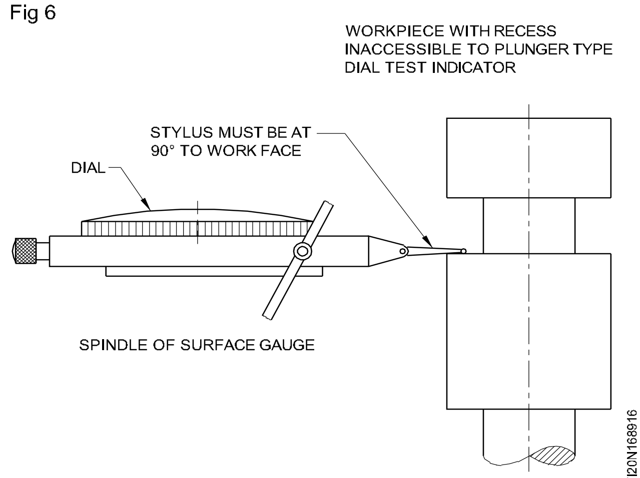
Fig 5



MECHANISM OF THE LEVER TYPE DIAL TEST INDICATOR

This can be conveniently mounted on a surface gauge stand, and can be used in places where the plunger type dial test indicator application is difficult. (Fig 6)

Fig 6



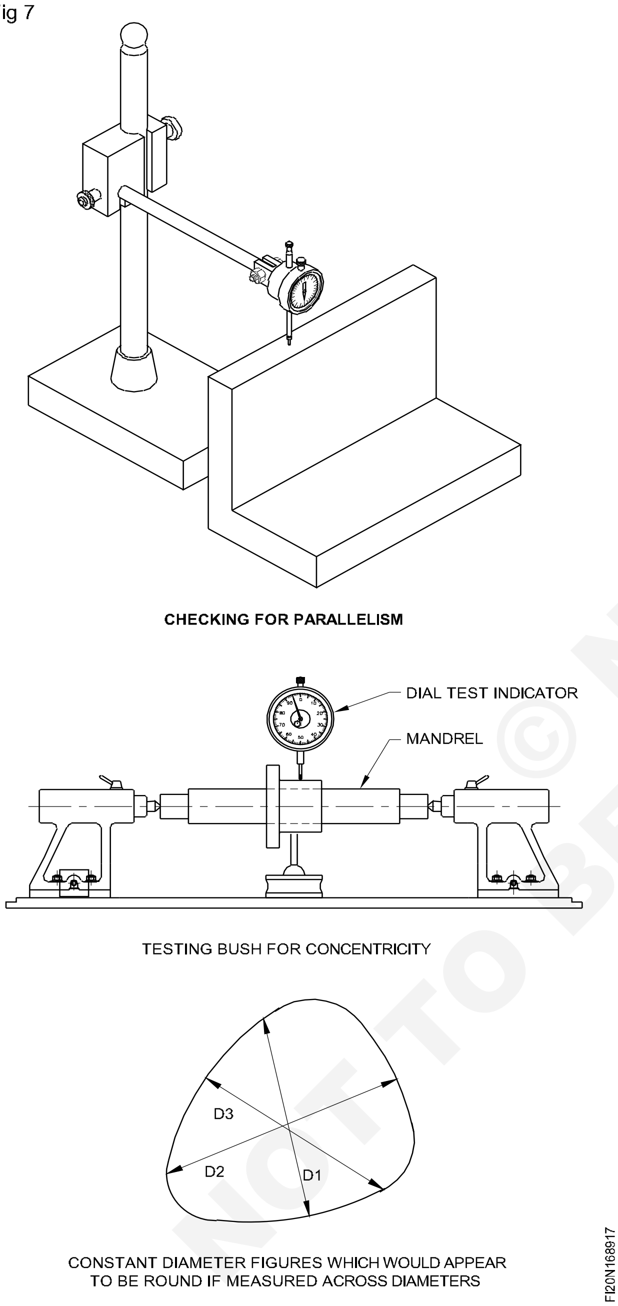
Important features of dial test indicators

An important feature of the dial test indicator is that the scale can be rotated by a ring bezel, enabling it to be set readily to zero.

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

Uses (Figure 7 shows few applications)

Fig 7



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

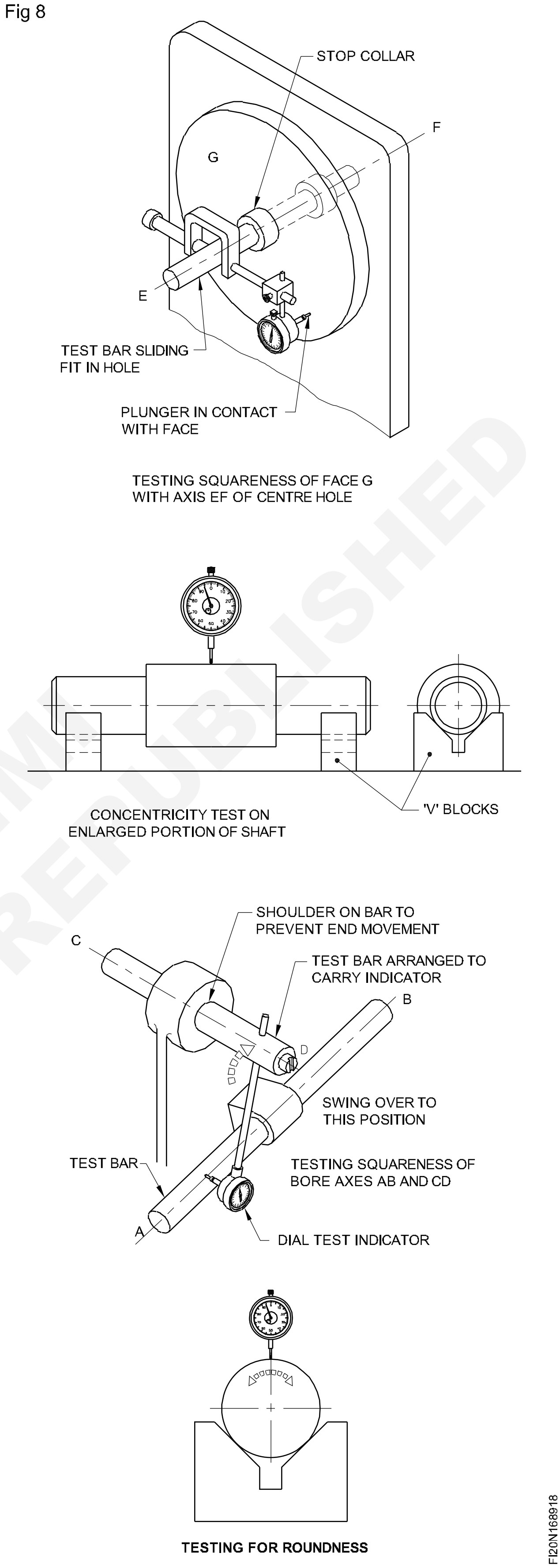
To check plane surfaces for parallelism and flatness.

To check parallelism of shafts and bars.

To check concentricity of holes and shafts.

Indicator stands (Fig 8)

Fig 8



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

The different types of stands are (Fig 9)

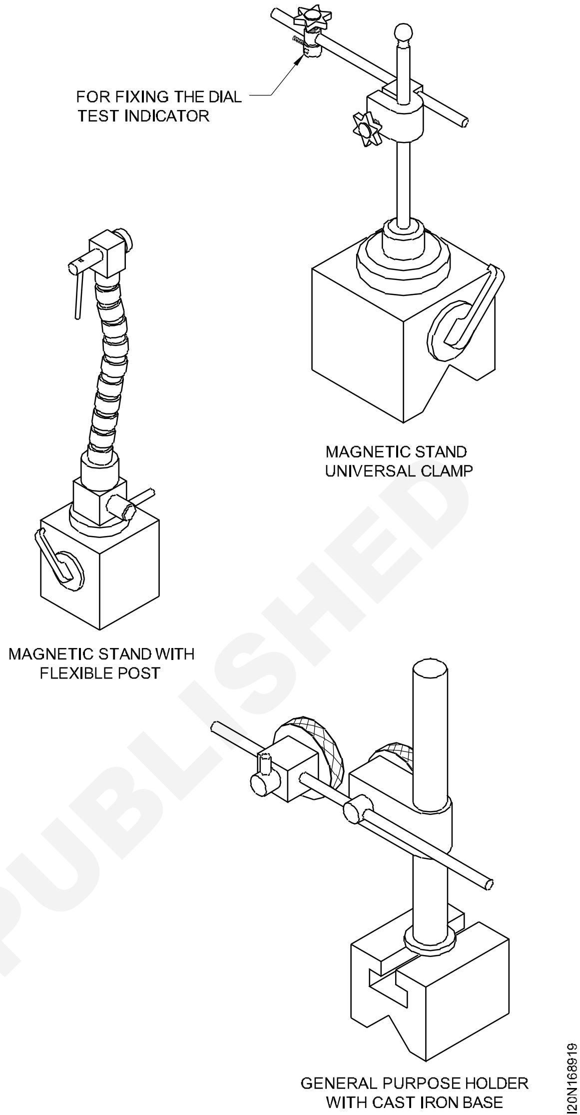
- Magnetic stand with universal clamp
- Magnetic stand with flexible post
- General purpose holder with cast iron base.

The arrows indicate the provisions in the clamps for insertion of the dial test indicator.

Care and maintenance of dial test indicator.

- Keep the dial test indicator spindle and point clean using a soft cloth.
- Store the dial test indicator in a safe, dry place and cover them to keep the dust and moisture out.
- Do the dial test indicator under gaging conditions at intervals during the operating day.

Fig 9



Comparators

Objectives: At the end of this lesson you shall be able to
- **state the principle of working of comparator gauges**
- **state the essential features of a good comparator gauge**
- **state the purpose of a comparator gauge.**
- **explain the parts and method of measurements o n bore dial gauge.**

Purpose of a comparator gauge

The purpose of all comparator gauges is to indicate the difference in the size between the standard (slip gauge or ring gauge) and the work being measured by means of some form of pointer on a scale at a magnification which is sufficient to read to the accuracy required. Almost every possible principle known to the Science of Physics for providing magnification has been used for the construction of these comparator gauges.

Essential features of a good comparator gauge

- Should be compact.
- Maximum rigidity.
- Maximum compensation for temperature effects.
- No backlash in the movement of the plunger and recording mechanism.
- Straight line characteristics of the scale readings.

- Most suitable measuring pressure which remains uniform throughout the scale.
- Indicator should be consistent in its return to zero.
- Method of indication should be clear and the pointer 'dead beat' (ie. free from oscillations).
- Should be able to withstand reasonable wrong usage.
- Should have a wide range of operations.

Principles of working

The following principles are employed in the commonly used comparator gauges.

- Mechanical
- Electronics
- Pneumatic
- Optical

Mechanical comparators

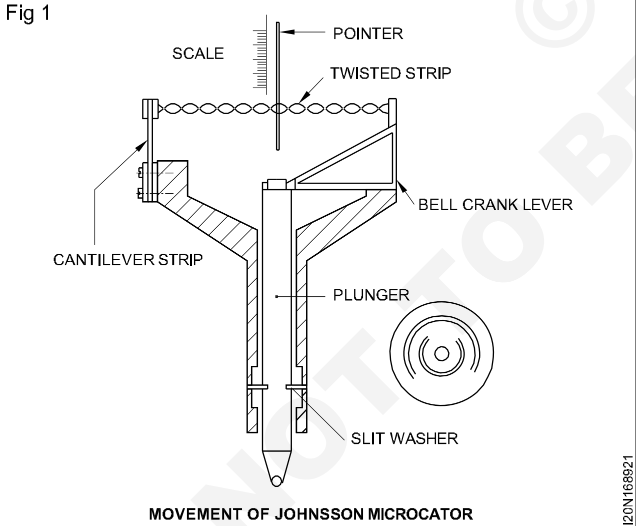
These are widely used and the familiar ones are the dial indicator fitted to the comparator stand, microcator, sigma comparator and red comparator.

Dial indicator fitted to the comparator stand.

Here, the plunger type dial indicator is used. The magnification is achieved by a suitable combination of gears, rack and pinion, steel band and levers. Generally the magnification range is between 100 or 1000 (least count 10 micron or 1 micron).

Microcator (Fig 1)

Fig 1



MOVEMENT OF JOHNSSON MICROCATOR

This is a simple and ingenious design, giving a very high magnification up to 25000 times (0.02 μ ie. 0.00002 mm. least count) It is compact, robust and free from friction and backlash.

When the plunger moves up, the bell crank lever is tilted and the twisting strip elongates. The helix angle in the twisted strip reduces and this causes the pointer, which is fixed along t

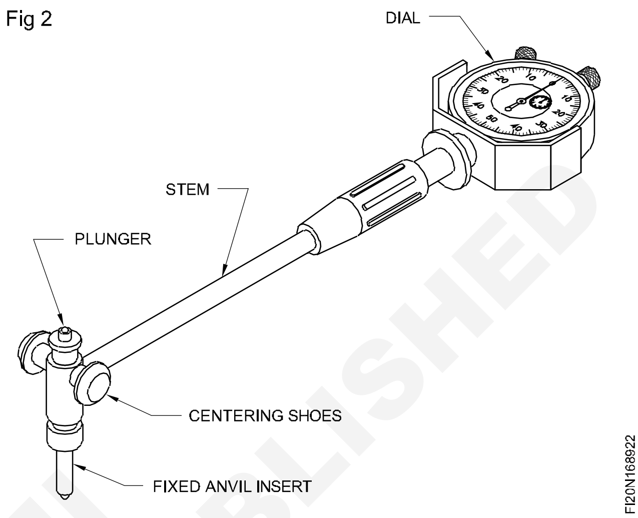
he helix of the strip, to move to one side. This movement is then read on the scale fitted behind it. When the plunger moves down, the entire process of movement is reversed and the pointer moves to the opposite side and this reading is read against the scale.

Bore dial gauge

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

Dial bore gauge (Fig 2)

Fig 2



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

Fixed anvil/inserts

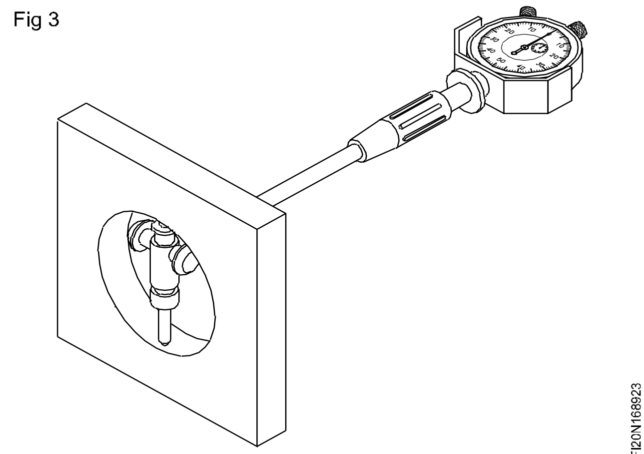
These anvils are interchangeable. The selection of the anvil is made depending on the diameter of the bore to be measured. For certain types of bore dial gauges, extension rings/washers are provided for extending the range of measurement.

Sliding plunger: This actuates the movement of the dial for reading the measurement.

Centering shoes/spherical supports

Certain types of bore dial gauges are provided with a pair of ground discs. (Fig 3)

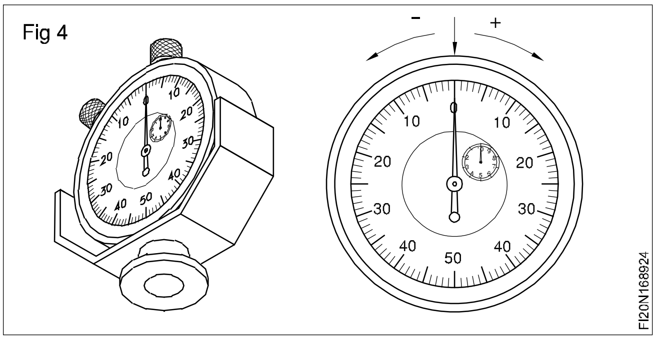
Fig 3



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

Dial Indicator (Fig 4)

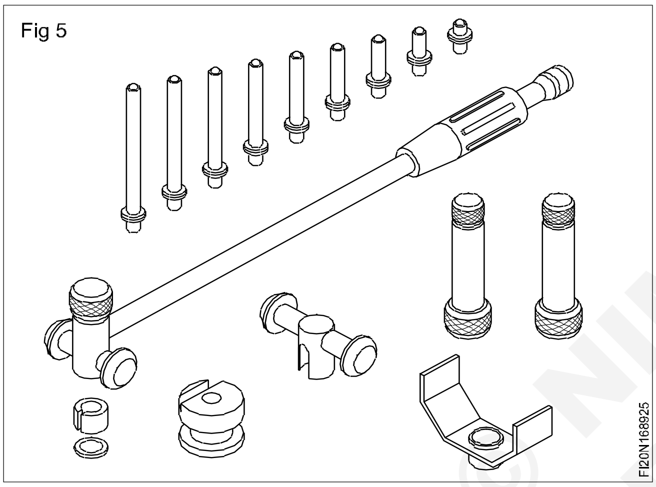
Fig 4



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

Bore dial gauges are available in various sizes with different measuring ranges. These are interchangeable measuring rods (external rods or combination washers) for measuring different sizes. (Fig 5)

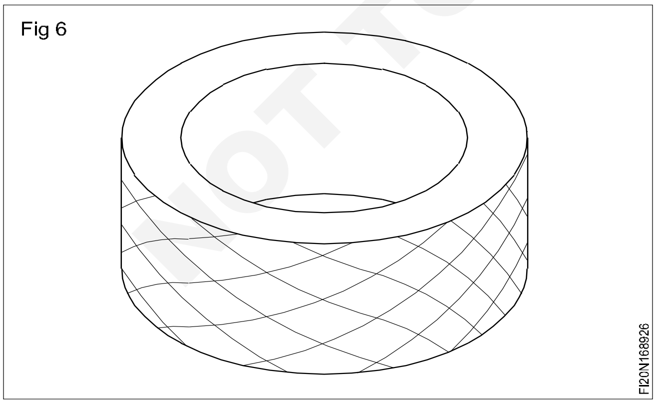
Fig 5



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

The dial gauge should be set to zero before taking measurement. Setting rings are available for zero setting. (Fig 6)

Fig 6



While taking measurements press the spring-loaded end (plunger) as it enters into the setting device or in the bore being measured. Slightly rock and steady the device for keeping the measuring faces in position. (Fig 7)

Slip gauges fixed in a setting fixture can also be used for zero setting. (Fig 8)

Fig 7

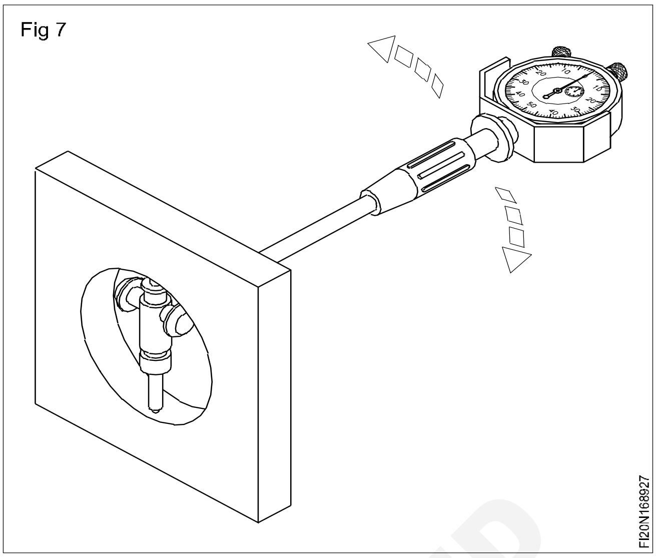
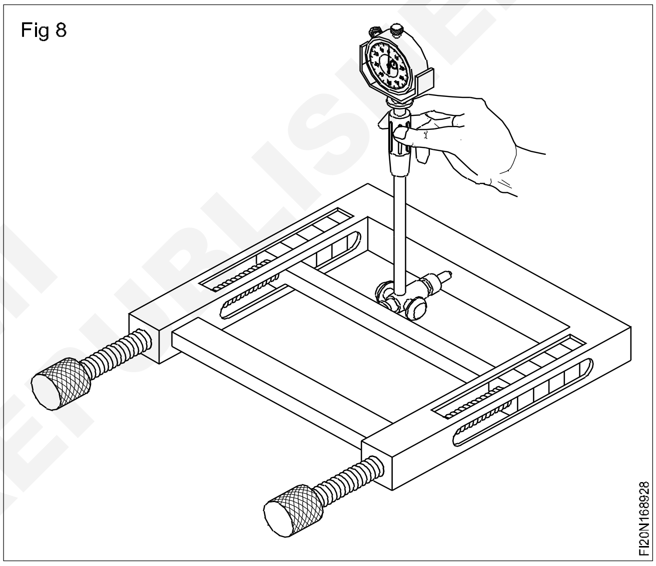
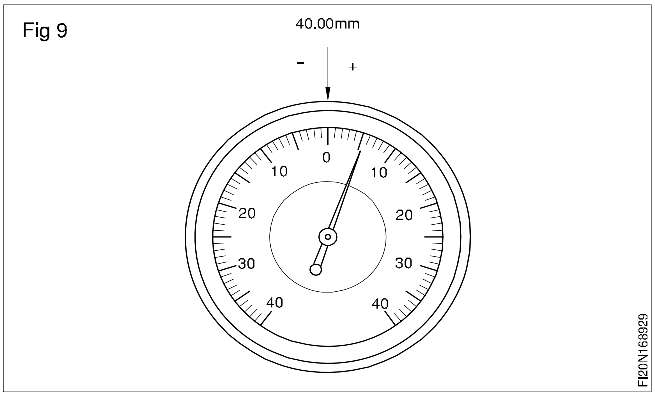


Fig 8



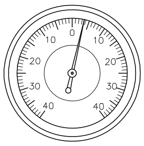
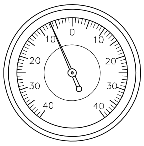
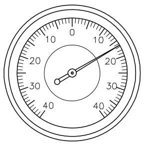
Reading the dial indicator (Fig 9)

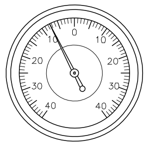
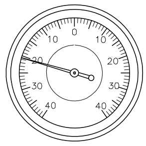
Fig 9



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

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

Classroom assignment			
Basic measurement		**Value measured**	
30.0 mm		29.97 - 29.98 30.02 - 30.03 30.03 - 30.04 30.04 - 30.05	
23.0 mm		22.92 - 22.93 22.93 - 22.94 22.94 - 22.95 22.96 - 22.97	
47.8 mm		47.86 - 47.87 47.88 - 47.89 47.92 - 47.93 47.96 - 47.97	

53.0 mm		52.92 - 52.93 52.93 - 52.94 53.96 - 53.97 53.97 - 53.98	
65.0 mm		64.75 - 64.76 64.79 - 64.80 64.83 - 64.84	

Digital dial indicator

Objectives: At the end of this lesson you shall be able to
- **define digital dial indicator.**

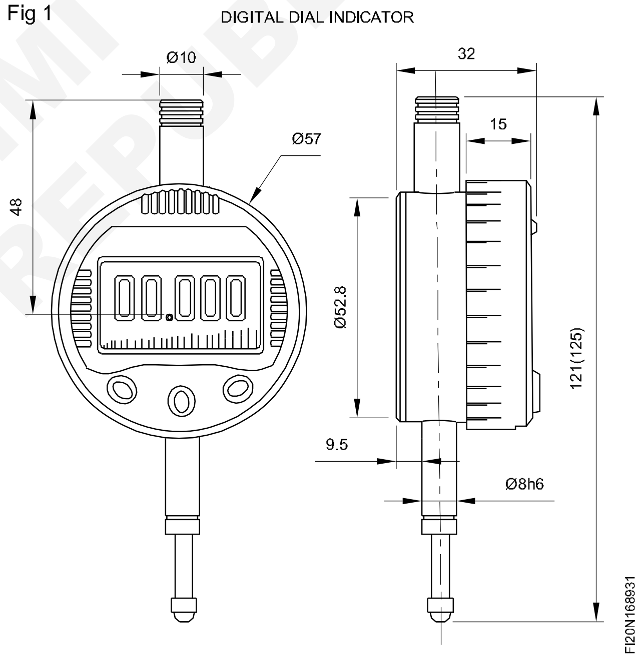
Digital dial indicator: With the advent of electronics, the clock face (dial) in some indicators are now a days replaced with digital displace (usually LCD's) and the dial readings are also replaced by linear encoders.

Digital indicators have some advantages over their analog predecessors, many models of digital indicator can record and transmit the data electronically through a computer, through an interface such as RS 232 or USB, this facilitates statistical process control (SPC), because a computer can record the measurement results in a tabular dataset (such as database table or spread sheet) and interpret them (by performing statistical analysis on them). This obviates manual recordings of long columns of numbers, which not only reduce the risk of the operator by avoiding errors (such as digit transpositions) but also really improves the productivity of the process by freeing the human efforts from time - consuming data recording and copying tasks.

Another advantages is that they can be switched between metric and british units by the press of a button, thus avoids the provision of separate unit conversion system.

Therefore the digital dial indicator is having more advantage over the ordinary dial indicator.

Fig 1



The digital dial indicator accuracy is 0.001mm in metric and 0.0001 inch in british.

Measurement of quality in cylindrical bore using three point internal micrometer

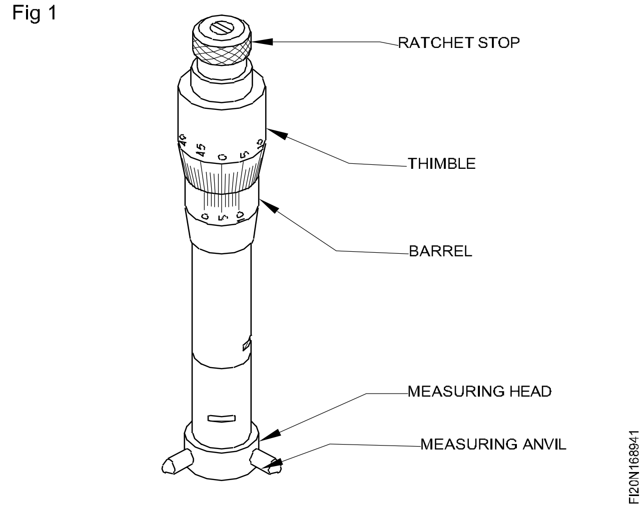
Objectives: This shall help you to
- **state the uses of a three-point internal micrometer**
- **identify the parts of a three-point internal micrometer**
- **state the features of the three-point internal micrometer.**

The three-point internal micrometers (Fig 1) are useful for:

- Measuring the diameters of through and blind holes.
- Checking cylindricity and roundness of bores.

The commonly used three-point internal micrometers have a least count of 0.005 mm.

Fig 1



Parts

- Measuring head consisting of three measuring anvils
- Ratchet stop
- Thimble
- Barrel

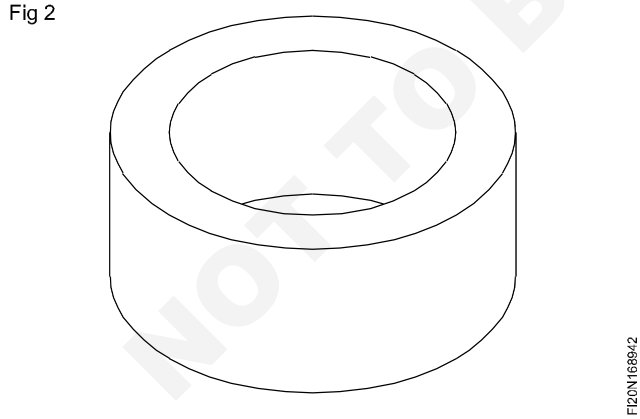
This micrometer has a cone spindle which advances when the thimble is rotated clockwise. The movement of the cone spindle makes the measuring anvils to move forward and backward uniformly. The three measuring anvils facilitate self-alignment of the instrument within the bore.

Three-point internal micrometers are available in different sizes permitting measurement within a range.

The ratchet stop permits uniform pressure between the anvils and the work-surface being measured.

These micrometers are provided with one or more zero setting rings. (Fig 2)

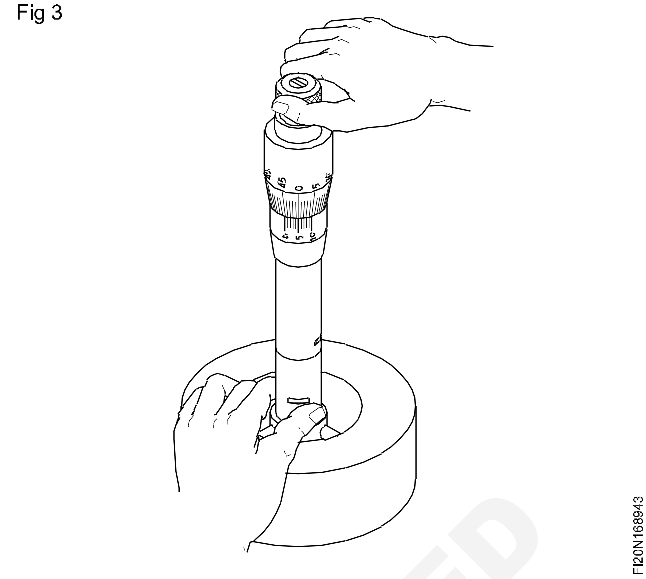
Fig 2



Before taking measurement, the zero setting has to be checked using setting ring. (Fig 3)

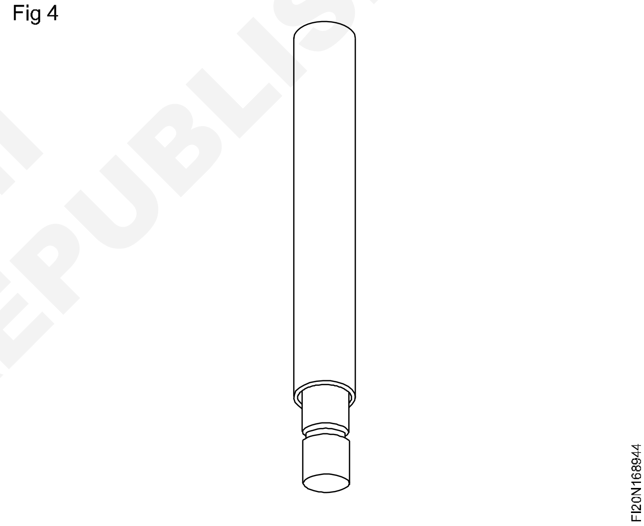
The position of the anvils can be reset by loosening the barrel using a screwdriver provided for this purpose.

Fig 3



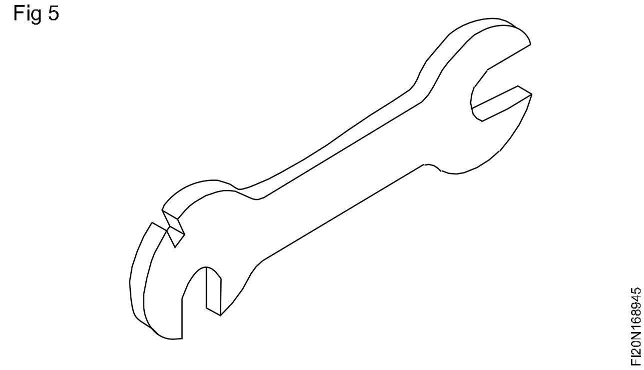
Depending on the depth of the bore the length of the micrometer cab be varied using an extension rod. (Fig 4)

Fig 4



A spanner is provided for changing the extension rods. (Fig 5)

Fig 5



These instruments are available in various sizes for different uses.

They are also available in analogue or digital read-outs.

Safety precautions to be observed while working on lathes

Objective: At the end of this lesson you shall be able to
- **state the precautions to be observed before starting work on a lathe, during work and after.**

Before starting the work

Ensure that the lubricating system is functioning.

The mating gears should be in proper mesh and the power feed levers are in neutral position.

The work area should be clean and tidy.

The safety guards should be in place.

During work

Never try to stop a rotating chuck with your hand. A rotating chuck is dangerous.

Switch off the machine before making any adjustment on the lathe.

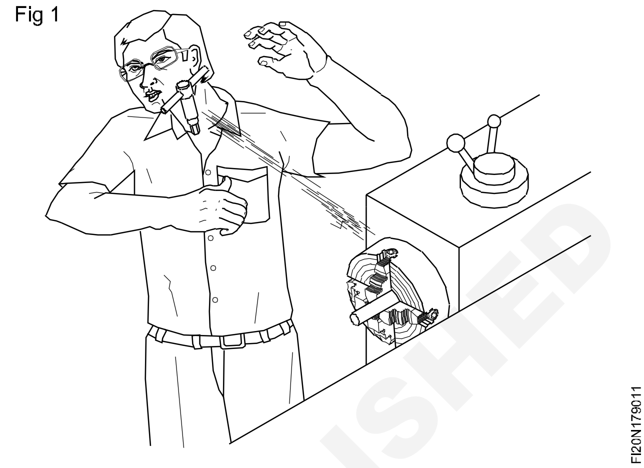
It is dangerous to leave the chuck key in the chuck. Remove it immediately after use. (Fig 1)

Single point tools are sharp and dangerous. Be extra careful when using them.

Chips are sharp and dangerous. Never remove them with your bare hands. Use a chip rake or brush.

You must always know where the emergency stop switch is.

Fig 1



After work

Clean the lathe with a brush and wipe with cotton waste.

Oil the bed ways and lubricating points.

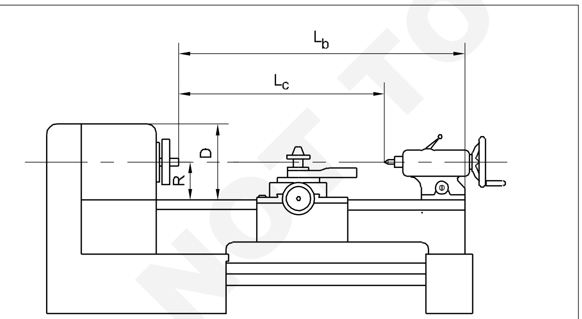
Clean the surroundings of the lathe, wipe the dirt and coolant and remove the swarf.

Specification of a centre lathe

Objective: At the end of this lesson you shall be able to
- **specify a centre lathe.**

Specification of a lathe (Fig 1)

Fig 1



R-RADIUS OF WORK (CENTRE HEIGHT OF LATHE)
D-DIAMETER OF WORK (SWING) L_C-LENGTH BETWEEN CENTRES L_b-LENGTH OF THE BED

A lathe is to be specified by the following.

The maximum diameter of a work that can be held.

The swing over bed. This is the perpendicular distance from the lathe axis to the top of the bed.

The length of the bed. The length of the bed-ways.

The maximum length of work that can be turned between centres.

The range of threads that can be cut. The capacity of the lathe. The swing over carriage.

The value of each division on the graduated collars of the cross-slide and compound slide.

Range of spindle speeds.

Range of feeds.

Size of the spindle bore.

Type of spindle nose.

The specifications help in communication between the seller and the buyer of the lathe.

It helps the operator of the lathe to decide whether the work in hand can be accommodated for performing the operations.

Constructional features of lathe

Objectives: At the end of this lesson you shall be able to
- **name the main parts of a lathe**
- **state the constructional features of lathe**
- **explain the principle of a lathe.**

Centre lathe is a machine which is used to bring the raw material to the required shape and size by metal removal. This is done by feeding a cutting tool against the direction of rotation of the work.

The machine tool on which turning is carried out is known as a lathe.

Lathe is a machine tool which holds the job in between the centre and rotates the job on its own axis. Due to this quality of holding the job from the centre and rotating the job, it is called centre lathe. Work can be held on a chuck and face plate. Chuck and face plate are mounted on the front of spindle. Cutting tool is fed against work after holding it in the tool post firmly. The work rotates on it own axis and tool is moved parallel to work. When tool moves parallel to axis it produces cylindrical surface and when it rotates at some angle, it produces taper surface.

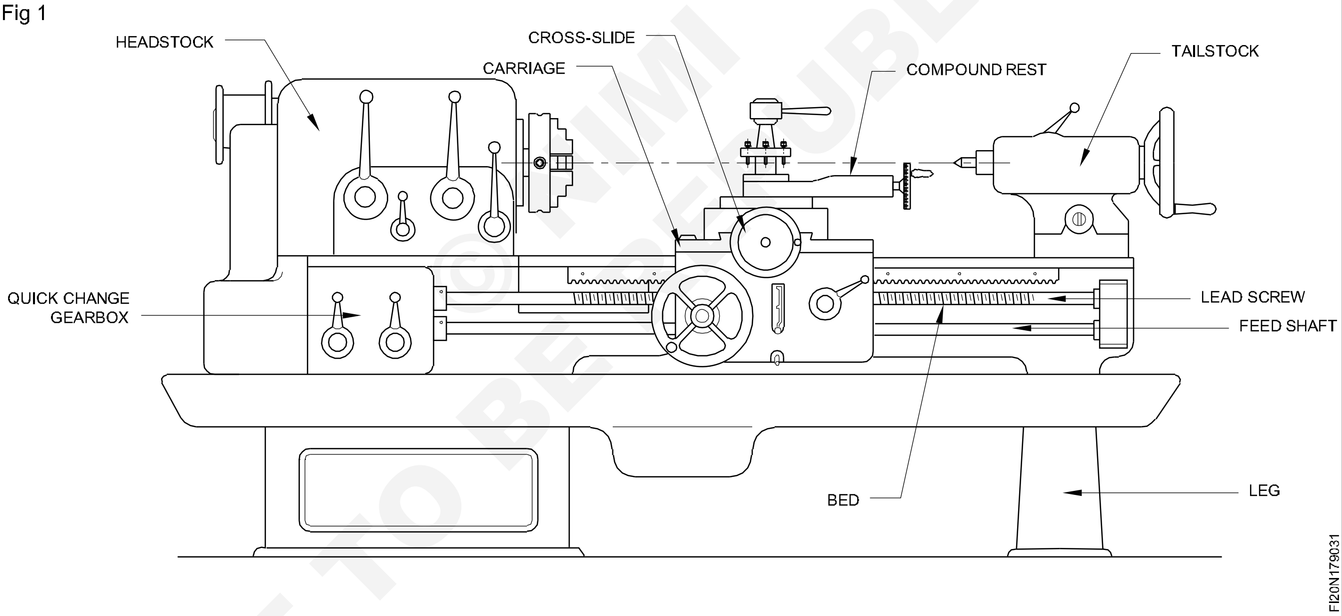
Constructional features of a lathe

A lathe should have provision :

- To hold the cutting tool, and feed it against the direction of rotation.
- To have parts, fixed and sliding, to get a relative movement of the cutting tool with respect to the rotation of the work.
- To have accessories and attachments for performing different operations.

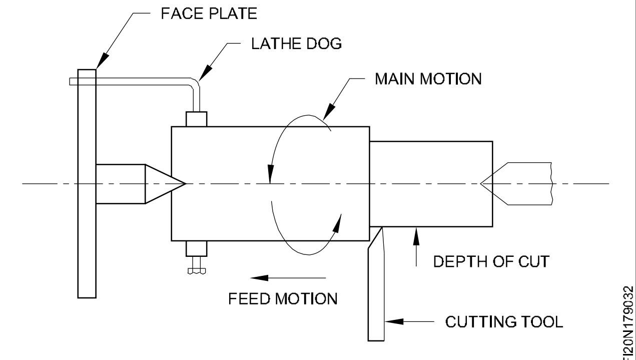
The following are the main parts of a lathe. (Fig 1)

Fig 1



- Headstock
- Tailstock
- Carriage
- Cross-slide
- Compound slide
- Bed
- Quick change gearbox
- Legs
- Feed shaft
- Lead screw

Fig 2



Working principle of Lathe (Fig 2)

Lathe main parts

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

Lathe bed

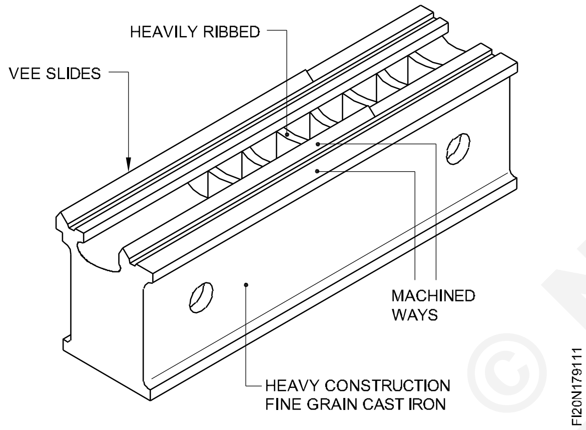
Functions of a lathe bed

The functions of a lathe bed are:

- To locate the fixed units in accurate relationship to each other.
- To provide slide-ways upon which the operating units can be moved.

Constructional features of a lathe bed (Fig 1)

Fig 1



The lathe bed generally consists of a single casting. In larger machines, the bed may be in two or more sections accurately assembled together. Web bracings are employed to increase the rigidity. For absorbing shock and vibration, the beds are made heavy.

A combined swarf and coolant tray is provided on lathes. This may be an integral part with the lathe bed.

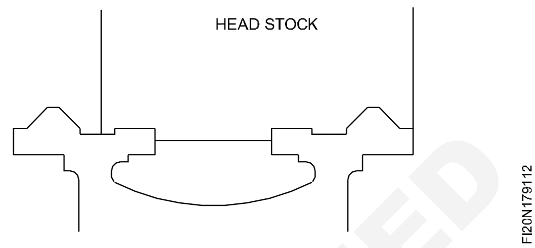
The bed is generally made by cast iron or welded sheet metal legs of box section. This provides the necessary working height for the lathe. Very often the electrical switch gear unit and the coolant pump assembly are housed in the box section of the legs at the headstock end.

Bed-ways (Fig 2)

The bed-ways or slide ways assist in accurate location and sliding of the accessories/parts mounted on this.

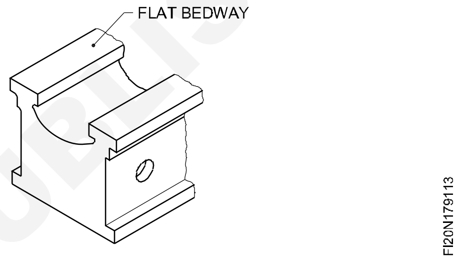
The bed-ways are of three types.

Fig 2



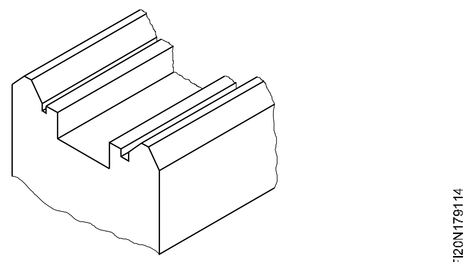
Flat bed-way (Fig 3)

Fig 3



'V' bed way (Fig 4)

Fig 4



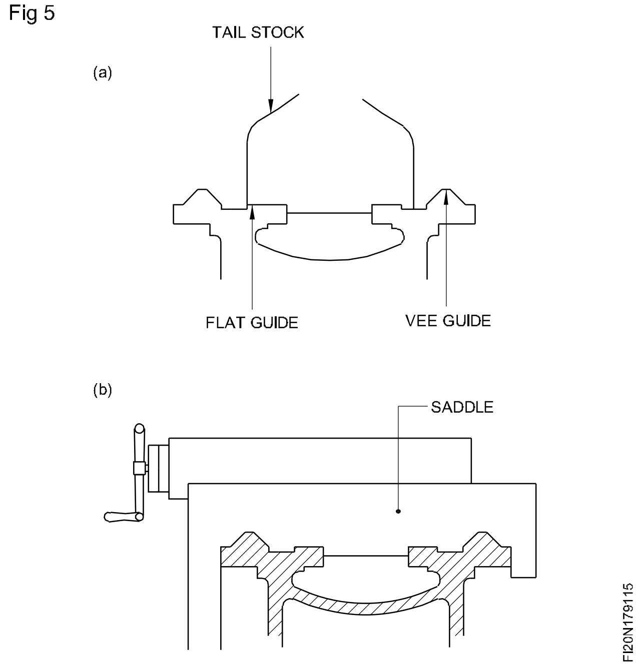
Combination bed way (Figs 5a & 5b)

Normally the bed-ways stop at a distance away from the headstock with a gap at this point. This enables to mount larger diameters of the work.

Some lathes have a detachable section of the bed, which can be fitted when desired, to enable the saddle to operate close to the headstock.

The bed-ways are highly finished by grinding. Some lathes have their bed-ways hand scraped. Some have their bed-ways hardened and ground. The wear-resisting qualities of bearing surfaces are improved by employing chilled iron castings.

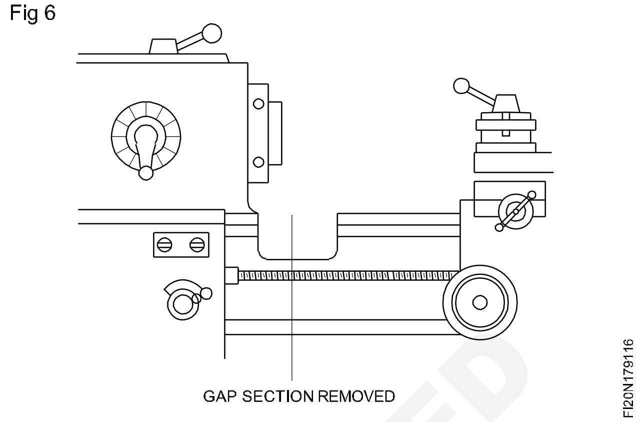
Fig 5



The beds are mostly made up of closely ground, grey cast iron.

Gap bedway (Fig 6)

Fig 6

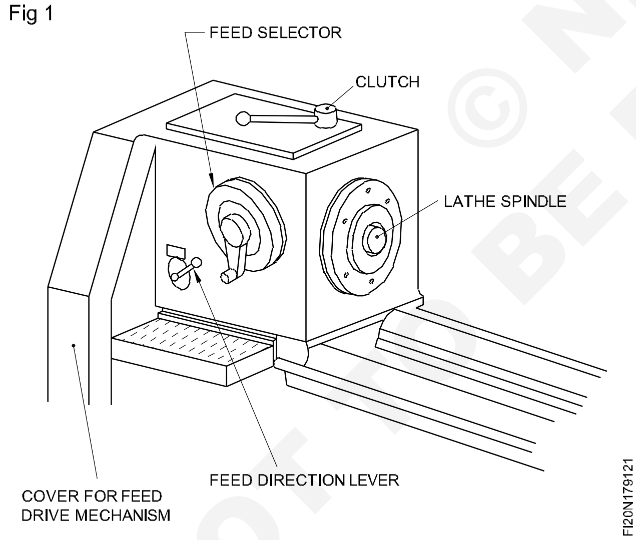


Headstock

Objectives: At the end of this lesson you shall be able to
- **state the function of the headstock**
- **differentiate between cone pulley headstock and all geared headstock.**

Functions (Fig 1)

Fig 1



To provide a means to assemble the work-holding devices. Transmit the drive from the main motor to the work.

To accommodate shafts, gears and levers for a wide range of varying work speeds.

To ensure arrangement for lubricating the gears, shafts and bearings.

Types of headstocks

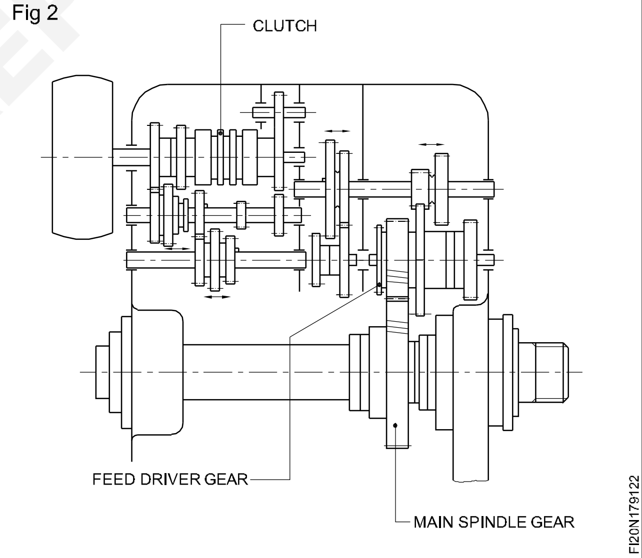
The following are the two types of headstocks.

1 All geared headstock.

2 Cone pulley headstock.

All geared headstock (Fig 2)

Fig 2



It is a box section casting having a removable top cover. It has internal webs for stiffening, and to take shaft bearings. It has an input shaft which is connected by means of 'V' belts to the main motor, and it runs at a constant speed. It is equipped with clutches and a brake.

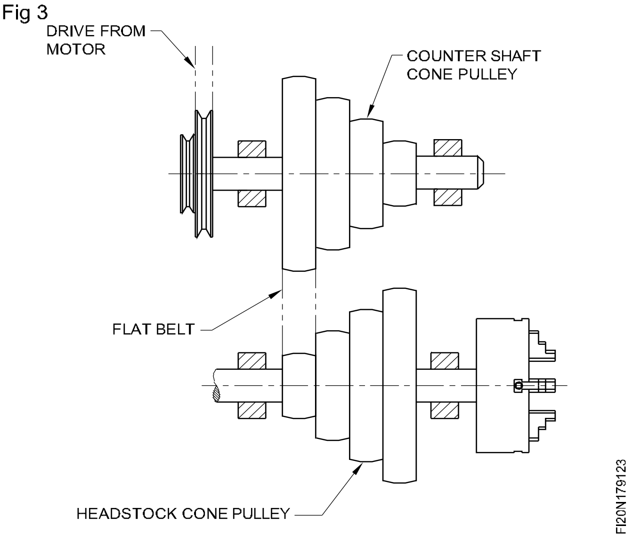
There may be two or more intermediate shafts on which sliding gears are mounted. The main spindle is the last driven shaft in the headstock assembly. The nose of the spindle is outside the headstock casting, and is designed to accommodate the work-holding devices.

The levers operating the forks for the sliding gears are situated outside in front of the headstock casting.

In the all-geared headstock, lubricating oil is filled for splash lubrication of the internal gears. A sight glass with an oil level mark is provided to see the oil level.

Cone pulley headstock (Fig 3)

Fig 3



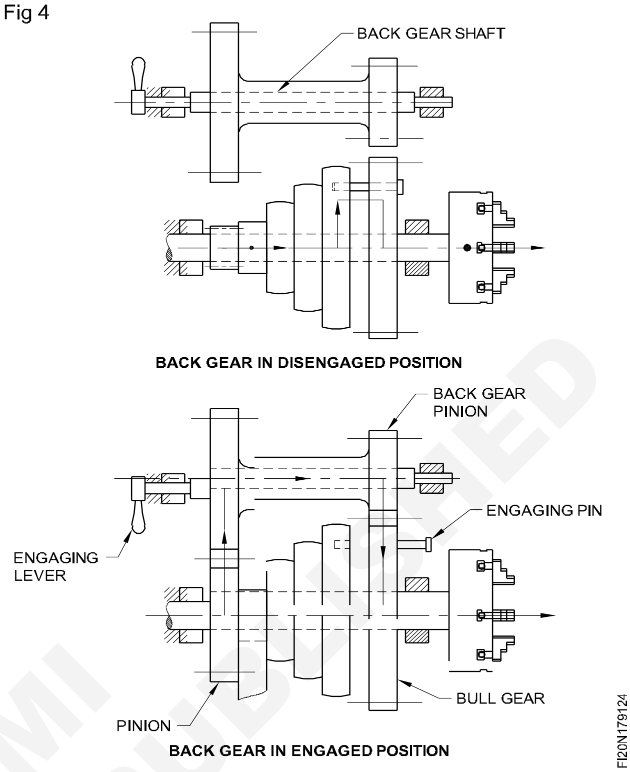
It has a stepped cone pulley mounted on the main spindle, and it is free to revolve. It is connected by means of a flat belt to a similar cone pulley, with steps arranged in the reverse order. This cone pulley gets the drive from the main motor.

The spindle is mounted on the bearing on the headstock casting and has a gear wheel called 'bull gear' keyed to it. A pinion is coupled to the cone pulley.

The back gear unit has a shaft which carries a gear and a pinion. The number of teeth of the gear and pinion on the back gear shaft corresponds to the number of teeth on the bull gear and pinion on the cone pulley. The axis of the back gear shaft is parallel to the axis of the main spindle. The back gear is engaged or disengaged with the cone pulley system by means of a lever. The back gear unit is engaged for reducing the spindle speeds. (Fig 4)

A three-stepped cone pulley headstock provides 3 direct ranges of speeds through a belt connection. With the back gear in engagement, 3 further ranges of reduced speeds can be obtained.

Fig 4



Advantages

- Can take up heavy load.
- Less noise during working.
- Easy to maintain.

Disadvantages

The number of spindle speeds is limited to the number of steps in the cone pulley.

It takes time to change the spindle speeds.

Carriage

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

Carriage is the feature of a lathe that provides the method of holding and moving the cutting tool. (Fig 1) It can be locked at any desired position on the lathe bed. It consists of two major parts namely, apron and saddle.

Apron (Fig 2)

The apron is bolted to the front of the saddle. It contains mechanism for moving and controlling the carriage. The main parts of an apron are :

- Traversing hand wheel
- Feed lever
- Feed selector
- Lead screw engagement lever.

Fig 1

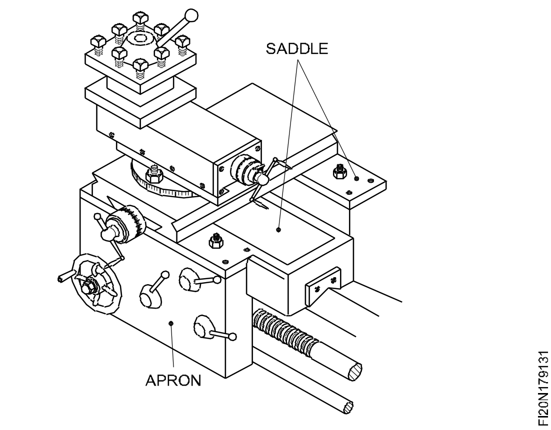
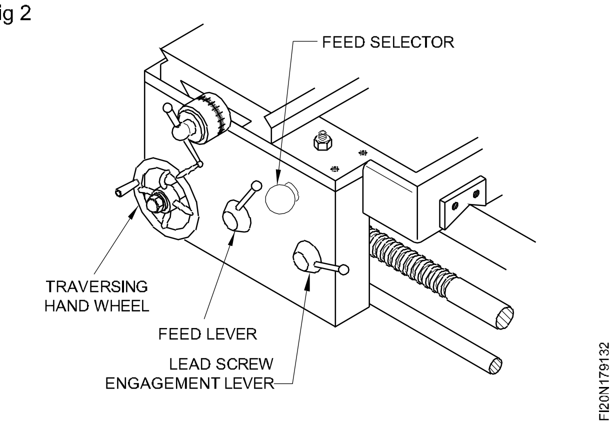


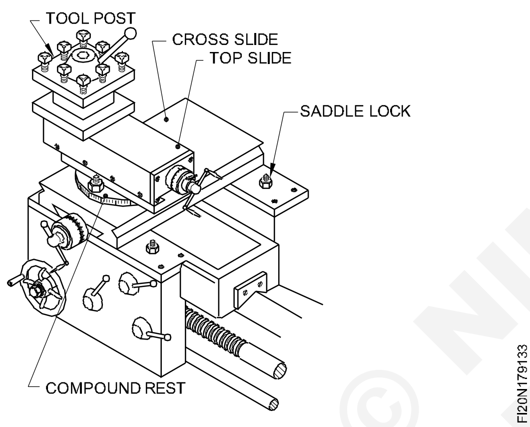
Fig 2



Saddle (Fig 3)

It is a 'H' shaped casting having 'V' guide grooves at the bottom face, corresponding to the lathe bed-ways for mounting on the lathe bed and for sliding.

Fig 3



Parts of a saddle

Cross-slide

The cross-slide is mounted on the top of the saddle, and it provides cross movement for the tool. This is fitted at right angles to the bed and is moved by means of a screwed spindle, fitted with a handle. A graduated collar, mounted on the screw rod along with the hand wheel, helps to set the fine movements of the cross- slide.

Compound rest

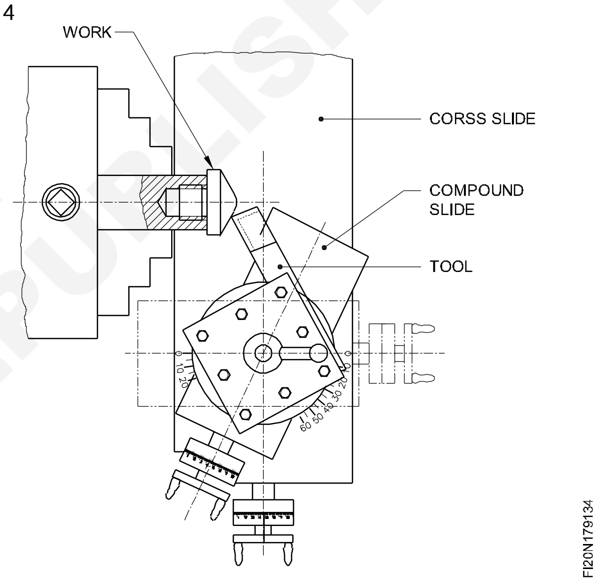
The compound rest is fitted on the top and to the front of the cross-slide. The compound rest can be swiveled horizontally through 360°.

Top slide

The top slide is fitted on the top of the compound rest. It supports the tool post which holds the cutting tool. The top slide provides a limited horizontal movement for the cutting tool.

By swiveled the compound rest, the top slide can be set at an angle to the cross-slide (Fig 4). Usually the compound rest is set in such a way that the top slide is at right angles to the cross-slide.

Fig 4



Tailstock

Objectives: At the end of this lesson you shall be able to
- **list the parts of a tailstock**
- **state the uses of a tailstock**
- **explain the function of a tailstock.**

Tailstock

It is a sliding unit on the bed-ways of the lathe bed. It is situated on the right hand side of the lathe. It is made in two parts namely the `base' and the `body'. The base bottom is machined accurately and has `V' grooves corresponding to the bed-ways. It can slide over the bed and can be clamped at any position on the bed by means of the clamping unit. The body of the tailstock is assembled to the base. Graduations are marked on the rear end of the base and a zero line is marked on the body.

When both zero lines coincide, the axis of the tailstock is in line with the axis of headstock.

The body and base are made out of cast iron. The parts of a tailstock are: (Fig 1)

a Base

b Body

c Spindle (barrel)

d Spindle locking lever

e Operating screw rod

f Operating nut

g Tailstock hand wheel

h Key

i Set screw/set over screw

j Clamping bolt

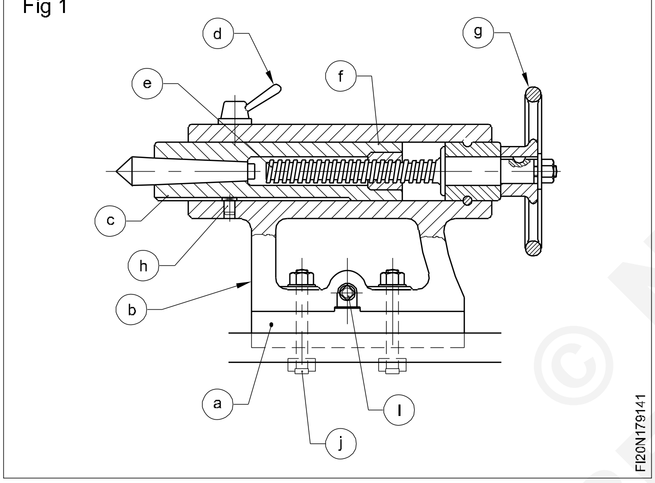
Functioning of a tailstock

By rotating the hand wheel, the barrel can be moved forward or backward. The barrel can be locked in any required position. The hollow end of the barrel at the front is provided with a Morse taper to accommodate the cutting tools with a taper shank. Graduations are sometimes marked on the barrel to indicate the movement of the barrel. With the help of the adjusting screws, the body can be moved over the base laterally, and the amount of movement may be read approximately referring to the graduations marked. This arrangement is to offset the centre of the tailstock as required for taper turning.

Purpose of the tailstock

To accommodate the dead center to support lengthy work to carry out lathe operations. (Fig 2)

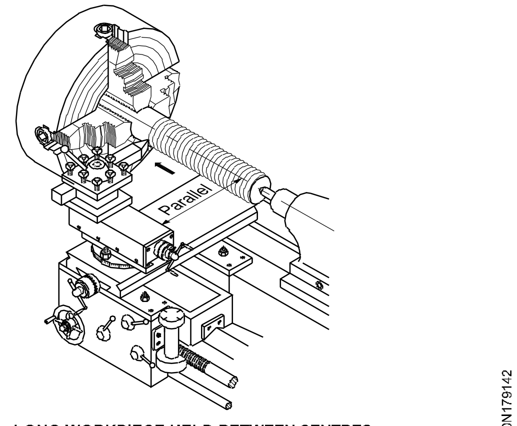
Fig 1



To hold cutting tools like drills, reamers, drill chucks provided with taper shank. (Fig 3)

To turn external taper by offsetting the body of the tailstock with respect to the base. (Fig 4)

Fig 2



LONG WORKPIECE HELD BETWEEN CENTRES

Fig 3

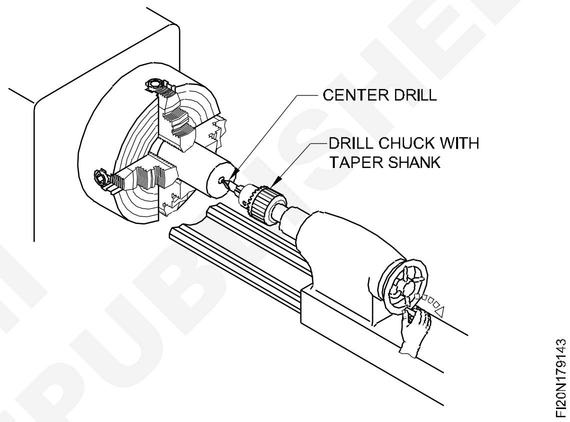
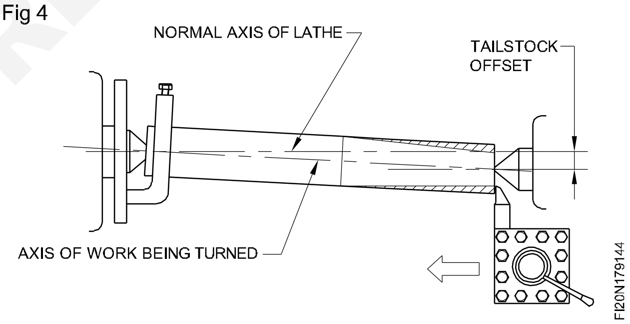


Fig 4

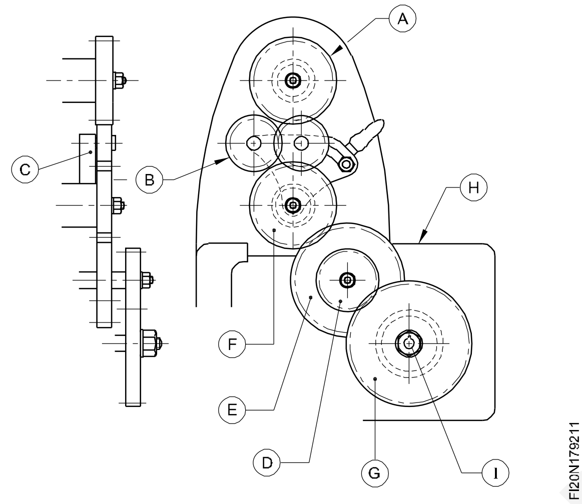


Feed & thread cutting mechanism

Objectives: At the end of this lesson you shall be able to
- **name the parts of the feeding mechanism**
- **state the functional features of the feeding mechanism.**

Feed mechanism (Fig 1)

Fig 1



The feed mechanism of a lathe enables automatic feeding for the tool longitudinally and transversely as needed. By automatic feeding the finish on the work will be better, the feeding of the tool will be at a uniform continuous rate and it takes less time to finish the operation while manual labour is avoided.

The feed mechanism comprises the following.

- Spindle gear (A)
- Tumbler gear unit (B)
- Fixed stud gear (C)
- Change gear unit (DEFG)
- Quick change gear box (H)
- Feed shaft / Lead screw (I)
- Apron mechanism (Fig 5)

The proportionate tool movement for each revolution of work is achieved through all the above units of the feed mechanism.

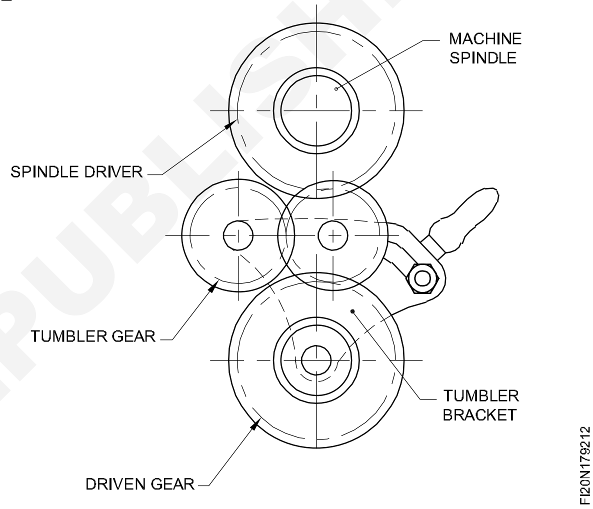
Spindle gear

The spindle gear is fitted to the main spindle, and it is outside the headstock casting. It revolves along with the main spindle.

Tumber gear unit

The tumbler gear unit set of three gears, having the same number of teeth and it connects the spindle gear to the fixed gear. It is also called the reversing gear unit as it is used to change the direction of feed of the tool for the same direction of rotation of the spindle.It can be engaged and disengaged with the fixed stud gear by the operation of the hand lever provided in the unit. (Fig 2)

Fig 2



The fixed stud gear

The fixed stud gear gets the drive from the main spindle gear through the tumbler gear unit and runs at the same number of revolutions per minute as the spindle gear on most lathes.

Change gear unit

The fixed stud gear transmits its drive through a change gear unit to the quick change gear box. The change gear unit has provision for changing the driver, the driven and the idler gears from the set of change gears available for the purpose of feed changing as an additional unit. (Fig 3)

Quick change gear box

The quick change gear box is provided with levers outside the box casting, and by shifting the levers, different gears are brought in mesh so that different feed rates can be given to the tool. A chart listing the different feed rates for the different positions of the levers is fixed to the casting, and by referring to the table, the levers may be engaged in position for the required feed rate. (Fig 4)

Fig 3

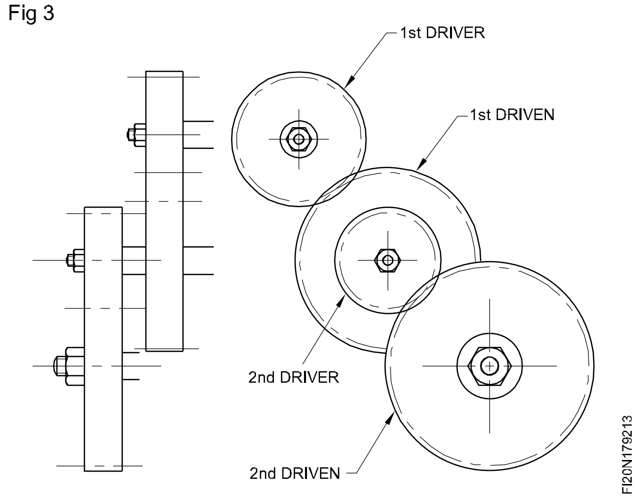
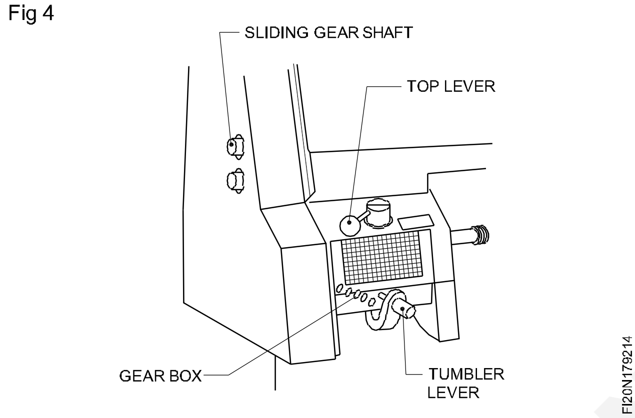


Fig 4



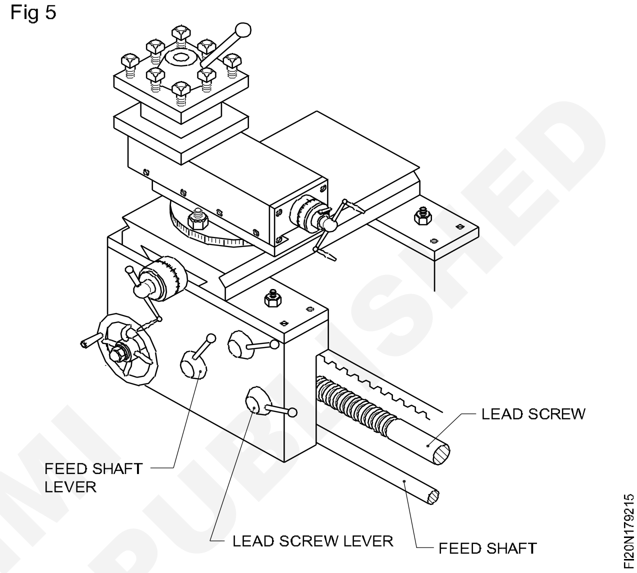
The feed shaft

The feed shaft gets its drive from the quick change gear box, and through the apron mechanism, the rotary movement of the feed shaft is converted into the linear movement of the tool.

The apron mechanism

The apron mechanism has the arrangement for transmitting the drive from the feed shaft to the saddle for longitudinal movement of the tool or to the cross-slide for the transverse movement of the tool. (Fig 5)

Fig 5



Thread cutting with simple and compound gear trains

Objective: At the end of this lesson you shall be able to
- **thread cutting with simple and compount gear trains.**

Change gear train

Change gear train is a train of gears serving the purpose of connecting the fixed stud gear to the quick change gearbox. The lathe is generally supplied with a set of gears which can be utilized to have a different ratio of motion between the spindle and the lead screw during thread cutting. The gears which are utilized for this purpose comprise the change gear train.

The change gear tran consists of driver and driven gears and idler gears.

Simple gear train

A simple gear train is a change gear train having only one driver and one driven wheel. Between the driver and the driven wheel, there may be an idler gear which does not affect the gear ratio. Its purpose is just to link the driver and the driven gears, as well as to get the desired direction to the driven wheel.

Fig 1 shows an arrangement of a simple gear train.

Fig 1

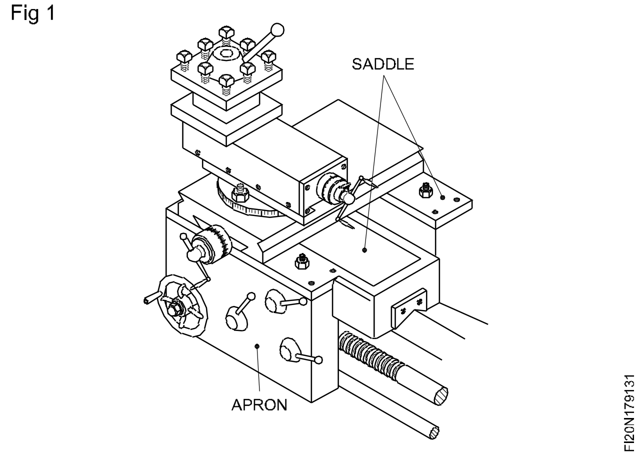
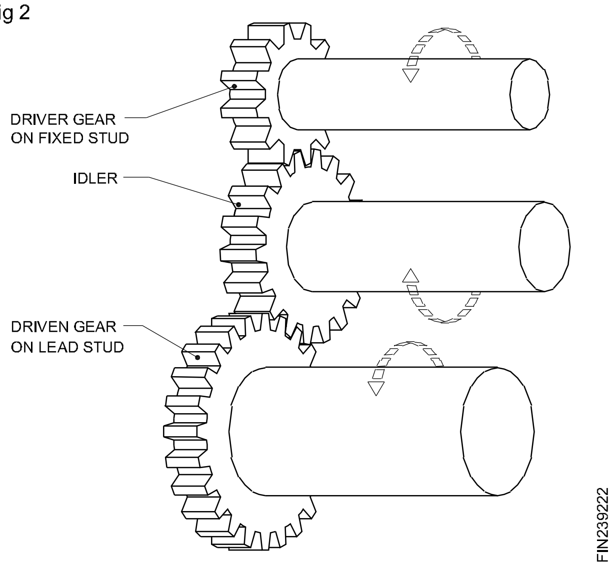


Fig 2 shows mountings of the driver and driven gears in a lathe.

Fig 2



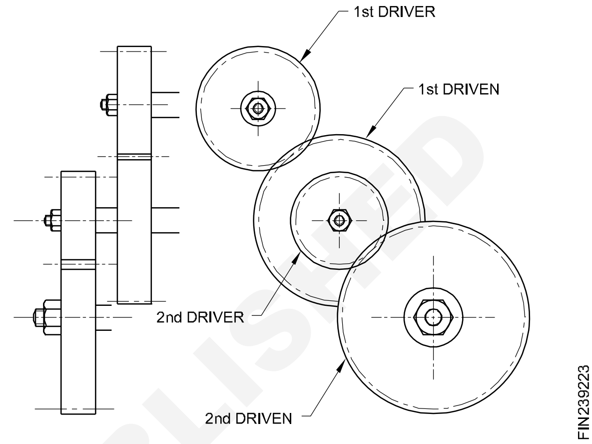
The driver gear and the driven gear are changed according to the pitch of the thread to be cut on the job.

Compound gear train

Sometimes, for the required ratio of motion between the spindle and the lead screw, it is not possible to obtain one driver and one driven wheel. The ratio is split up and then the change gears are obtained from the available set of gears which will result in having more than one driver and one driven wheel. Such a change gear tain is called a compound gear train.

Fig 3 shows the arrangement of a compound gear train.

Fig 3



Holding the job between centre and work with catch plate and dog

Objectives: At the end of this lesson you shall be able to
- **preparing work for turning between centre**
- **to set the catch plate**
- **working with catch plate and dog**

Turning work in-between centres avoids the need for truing the work. The work turned will be parallel through-out. But it requires great skill to perform operations especially like knurling, thread cutting, undercutting. It is limited to external operations only. The work needs the following preparations to be carried out before the actual operations are to be performed.

Face both sides of the work, and maintain the total length accurately within limits.

Choose the correct size and type of centre drill and do centre drilling at both ends.

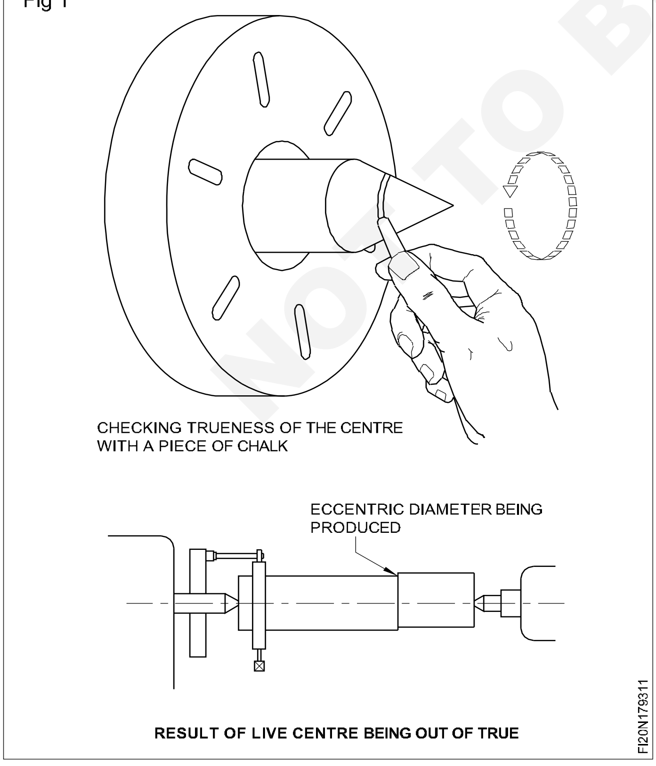
Diamantle the chuck from the spindle nose and assemble the driving plate or catch plate.

Assemble the spindle sleeve to the spindle nose and fix live centre to the sleeve.

Ensure that the spindle sleeve and live centre are free from damages, burrs and are thoroughly cleaned before assembly.

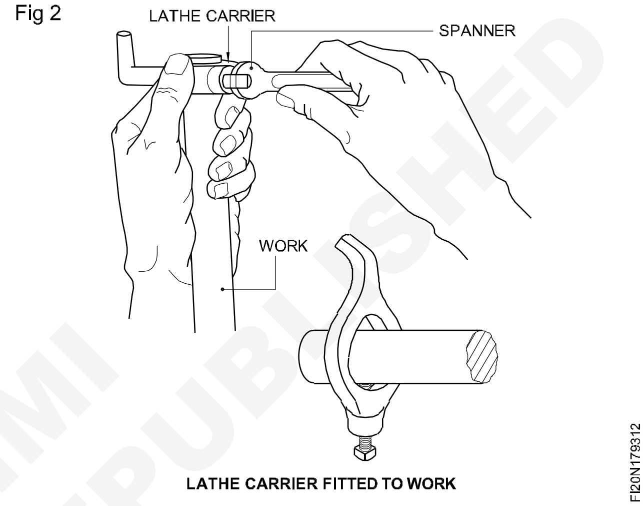
Check for the true running of the live centre. (Fig 1)

Fig 1



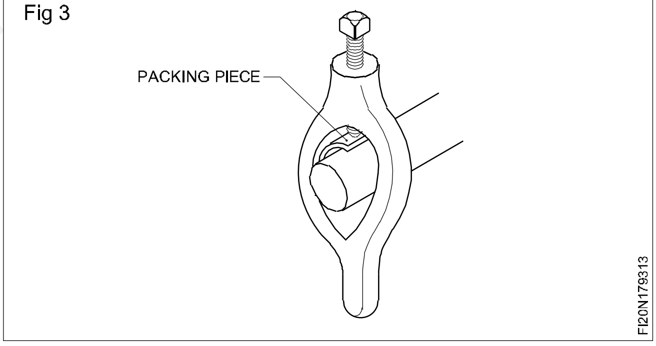
Select a suitable lathe carrier according to the diameter of the work and fasten it on one end of the work with the bent tail pointing outwards. (Fig 2)

Fig 2



Work that has a finished surface should be protected by inserting a small sheet of copper or brass between the end of the screw in the carrier and the work. (Fig 3)

Fig 3



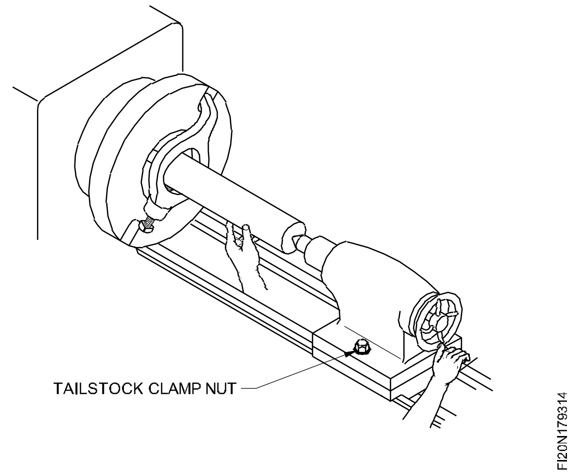
Apply a suitable lubricant (soft grease) to the centre hole of the workpiece to be engaged by the tailstock dead centre.

Move the tailstock to a position on the bed to suit the length of the workpiece. The tailstock spindle should extend approximately 60 to 100 mm beyond the tailstock.

Ensure there is sufficient space for the saddle to operate before clamping the tailstock to the bed.

Clamp the tailstock in position by tightening the tailstock clamp nut. (Fig 4)

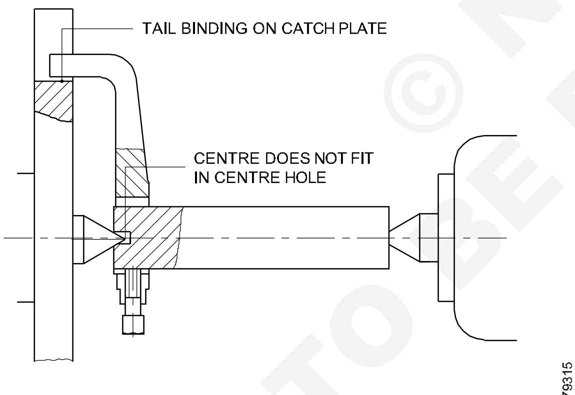
Fig 4



Engage the work-centre hole with the point of live centre and with the tail of the lathe carrier in the slot in the catch plate. Hold the work in this position with hand.

Ensure that the tail of the lathe carrier does not rest on the bottom of the slot in the driving plate. This will not permit the centre entering the centre hole of the work for proper seating. (Fig 5)

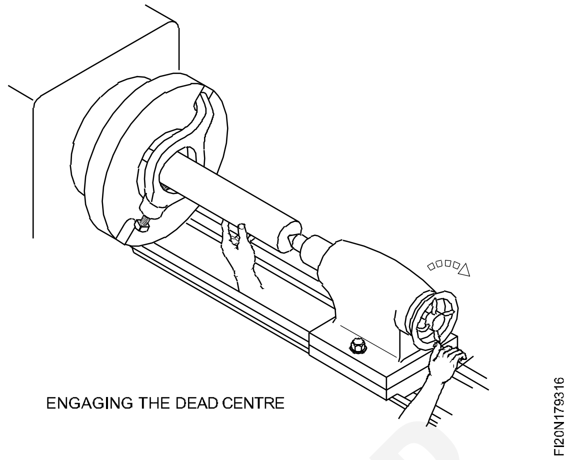
Fig 5



A LATHE CARRIER BINDING IN THE DRIVE PLATE CAUSES INACCURACIES SINCE THE WORK IS FORCED OFF THE LATHE CENTRE

Advance the tailstock spindle by the hand wheel rotation until the point of dead centre enters the centre hole of the work with proper seating eliminating all endwise movement. (Fig 6)

Fig 6



ENGAGING THE DEAD CENTRE

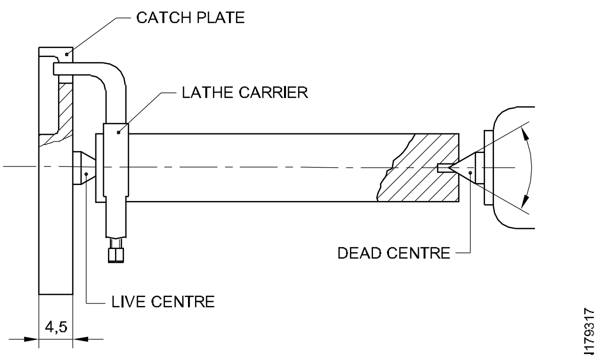
Move the tail of the carrier back and forth. At the same time adjust the hand wheel until only a slight resistance is felt.

Tighten the tailstock spindle clamp at this position and check that the resistance does not change. Set the machine for about 250 r.p.m. and allow the work to run for a few seconds.

Check once again for the resistance and adjust the tailstock spindle, if needed.

Work is now ready for operations. (Fig 7)

Fig 7



WORK HELD BETWEEN CENTRES

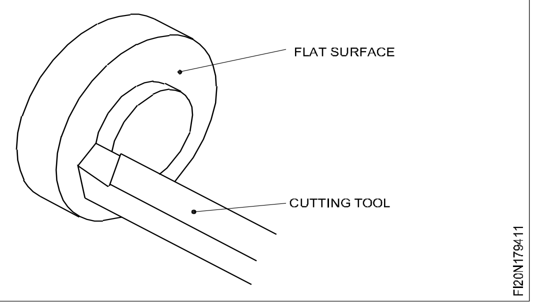
Before holding the work in between centres ensure that the centres are aligned.

Simple description of facing and roughing tool

Objectives: At the end of this lesson you shall be able to
- **state the purpose of facing**
- **setting the rough facing tool**
- **state the reasons for the defects**
- **state the remedies to overcome the defects in facing**

Facing: This is an operation of removing metal from the work-face by feeding the tool at right angles to the axis of the work. (Fig 1)

Fig 1



Purpose of facing

- To have a reference plane to mark and measure the step lengths of the work.
- To have a face at right angle to the axis of the work.
- To remove the rough surface on the faces of the work and have finished faces instead.
- To maintain the total length of the work.

Facing may be rough or finish facing. Rough facing is done to remove the excess metal on the face of the work by coarse feeding with more depth of cut, leaving sufficient metal for finishing. Rough facing is done by feeding the tool from the periphery of work towards the centre of the work. Finish facing is the operation to have a smooth face by removing the rough surface produced by the rough facing.

Finish facing is done by feeding the tool from the centre of the work towards the periphery. (Figs 2a and 2b)

Rough facing is done by choosing a spindle RPM according to the average diameter of the work, the recommended cutting speed, with a coarse feed and more depth of cut.

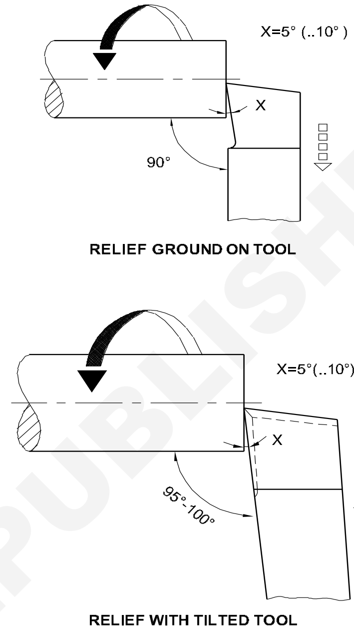
Finish facing is done by choosing a cutting speed about twice that of the cutting speed for roughing, with a fine feed rate of 0.05 mm approximately and with a depth of cut of not more than 0.1 mm.

The following are the defects found in facing work (Fig 3)

A concave face: This is caused by the tool digging into the work during the feeding as the tool is not clamped rigidly. By clamping the tool rigidly with minimum overhang, this defect can be avoided.

A convex face: This is caused by the blunt cutting edge of the tool and the carriage not being locked. To avoid this

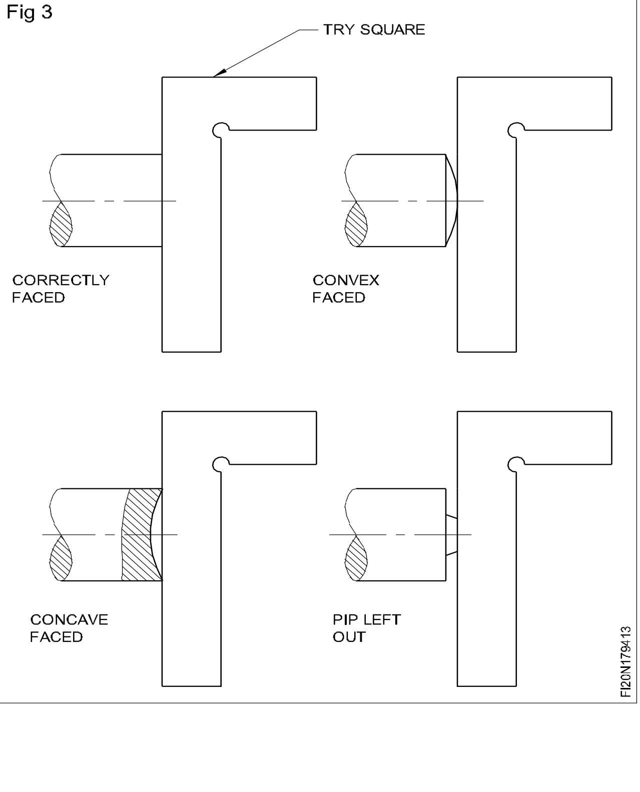
Fig 2



defect, re-sharpen the tool and use it; Also lock the carriage to the bed of the lathe.

A pip left in the centre : This is due to the tool not being set to the correct centre height. By placing the tool to the centre height, this defect can be avoided.

Fig 3



Nomenclature of single point cutting tools and multi point cutting tools

Objectives: At the end of this lesson you shall be able to
- **name the types of cutting tool**
- **state the nomenclature of single point cutting tools**
- **state the nomenclaure of multi point cutting tools**

Lathe cutting tools are divided into two groups. These are

1 Single point cutting tools

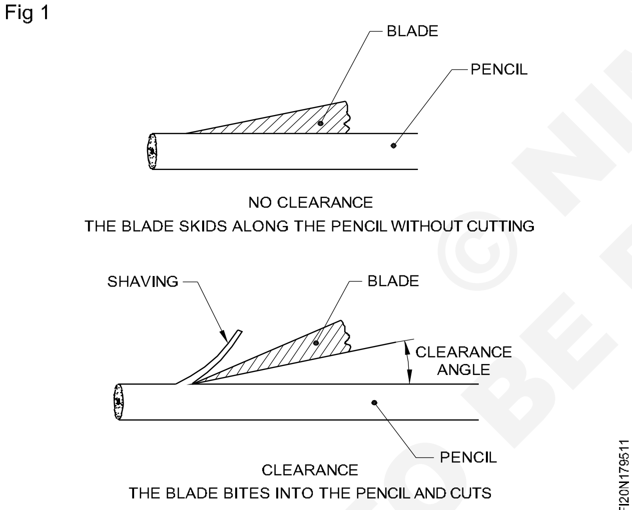
2 Multi point cutting tools

Single point cutting tool nomenclature

The tool acts like a wedge during turning. The wedge shaped cutting edge penetrates into the work and removes the metal. This necessitates the grinding of a tool cutting edge to a wedge shape.

When we sharpen a pencil with a pen knife by trial and error, we find that the knife must be presented to the wood at a definite angle, if success is to be achieved. (Fig 1)

Fig 1



If, in the place of a wooden pencil, a piece of soft metal such as brass is cut, it will be found that the cutting edge of the blade soon becomes blunt, and the cutting edge gets crumbled. For the blade to cut the brass successfully, the cutting edge must be ground to a less acute angle. (Fig 2)

The angle shown in Fig 1 is called as clearance angle and that shown in Fig 2 is a wedge angle.

Angles ground on a lathe cutting tool (Fig 3)

All the angles given below may not be located or found in every tool. As an example a roughing tool is chosen. The angles and clearances ground on this tool are:

1 Approach angle

2 Trail angle

3 Top rake angle

Fig 2

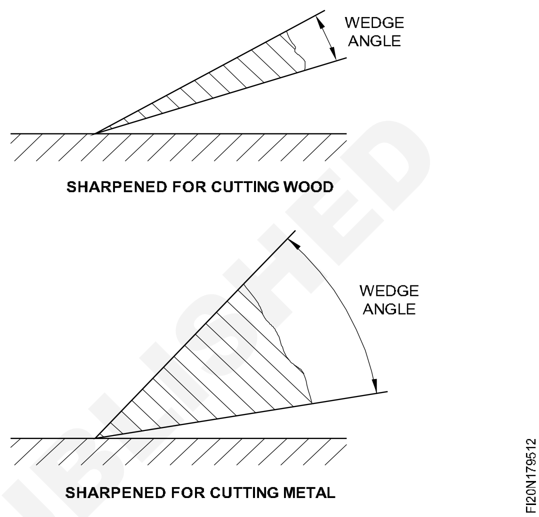
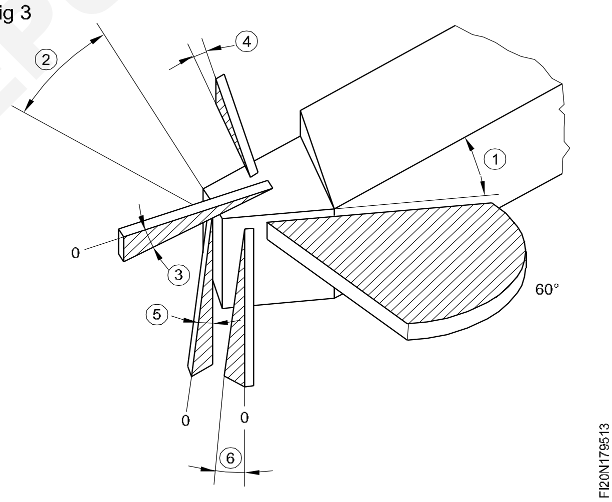


Fig 3



4 Side rake angle

5 Front clearance angle

6 Side clearance angle

Multi point cutting tools used in lathe are:

- Drill
- Reamed
- Tap
- Die

Tool selection based on different requirements

Objectives: At the end of this lesson you shall be able to
- **state the qualities of good cutting tool material**
- **state the factors to be remembered when selecting tool**
- **name the different types of tool**
- **name the shapes of the tool**

Cutting tool materials

Tool materials should be:

- Harder and stronger than the material being cut
- Tough to resist shock loads
- Resistant to abrasion thus contributing to long tool life.

Cutting tool material should possess the following qualities.

- Cold hardness
- Red hardness
- Toughness

Cold hardness

It is the amount of hardness possessed by a material at normal temperature. Hardness is the property by which it can cut/scratch other metals. When hardness increases, brittleness also increases, and a material, which has too much of cold hardness, is not suitable for the manufacture of cutting tools.

Red hardness

It is the ability of a tool material to retain most of its cold hardness property even at very high temperatures. While machining, the friction between the tool and the work, the tool and the chips, causes heat to be generated, and the tool loses its hardness, and its efficiency to cut diminishes. If a tool maintains its cutting efficiency even at increased temperatures during cutting, it can be said that it possesses the red hardness property.

Toughness

The property to resist breakage due to sudden load that results during metal cutting is termed as `toughness' This will reduce the breakage of the cutting edges of tools.

The following factors are to be considered, when selecting a tool material.

- Material to be machined.
- Condition of the machine tool.(rigidity and efficiency)
- The total quantity of production and the rate of production.
- The dimensional accuracy required and the quality of surface finish.
- The amount of coolant applied and method of application.
- Condition and form of material to be machined.

Grouping of tool material

The three groups under which tool materials fall are:

- ferrous tool materials
- non-ferrous tool materials
- non-metallic tool materials.

Ferrous tool materials

These materials have iron as their chief constituent. High carbon steel (tool steel) and high speed steel belong to this group.

Non-ferrous tool materials

These do not have iron, and they are formed by alloying elements like tungsten, vanadium and molybdenum. Stellate belongs to this group.

Carbides

These materials are also non-ferrous. They are manufactured by powder metallurgy technique. Carbon and tungsten are the chief alloying elements.

Non-metallic materials

These tool materials are made out of non metals. Ceramics and diamonds belong to this group.

High carbon steel is the first tool material introduced for manufacturing cutting tools. It has poor red hardness property, and it loses its cutting efficiency very quickly. Alloying elements like tungsten, chromium and vanadium, are used to produce high speed steel tool material. Its red hardness property is more than that of high carbon steel.

High speed steel is used for making solid tools, brazed tools and inserted bits. It is costlier than high carbon steel. Carbide cutting tools can retain their hardness at very high temperatures, and their cutting efficiency is higher than that of high speed steel. Due to its brittleness and cost, a carbide tool cannot be used as a solid tool. It is used as a brazed tool and throw away tool bit.

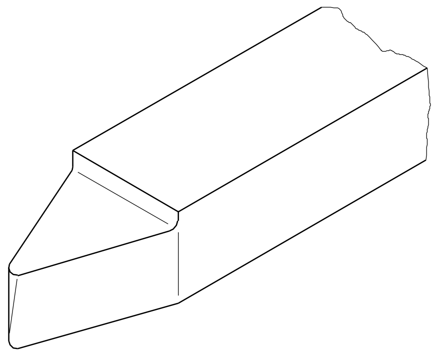
Lathe cutting tool types

The tools used on lathes are

- Solid type tools
- Brazed type tools
- Inserted bits with holders
- Throw-away type tools. (carbide)

Solid tools (Fig 1)

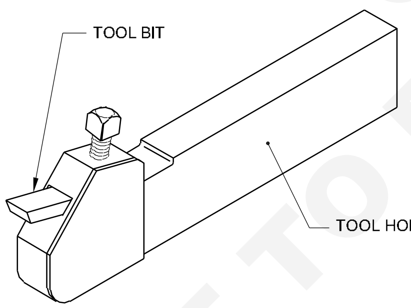
Fig 1



These are tools having their cutting edges ground on solid bits of square, rectangular and round cross-sections. Most of the lathe cutting tools are of the solid type, and high carbon steel and high speed steel tools are used. The length and cross-section of the tool depend upon the capacity of the machine, the type of tool post and the nature of the operation.

Inserted bits with holders (Fig 2)

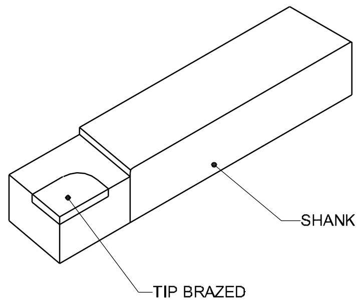
Fig 2



Solid high speed steel tools are costly; hence, they are sometimes used as inserted bits. These bits are small in sizes, and are inserted in the holes of the holder. These holders are held and clamped in the tool posts to carry out the operations.The disadvantage in this type of tools is that the rigidity of the tool is poor.

Brazed tools (Fig 3)

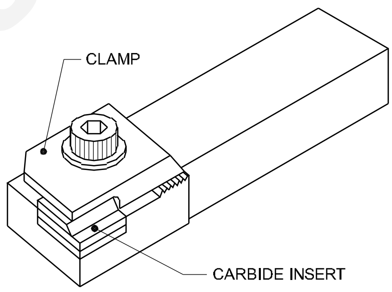
Fig 3



These tools are made up of two different metals. The cutting portions of these tools are of cutting tool materials, and the body of the tools do not possess any cutting ability, and are tough. Tungsten carbide tools are mostly of the brazed type. Tungsten carbide bits of square, rectangular and triangular shape are brazed to the tips of the shank. The tips of the shank metal pieces are machined on the top surface according to the shape of the fits so as to accomodate the carbide bits. These tools are economical, and give better rigidity for the tools than the inserted bits clamped in the tool-holders. This is applicable to high speed steel brazed tools also.

Throw-away type tools (Fig 4)

Fig 4



Carbide brazed tools when blunt or broken need grinding which is time consuming and expensive. Hence, they are used as throw-away inserts in mass production. Special tool- holders are needed and the carbide bits of rectangular, square or triangular shapes are clamped in the seating faces and machined on this type of special holders.

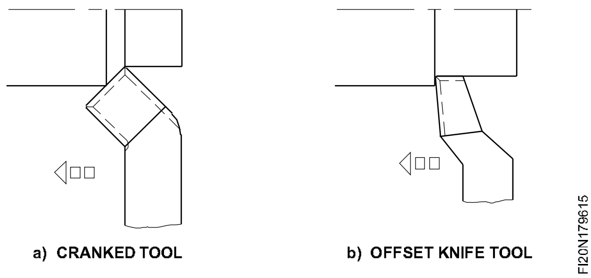
The seating faces are machined in such a way that the rake and clearances needed for the cutting bits are automatically achieved when the bits are clamped.

Lathe cutting tool shapes

Lathe cutting tools are available in a variety of shapes for performing different operations. Some of the lathe cutting tools generally used are:

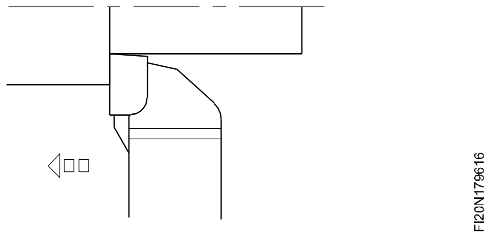
- Facing tool (Figs 5a and 5b)

Fig 5



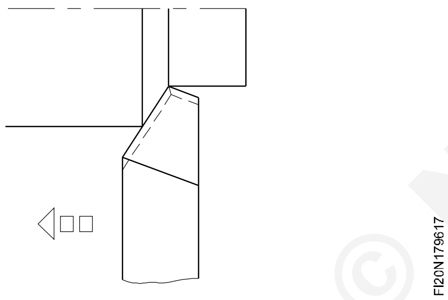
- Knife edge tool (Fig 6)

Fig 6



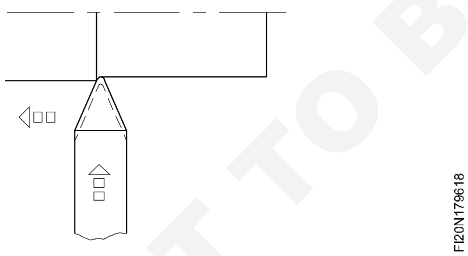
- Roughing tool (Fig 7)

Fig 7



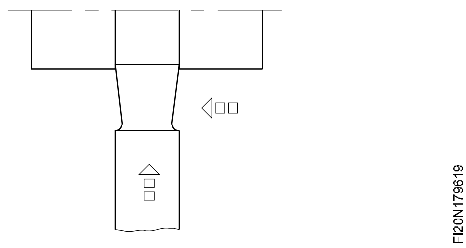
- Round nose finishing tool (Fig 8)

Fig 8



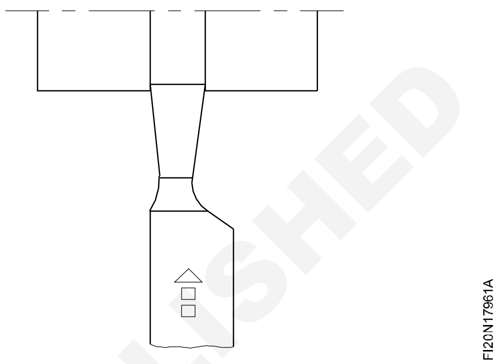
- Broad nose finishing tool (Fig 9)

Fig 9



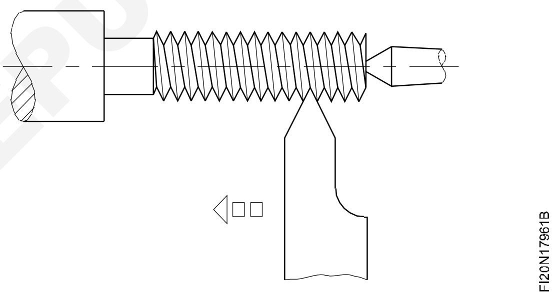
- Undercutting tool/parting off tool (Fig 10)

Fig 10



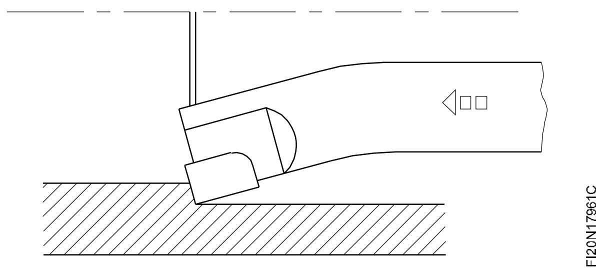
- External threading tool (Fig 11)

Fig 11



- Boring tool (Fig 12)

Fig 12

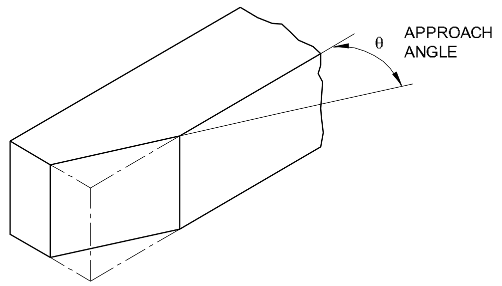


Necessity of tool angles

Objectives: At the end of this lesson you shall be able to
- **name the different angle of the tool**
- **state use of the each angle**
- **state the effect of the incorrect angle.**

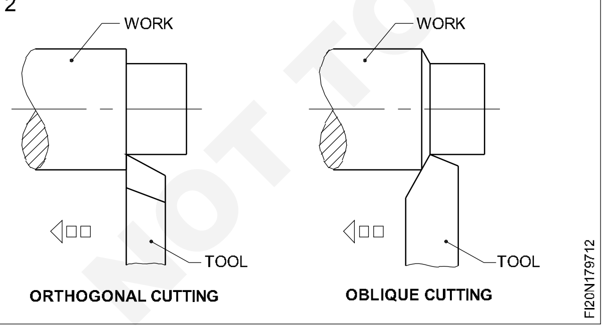
Approach angle (Fig 1)

Fig 1



This is also known as side cutting-edge angle. This is ground on the side of the cutting tool. The cutting will be oblique while cutting. The angle ground may range from 25° to 40° but as a standard a 30° angle is normally provided. The oblique cutting has the advantages over the orthogonal cutting, in which the cutting edge is straight. More depth of cut is given in the case of oblique cutting, since, when the tool is fed to the work, the contact surface of the tool increases gradually as the tool advances, whereas in the case of the orthogonal cutting, the length of the cutting edge for the given depth fully contacts the work from the beginning itself which gives a sudden maximum load on the tool face. The area over which heat is distributed is greater in oblique cutting. (Fig 2)

Fig 2



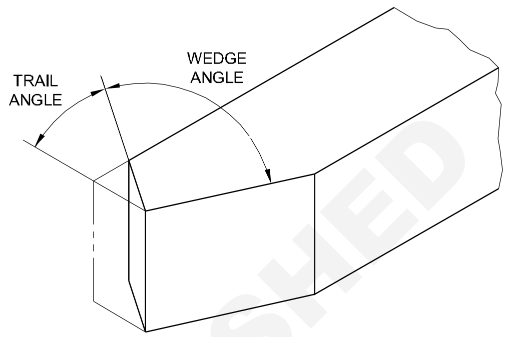
ORTHOGONAL CUTTING   OBLIQUE CUTTING

Trail angle (Fig 3)

It is also known as end-cutting edge angle, and is ground at 30° to a line perpendicular to the axis of the tool, as illustrated.

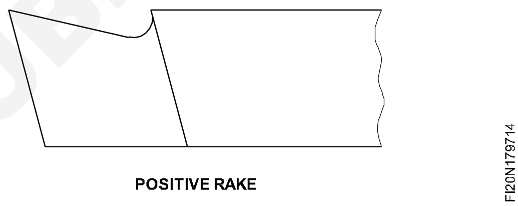
The approach angle and trail angle ground will form the wedge angle of 90° for the tool.

Fig 3



Top or back rake angle (Fig 4)

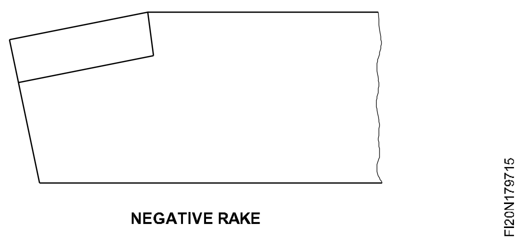
Fig 4



POSITIVE RAKE

The rake angle ground on a tool controls the geometry of chip formation. Thereby, it controls the cutting action of the tool. The top or back rake angle of the tool is ground on the top of the tool, and it is a slope formed between the front of the cutting edge and the top of the face. If the slope is from the front towards the back of the tool, it is known as a positive top rake angle, and if the slope is from the back of the tool towards the front of the cutting edge, it is known as a negative back rake angle. (Fig 5)

Fig 5



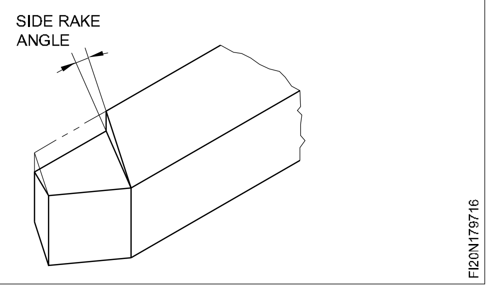
NEGATIVE RAKE

The top rake angle may be ground positive, negative or zero according to the material to be machined. When turning soft, ductile materials, which form curly chips, the positive top rake angle ground will be comparatively more than for turning hard brittle metals.

When turning hard metals with carbide tools, it is the usual practice to give a negative top rake. Negative top rake tools have more strength than tools with positive top rake angles.

Side rake angle (Fig 6)

Fig 6

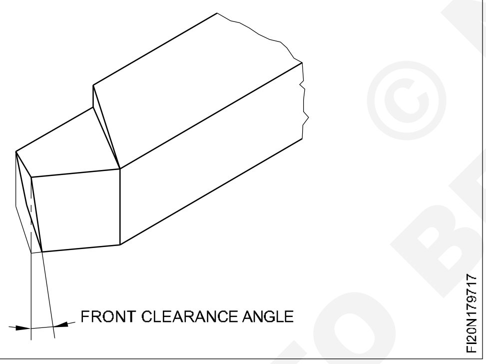


A side rake angle is the slope between the side of the cutting edge to the top face of the tool width wise. The slope is from the cutting edge to the rear side of the tool. It varies from 0° to 20°, according to the material to be machined.

The top and side rake, ground on a tool control the chip flow, and this results in a true rake angle which is the direction in which the chip that shears away from the work passes.

Front clearance angle (Fig 7)

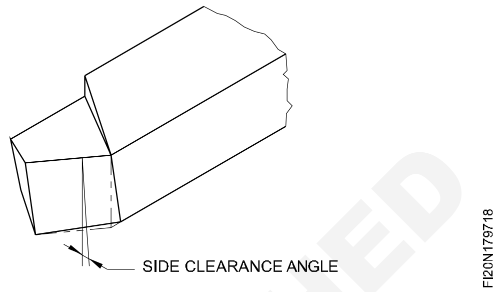
Fig 7



It is the slope between the front of the cutting edge to a line perpendicular to the axis of the tool drawn downwards which is known as the front clearance angle. The slope is from the top to the bottom of the tool, and permits only the cutting edge to contact the work, and avoids any rubbing action. If the clearance ground is more, it will weaken the cutting edge.

Side clearance angle (Fig 8)

Fig 8



The clearance angle is the slope formed between the side cutting edge of the tool with a line perpendicular to the tool axis drawn downwards at the side cutting edge of the tool. The slope is from the top of the side cutting edge to the bottom face. This is also ground to prevent the tool from rubbing with the work, and allows only the cutting edge to contact the work during turning. The side clearance angle needs to be increased when the feed rate is increased.

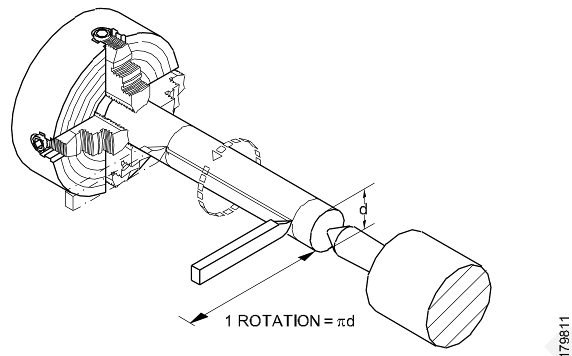
When grinding rake and clearance angles, it is better to refer to the standard chart provided with the recommended values and grind. However, actual operation will indicate the performance of the tool, and will indicate to us, if any modifications are needed for the angles ground on the tool.

Lathe cutting speed and feed, use of coolants, lubricants

Objectives: At the end of this lesson you shall be able to
- **distinguish between cutting speed and feed**
- **read and select the recommended cutting speed for different materials from the chart**
- **point out the factors governing the cutting speed**
- **state the factors governing feed.**

Cutting speed is the speed at which the cutting edge passes over the material, and it is expressed in metres per minute. (Fig 1)

Fig 1



CUTTING SPEED FOR TURNING OPERATION

When a work of a diameter 'd' is turned in one revolution the length of the portion of work in contact with the tool is π x d. When the work is making 'n' rev/min, the length of the work in contact with the tool is π x D x n. This is converted into metres and expressed in a formula form as

$$V = \frac{\pi dn}{1000} \text{ metre/min}$$

where

V = cutting speed in m/min.

$\pi = 3.14$

d = diameter of the work in mm.

n = RPM.

When more material is to be removed in lesser time, a higher cutting speed is needed. This makes the spindle to run faster but the life of the tool will be reduced due to more heat being developed. The recommended cutting speeds are given in a chart. As far as possible the recommended cutting speeds are to be chosen from the chart and the spindle speed calculated before performing the operation. (Fig 2) Correct cutting speed will provide normal tool life under normal working condition.

Example

Find out the rpm of a spindle for a 50 mm bar to cut at 25 m/min.

$$V = \frac{\pi dn}{1000} \qquad n = \frac{1000V}{\pi xD}$$

$$\frac{1000x25}{3.14x50} = \frac{500}{3.14} = 159pm$$

Factors governing the cutting speed

- Finish required
- Depth of cut
- Tool geometry
- Properties and rigidity of the cutting tool and its mounting.
- Properties of the workpiece material
- Rigidity of the workpiece
- The type of cutting fluid used.

Feed (Fig 3)

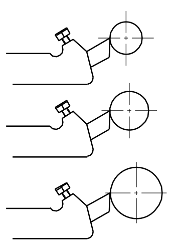
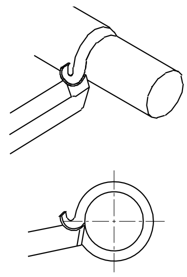
The feed of the tool is the distance it moves along the work for each revolution of the work and it is expressed in mm/rev.

The factors governing the feed are:

- Tool geometry
- Surface finish required on work
- Rigidity of the tool.

Rate of metal removal

The volume of metal removal is the volume of chip that is removed from the work in one minute, and it is found by multiplying the cutting speed, feed rate and the depth of cut.

Cutting speed 30 m / min	Length of metal passing over cutting tool in one revolution	Calculated RPM of spindle
Fig 2  ∅ 25 mm	----------------78.56 mm	1528 
∅ 50 mm	----------------157.12 mm	764
∅ 75 mm	----------------235.68 mm	509.3

Relationship of RPM to the cutting speed on different diameters.

Table 1

Cutting speeds and feeds for H.S.S tool

Material being turned	Feed mm/rev	Cutting speed m/min
Aluminium	0.2-1.00	70-100
Brass (alpha)-ductile	0.2-1.00	50-80
Brass (free cutting)	0.2-1.5	70-100
Bronze (phosphor)	0.2-1.00	35-70
Cast iron (grey)	0.15-0.7	25-40
Copper	0.2-1.00	35-70
Steel (mild)	0.2-1.00	35-50
Steel (medium-carbon)	0.15-0.7	30-35
Steel (Alloy-high tensile)	0.08-0.3	5-10
Thermo-setting plastics	0.2-1.00	35-50

Note

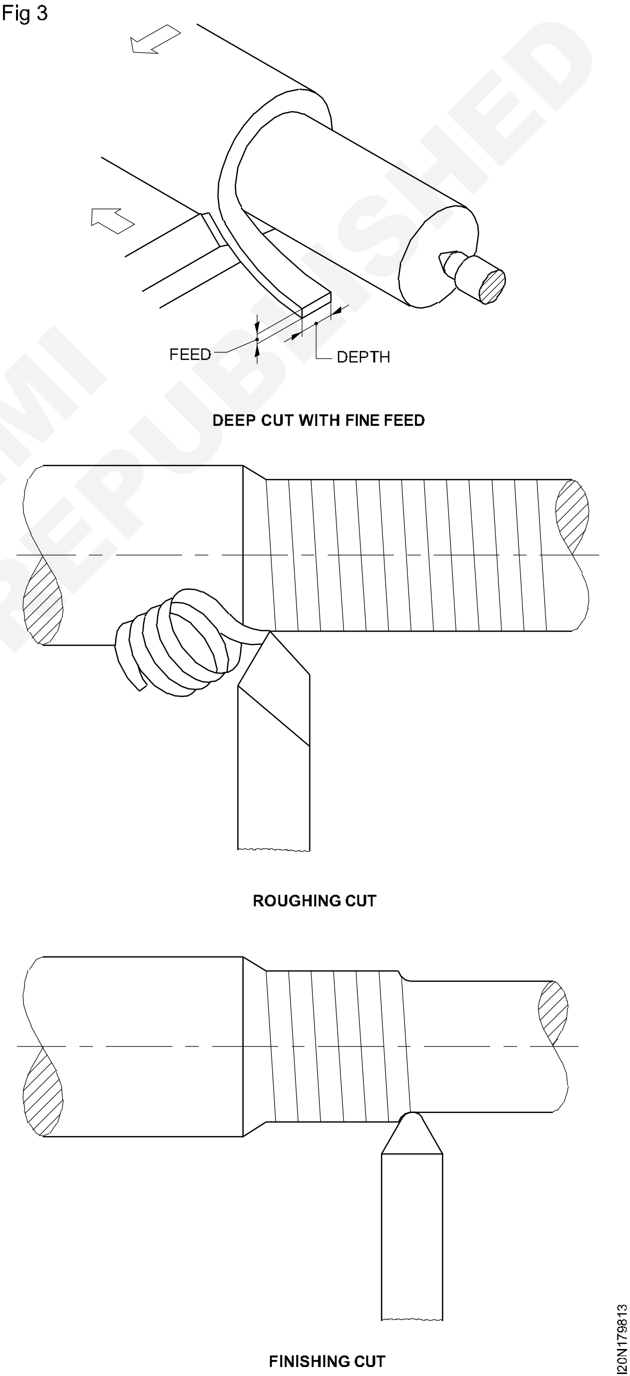
For super HSS tools the feeds should remain the same, but cutting speeds could be increased by 15% to 20%.

A lower speed range is suitable for heavy, roughing cuts. A higher speed range is suitable for light, finishing cuts.

The feed is selected to suit the finish required and the rate of metal removal.

When carbide tools are used, 3 to 4 times higher cutting speed to that required for H.S.S. tools may be chosen.

Fig 3



DEEP CUT WITH FINE FEED

ROUGHING CUT

FINISHING CUT

Comparison of HSS and Carbide Tools

HSS Tool	Carbide Tool
• Ferrous tool material have iron as their chief constituent.	• Non-Ferrous tool material do not have iron.
• Alloying tungsten, chromium and vanadium to high carbon steel, high speed steel tool material is produced.	• Carbide cutting tools can retain their hardness at very high temperature that of high speed steel.
• Cutting speed is low.	• Cutting speed is high.
• Solid tool.	• It is a brazed tool bit and throw away tool bit die to brittleness.
• Cost low.	• Cost high.

Coolants & lubricants (Cutting fluids)

Objectives: At the end of this lesson you shall be able to
- **state the properties of cutting fluids**
- **state the purpose of using a cutting fluid**
- **name the different cutting fluids**
- **distinguish the characteristics of each type of cutting fluids**
- **select a proper cutting fluid to suit various materials and machining operations.**

Coolants (Cutting fluids)

Coolants (Cutting fluids) play an important role in reducing the wear of cutting tools.

Coolants (Cutting fluids) are essential in most metal cutting operations. During a machining process, considerable heat and friction are created by the plastic deformation of metal occurring in the shear zone when the chip slides along the chip tool interface. This heat and friction cause the metal to adhere to the cutting edge of the tool, and the tool may break down. The result is poor finish and inaccurate work.

The advantages of a cutting fluid is it :

- Cools the tool and the workpiece
- Lubricates the chip / tool interface and reduces the tool wear due to friction
- Prevents chip welding
- Improves the surface finish of the workpiece
- Flushes away the chips
- Prevents corrosion of the work and the machine.

A good cutting fluid should have the following properties.

- Good lubricating quality
- Rust resistance
- Stability both in storage and in use
- Resistant to separation from solution after it is mixed with water
- Transparency
- Relatively low viscosity
- Non-flammability

The following are the main purposes of cutting fluids.

- To cool the cutting tool and the workpiece as heat is generated during cutting operation because of friction between the tool and the workpiece.
- To cool the cutting edge of the tool and to prevent any wear on the tool.
- To prevent the formation of chip welding.
- To give a good cutting efficiency to the tool.
- To give a good surface finish on the job.
- To act as a lubricant for the tool and the machine.

The different types of cutting fluids are:

- Soluble mineral oils
- Straight mineral oils
- Straight fatty oils
- Compounded or blended oils
- Sulphurised oils.

Cutting fluids - Types and Characteristics

Soluble mineral oils

They are made from mineral oils with emulsifying material added to make for mixing with water. Soluble oil is diluted with water to form an emulsion. The water cools whilst the oil lubricates. The extent of dilution depends upon the type of operation.

Straight mineral oils

They are purely mineral oils. Lighter oils are used when cooling and lubrication are required. Heavier oils are used when lubrication is mainly essential. They are used on automats. They protect the machine parts and workpieces from rusting.

Lard oils

Lard oils are usually blended with mineral oils to prevent deterioration, reduce cost and destroy the objectionable odour. For machining under extreme conditions, they are an excellent lubricant.

Sulphurised oils

To suit extreme cutting conditions of modern tools sulphurised oils have been devised. The addition of sulphur improves performance on difficult operations. Its lubricating property prevents the welding of chip on to the tool.

Coolants (Cutting fluids) plan an important role in reducing the wear of cutting tools.

Recommended cutting fluids for various metals

Material	Drilling	Reaming	Threading	Turning	Milling
Aluminium	Soluble oil Kerosene Kerosene and Lard oil	Soluble oil Kerosene Mineral oil	Soluble oil Kerosene and Lard oil	Soluble oil	Dry Soluble oil Lard oil Mineral oil
Brass	Dry Soluble oil Mineral oil Lard oil	Dry Soluble oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil
Bronze	Dry Soluble oil Mineral oil Lard oil	Dry Soluble oil Mineral oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil Mineral oil Lard oil
Cast iron	Dry Air jet Soluble oil Lard oil	Dry Soluble oil Mineral oil Lard oil	Dry Sulphurized oil Mineral oi Lard oil	Dry Soluble oil	Dry Soluble oil
Copper	Dry Soluble oil Mineral oil Lard oil Kerosene Oil	Soluble oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil
Steel Alloys	Soluble oil Sulphurized oil Mineral oil Lard oil	Soluble oil Sulphurized oil Mineral oil Lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Mineral oil Lard oil
General purpose steel	Soluble oil Sulphurized oil Lard oil	Soluble oil Sulphurized oil Lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Lard oil

Lubricants

Objectives: At the end of this lesson you shall be able to
- **state the purpose of using lubricants**
- **state the properties of lubricants**
- **state the qualities of a good lubricant.**

With the movement of two mating parts of the machine, heat is generated. If it is not controlled, the temperature may rise resulting in total damage of the mating parts. Therefore a film of cooling medium with high viscosity is applied between the mating parts which is known as a 'lubricant'.

A 'lubricant' is a substance having an oily property available in the form of fluid, semi-fluid, or solid state. It is the lifeblood of the machine, keeping the vital parts in perfect condition and prolonging the life of the machine. It saves the machine and its parts from corrosion, wear and tear and it minimises friction.

Purpose of using lubricants

- Reduces friction
- Prevents wear
- Prevents adhesion
- Aids in distributing the load
- Cools the moving elements
- Prevents corrosion
- Improves machine efficiency

Properties of Lubricants

Viscosity

It is the fluidity of an oil by which it can withstand high pressure or load without squeezing out from the bearing surface.

Oiliness

Oiliness refers to a combination of wettability, surface tension and slipperiness. (The capacity of the oil to leave an oily skin on the metal.

Flash point

It is the temperature at which the vapour is given off from the oil (it decomposes under pressure soon).

Fire point

It is the temperature at which the oil catches fire and continues to be in flame.

Pour point

The temperature at which the lubricant is able to flow when poured.

Emulsification and de- emulsibility

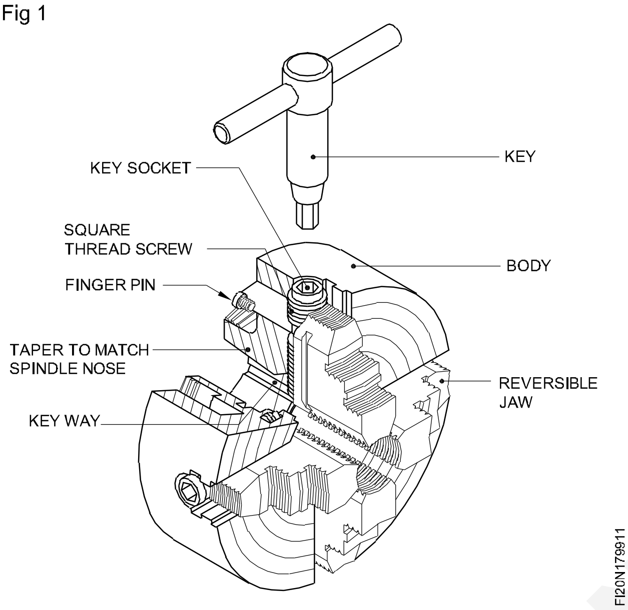
Emulsification indicates the tendency of an oil to mix immediately with water to form a more or less stable emulsion. De-emulsibility indicates the readiness with which subsequent separation will occur.

Chucks and chucking - the independent 4 jaw chuck

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of a 4 jaw chuck**
- **name the parts of a 4 jaw chuck.**

4 Jaw chuck (Fig 1)

Fig 1



The four jaw chuck is also called as independent chuck, since each jaw can be adjusted independently; work can be trued to within 0.001" or 0.02mm accuracy, using this chuck.

This type of chuck is much more heavily constructed than the self-centering chuck, and has much greater holding power. Each jaw is moved independently by a square thread screw. The jaws are reversible for holding large diameter jobs. The independent 4 jaw chuck has four jaws, each working independently of the others in its own slot in the chuck body and actuated by its own separate square threaded screw. By suitable adjustment of the jaws, a workpiece can be set to run either true or eccentric as required.

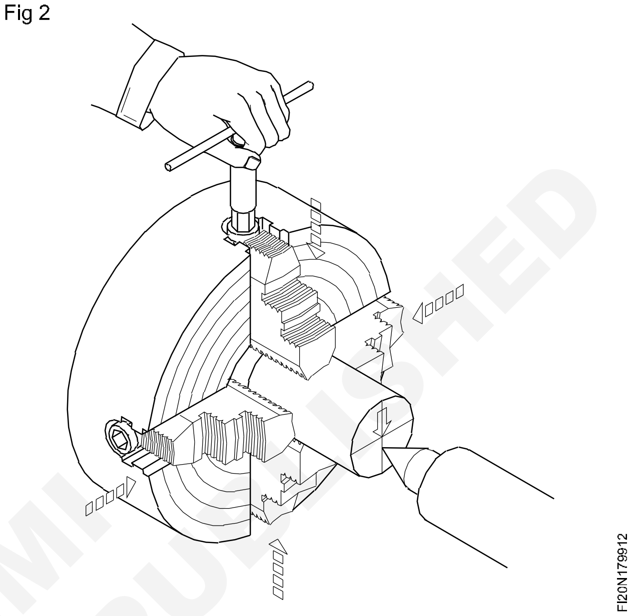
To set the job for the second time, it can be trued with the help of a dial test indicator.

The check on the workpiece should be carried out near the chuck and repeated as far from it as the workpiece permits, to ensure that the work is not held in the chuck at an angle to the axis of rotation.

The independent adjustment also provides the facility of deliberately setting the work off-centre to produce an eccentric workpiece. (Fig 2)

The parts of a 4 jaw chuck are:

Fig 2



- Back plate
- Body
- Jaws
- Square threaded screw shaft.

Back plate

The back plate is fastened to the back of the body by means of Allen screws. It is made out of cast iron/steel. Its bore is tapered to suit the taper of the spindle nose. It has a key way which fits into the key provided on the spindle nose. There is a step in front and on which the thread is cut. A threaded collar, which is mounted on the spindle, locks the chuck by means of the thread, and locates by means of the taper and key. Some chucks do not have back plates.

Body (Fig 1)

The body is made out of cast iron/cast steel and the face is flame-hardened. It has four openings at 90° apart to assemble the jaws and operate them. Four screw shafts are fixed on the periphery of the body by means of finger pins. The screw is rotated by means of a chuck key. The body, hollow in the cross-section, has equi-spaced circular rings provided on the face, which are marked by numerical numbers. Number 1 starts in the middle, and increases towards the periphery.

Jaws (Fig 1)

Jaws are made out of high carbon steel. hardened and tempered, which slide on the openings of the body. These jaws are reversible for holding hollow work.

The back side of the jaws are square-threaded which help in fixing the jaws with the operating screws.

Screw shaft (Fig 1)

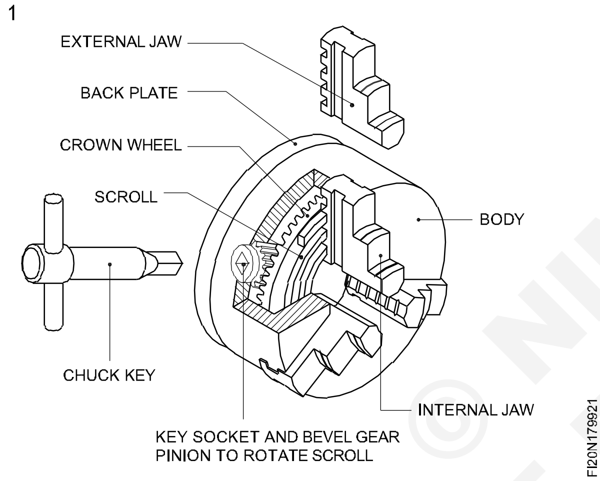
The screw shaft is made out of high carbon steel, hardened, tempered and ground. The top portion of the screw shaft is provided with a square slot to accommodate the chuck key. On the body portion, a left hand square thread is cut. In the middle of the screw shaft, a narrow step is made and held by means of finger pins. The finger pins permit the screws to rotate but not to advance.

3 Jaw chuck

Objectives: At the end of this lesson you shall be able to
- **identify the parts of a 3 jaw chuck**
- **state the constructional features of a 3 jaw chuck**
- **distinguish between a 3 jaw chuck and a 4 jaw chuck**
- **state the merits and demerits of a 4 jaw chuck over a 3 jaw chuck**
- **specify a chuck.**

3 Jaw chuck (Fig 1)

Fig 1



The 3 jaw chuck is also known as a self-centering chuck. The majority of the chucks have two sets of jaws for holding internal and external diameters. Only perfect round work with equally spaced flats divisible by three should be held in a 3 jaw chuck.

From the construction of a 3 jaw chuck it is seen that the scroll not only clamps a component in place, it also locates the component. This is fundamentally a bad practice, since any wear in the scroll and/or the jaws impairs the accuracy of location. Further there is no means of adjustment possible to compensate for this wear.

The jaws of this type of chuck are not reversible, and separate internal and external jaws have to be used.

The parts of a 3 jaw chuck are:

- Back plate
- Body
- Jaws
- Crown wheel and
- Pinion.

Back plate (Fig 1)**:** The back plate is fastened at the back of the body by means of allen screws. It is made out of cast iron. Its bore is tapered to suit the taper of the spindle nose. It has a key- way which fits into the key provided on the spindle nose. There is a step in the front on which the thread is cut. The threaded collar, which is mounted on the spindle, locks the chuck by means of the thread and locates by mean of the taper and the key.

Body (Fig 1): The body is made out of cast steel, and the face is hardened. It has three openings 120° apart to assemble the jaws and operate them. Three pinions are fixed on the periphery of the body to operate the jaws by means of a chuck key. It is hollow in its cross-section. A crown wheel is housed inside the body.

Jaws (Fig 1): The jaws are made out of high carbon steel, hardened and tempered, which slide on the openings of the body. Generally there are two sets of jaws viz. external jaws and internal jaws. External jaws are used for holding solid works. Internal jaws are used for holding hollow works. Steps on the jaws increase the clamping range. The back side of the jaws is cut with scroll thread. Each jaw is numbered in a sequential manner, which helps in fixing the jaws in the corresponding numbered slots.

Crown wheel (Fig 1): The crown wheel is made out of alloy steel, hardened and tempered. On one side of the crown wheel, a scroll thread is cut to operate the jaws, and the other side is tapered on which bevel gear teeth are cut to mesh with the pinion. When the pinion is rotated by means of a chuck key, the crown wheel rotates, thus causing the jaws to move inward or outward, depending upon the rotation .

Pinion (Fig 1): Pinion is made out of high carbon steel, hardened and tempered. It is fitted on the periphery of the body. On the top of the pinion a square slot is provided to accommodate the chuck key. It has a tapered portion on which bevel gear teeth are cut, which match with the crown wheel.

Comparison between 3 jaw chuck and 4 jaw chuck

3 Jaw chuck	4 Jaw chuck
Only cylindrical, hexagonal work can be held.	A wide range of regular and irregular shapes can be held.
Internal and external jaws are available.	Jaws are reversible for external and internal holding.
Setting up of work is easy.	Setting up of work is difficult.
Less gripping power.	More gripping power.
Depth of cut is comparatively less.	More depth of cut can be given.
Heavier jobs cannot be turned.	Heavier jobs can be turned.
Workpieces cannot be set for eccentric turning.	Workpieces can be set for eccentric turning.
Concentric circles are not provided on the face.	Concentric circles are provided which help for approximate setting of jaws.
Accuracy decreases as the chuck gets worn out.	There is no loss of accuracy as the chuck gets worn out.

Merits of a 4 jaw chuck

- A wide range of regular and irregular shapes can be held.
- Work can be set to run concentrically or eccentrically at will.
- Has considerable gripping power, and hence heavy cuts can be given.
- The jaws are reversible for internal and external work.
- Work can be readily performed on the end face of the job.
- There is no loss of accuracy as the chuck gets wornout.

De-merits of a 4 jaw chuck

- Workpieces must be individually set.
- The gripping power is so great that fine work can be easily damaged during setting.

Merits of a 3 jaw chuck

- Work can be set with ease.
- A wide range of cylindrical and hexagonal work can be held.
- Internal and external jaws are available.

De-merits of a 3 jaw chuck

- Accuracy decreases as chuck becomes worn out.
- Run out cannot be corrected.
- Only round and hexagonal components can be held.
- When accurate setting or concentricity with an existing diameter is required, a self-centering chuck is not used.

Specification of chuck

To specify a chuck, it is essential to provide :

- Type of chuck.
- Capacity of chuck.
- Diameter of the body.
- Width of the body.

The method of mounting to the spindle nose.

Example

3 Jaw self-centering chuck.

Gripping capacity 450 mm.

Diameter of the body 500 mm.

Width of the body 125 mm.

Tapered or threaded method of mounting.

Method of cleaning the thread of the chuck mounting

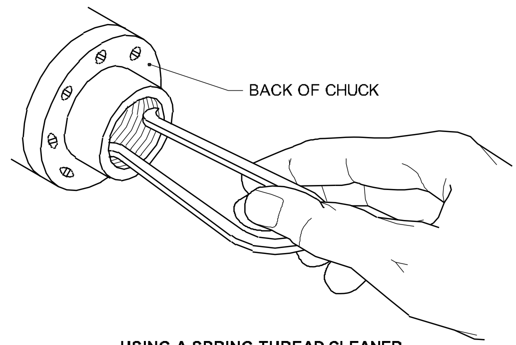
Objective: At the end of this lesson you shall be able to
- **state the uses of thread cleaner.**

Thread cleaners are used to clean all the mating parts of the chuck and spindle as, otherwise, the dirt on these surfaces could result in the following.

Cause the chuck to run out of true.

Damage the threads or taper on the spindle or chuck. (Fig 1)

Fig 1



USING A SPRING THREAD CLEANER

Mounting and dismounting of chucks

Objective: At the end of this lesson you shall be able to
- **explain the method of mounting and dismounting chucks from spindle noses.**

To perform lathe operations on work materials, it may not be always possible to have only one type work-holding device fitted to the spindle. Hence it becomes an absolute necessity for dismounting the work-holding device already assembled to the spindle and mount that work-holding device which is needed for the work in hand.

For an easy understanding of different spindle noses and their applications, the mounting of different work-holding devices are illustrated.

When mounting a chuck on the headstock spindle, exercise care to prevent damage occurring to the chuck or spindle.

Damage may reduce the accuracy of the lathe. The points set out below are important and should be followed.

Before mounting

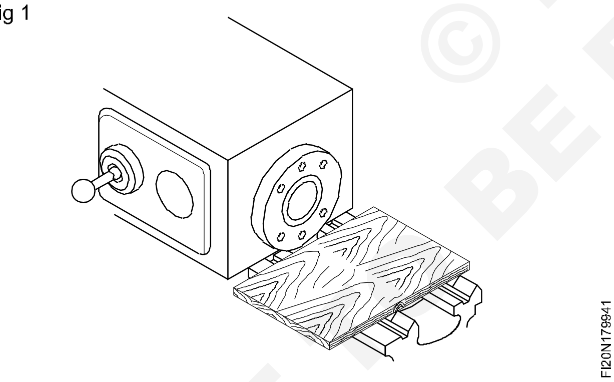
Before attempting to mount a chuck, ensure that it is the correct one for the lathe and for the job in hand.

Do not use power to mount a chuck on spindle noses.

To prevent such damage from occuring, take the following steps.

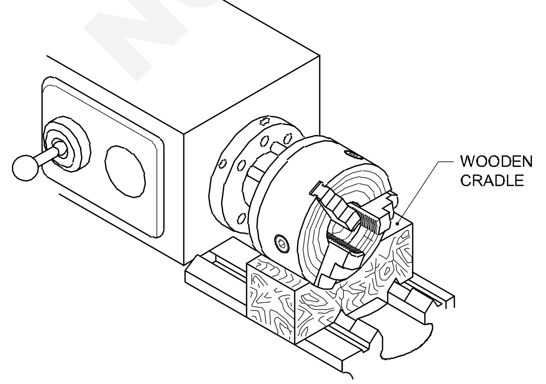
Place a wooden board on the lathe bed when mounting light chucks to prevent damage to the slideways. (Fig 1)

Fig 1



For large chucks place a wooden cradle between the chucks and the lathe bed. (Fig 2)

Fig 2



CHUCK SUPPORTED ON WOODEN CRADLE

In addition to protecting the bed slideways it makes fitting the chuck easier and safer.

Always seek assistance when mounting large and heavy chucks.

Lubricate the mating surfaces with a light film of oil.

After mounting

Set the speed-change lever to the slowest speed.

Turn on the power to the motor.

Switch on the motor.

Engage the clutch lever.

The chuck would now begin revolving.

Check that the diameter and face of the chuck are running true by observing the surfaces.

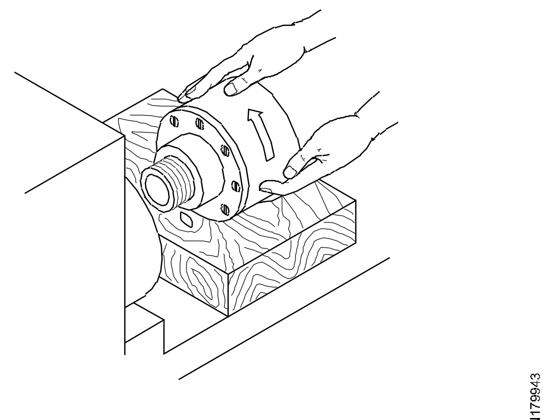
Mounting chuck on to the threaded spindle (Fig 3)

Switch off the motor.

Place the chuck on the wooden plank or cradle and slide it close to the spindle nose.

Turn the spindle anticlockwise by hand and engage the chuck on the spindle threads. (Fig 3)

Fig 3



MOUNTING THREADED CHUCK

Set the speed-change lever to the slowest speed. Screw the chuck in until it fits firmly on the spindle.

The chuck should easily screw into the spindle. If any resistance is felt, remove the chuck and check that the threads are clean and not damaged.

Mounting on tapered spindle (Fig 4)

Switch off the motor.

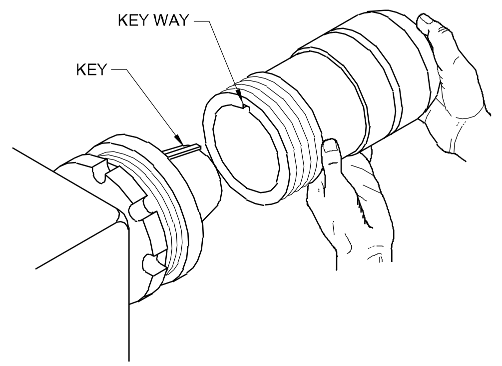
Hence the chuck on the wooden board or cradle and slide it close to the spindle nose.

Turn the spindle by hand until the key on the spindle nose lines up with the keyway in the chuck.

Set the speed-change lever to the slowest speed.

Push the chuck on to the spindle and turn the locking ring anticlockwise. (Fig 4)

Fig 4

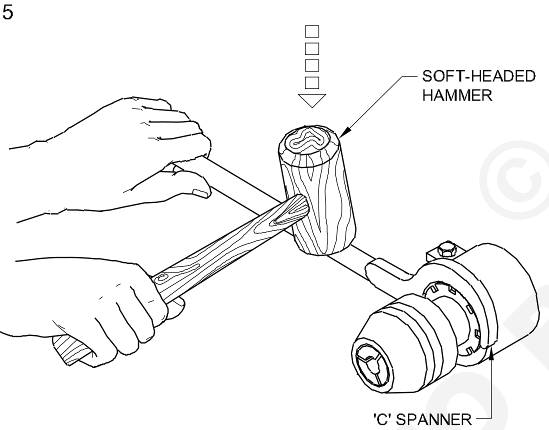


MOUNTING THREADED CHUCK

The figure given here illustrates a small chuck held with both hands and being mounted. Engage the special ‘C’ spanner on the locking ring.

The spanner should fit around the top of the locking ring with the handle pointing downwards. Grip the end of the handle with one hand and firmly strike the other end with the other hand in an anticlockwise direction. This would securely tighten the locking ring. (Fig 5)

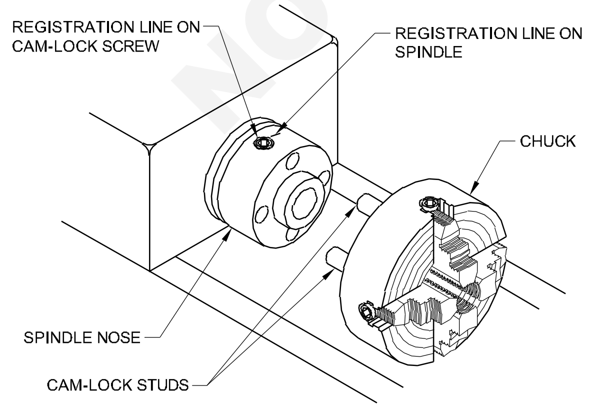
Fig 5



LOCK CHUCK ON SPINDLE

Mounting on a cam-lock spindle (Fig 6)

Fig 6



MOUNTING CHUCK ON CAM-LOCK SPINDLE

Switch off the motor.

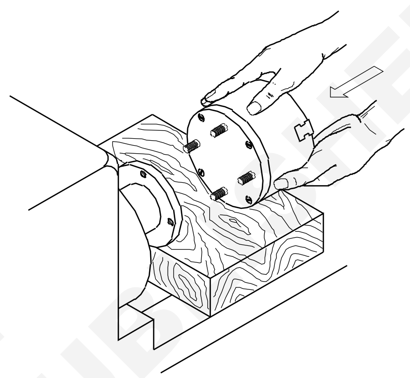
Place the chuck on a wooden board or cradle and slide it close to the spindle nose. Disengage the clutch to permit free rotation of the spindle. Insert the correct chuck key into a cam-locking screw on the spindle.

Turn each cam-locking screw so that the registration line is vertical or aligns with the corresponding line on the spindle. Turn the spindle by hand until the clearance holes on the spindle align with the cam-lock studs on the chuck.

Set the speed. Change lever to the slowest speed. Push the chuck on to the spindle. Tighten each cam-lock screw in a clockwise direction.

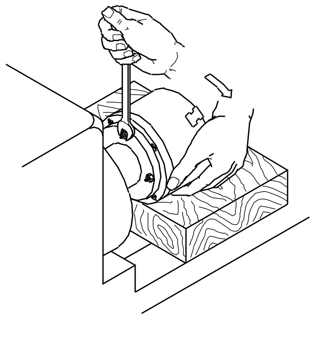
Mounting on to a bolted spindle (Figs 7 and 8)

Fig 7



MOUNTING CHUCK TO BOLTED SPINDLE

Fig 8



TIGHTEN NUTS FIRMLY

Switch off the motor.

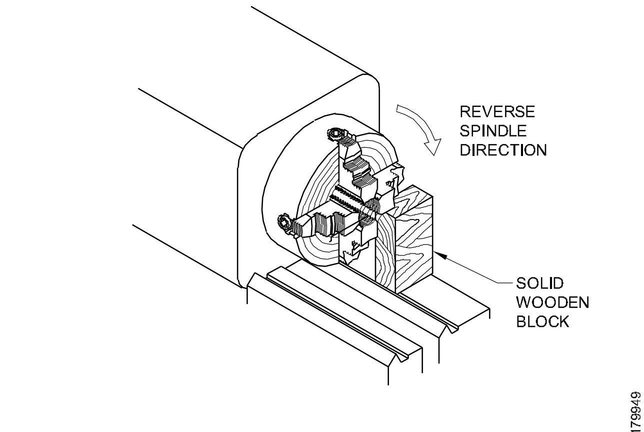
Place the chuck on a wooden board or cradle. Remove nuts and washers from the studs on the chuck. Disengage the clutch to permit free rotation of the spindle. Turn the spindle by hand until the key in the spindle lines up with the slot in the chuck. Set the speed- change lever to the slowest speed. Push the chuck on to the spindle. Fit washers and nuts to the studs.

Hold the chuck in position when fitting nuts.

Tighten the nuts in an anticlockwise direction using a spanner on the opposite nuts.

Dismounting chucks from a threaded spindle (Fig 9)

Fig 9



REMOVING SCREWED CHUCK FROM SPINDLE

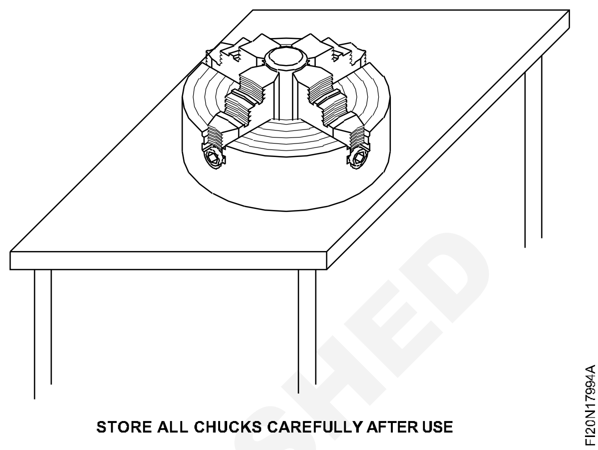
Switch off the motor. Set the speed change lever to the slowest speed. Place a solid wooden block between one of the chuck jaws and the rear of the lathe-bed.

The length of the wooden block should be slightly less than the centre height of the lathe.

Turn the lathe spindle clockwise by hand to loosen the chuck from the spindle nose.

Remove the wooden block. Place the wooden board or cradle on the lathe-bed. Unscrew the chuck from the spindle. Clean and store the chuck (Fig 10)

Fig 10



STORE ALL CHUCKS CAREFULLY AFTER USE

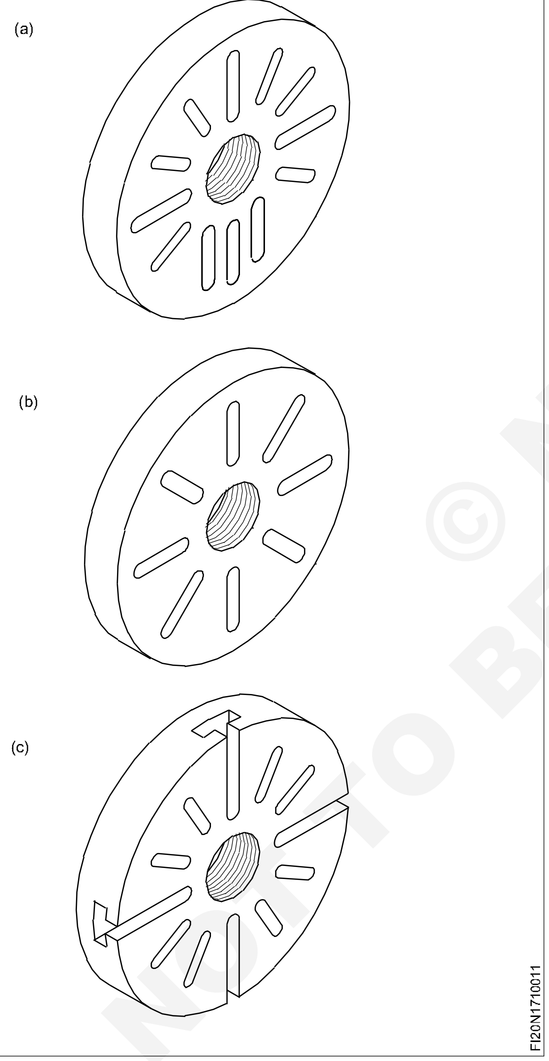
Face plate

Objectives: At the end of this lesson you shall be able to
- **state the types of face plate**
- **state the uses of face plates**

The different types of face plates are:

- Face plates with only elongated radial slots (Fig 1a)
- Face plates with elongated slots 'T' slots. (Fig 1b)
- Face plates with elongated radial slots and additional parallel slots. (Fig 1c)

Fig 1



Face plates are used along with the following accessories.

Clamps, 'T' bolts, Angle plate, Parallels, counterweight, Stepped block, 'V' Block etc.

Large, flat, irregular shaped workpieces, castings, jigs and fixtures may be firmly clamped to a face plate for various turning operations.

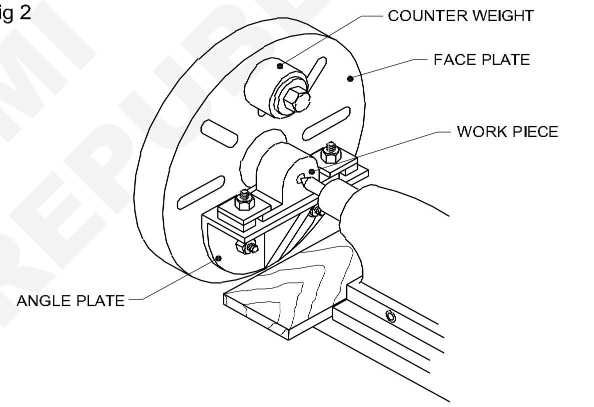
A work can be mounted on a face plate while the face plate is on the lathe spindle or on the workbench. If the workpiece is heavy or awkward to hold, the workpiece is mounted while the face plate is on the workbench. Before mounting the face plate set up to the spindle, it is advantageous to locate the workpiece on the face plate and centre the workpiece. Centre a punch mark or hole approximately on the face plate. This makes it easier to true the work after the face plate is mounted on to the spindle.

The poisition of the bolts and clamps is very important, if a workpiece is to be clamped effectively.

If a number of duplicate pieces are to be machined, the face plate itself can be set up as a fixture, using parallel strips and stop blocks.

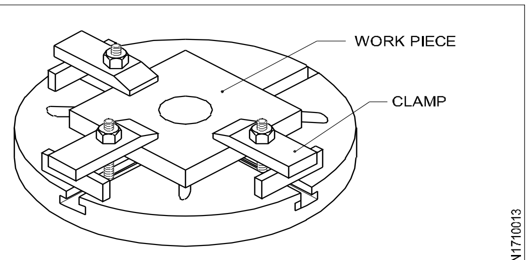
The application of the face plate with accessories in different set ups is shown in the sketches below. (Figs 2,3&4)

Fig 2



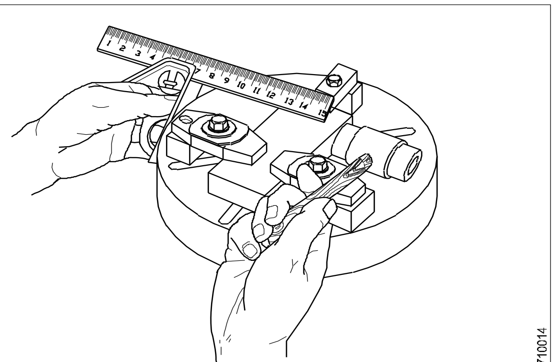
WORK HELD BY AN ANGLE PLATE

Fig 3



WORK CLAMPED DIRECTLY TO FACE PLATE

Fig 4



LOCATING WORK ON A FACE PLATE

Drilling

Objectives: At the end of this lesson you shall be able to
- **state the drilling process done in a lathe**
- **state the methods of holding the drill in the tail stock.**

Lathe can be used for drilling

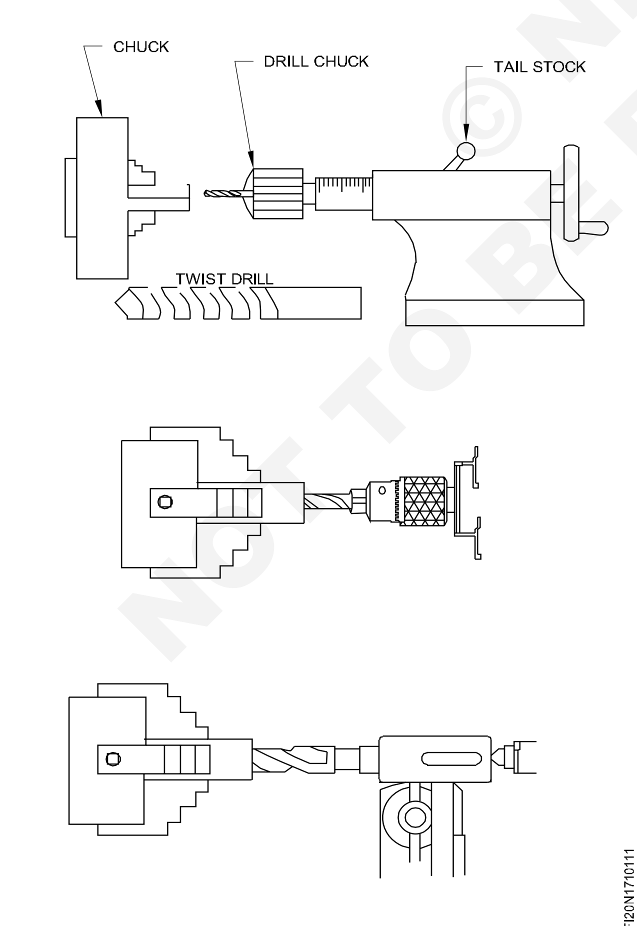
Before doing internal operation like boring, reaming and tapping. Although lathe is not a drilling machine time and effort are saved by using the lathe for drilling operations instead of changing the work to the other machines. Prior to drilling the end of the work piece on the lathe, the end face to be drilled must be spotted (center punched) and then centre drilled so that the drill will start properly

The head stock and tail stock spindle should be aligned for all drilling, reaming and tapping in order to produce a true hole.

Straight shank and taper shank drills can be held in the tailstock spindle as held in the drilling machine spindle using drill chuck sleeve and sockets. Since the tail stock spindle has the mores taper. (Fig 1)

Methods of holding drills in a tail stock (Fig 1)

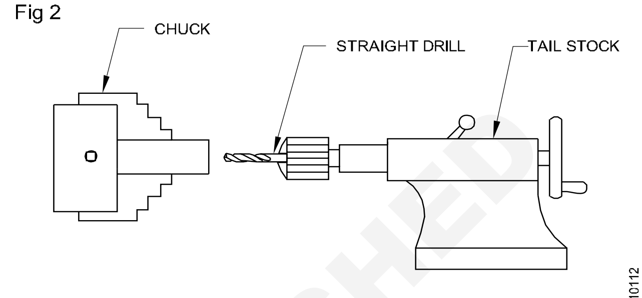
Fig 1



The different methods of holding drill in the tailshock are

- By using drill chuck (Fig 2)

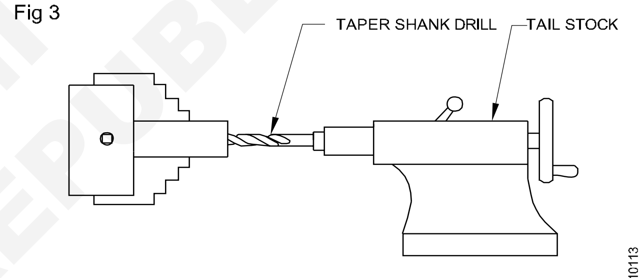
Fig 2



HOLDING STRAIGHT SHANK USING DRILL CHUCK

- By directly fitting in the tailstock spindle (Fig 3)

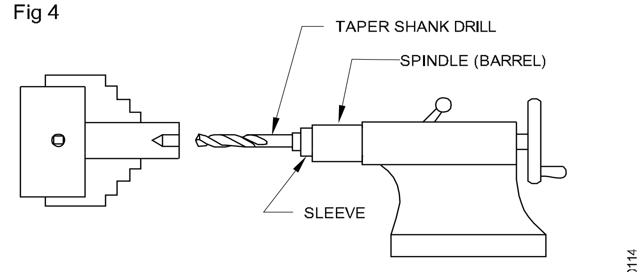
Fig 3



HOLDING TO TAPER SHANK DRILL DIRECTLY IN THE SPINDLE

- By using drill sleeve (Fig 4)

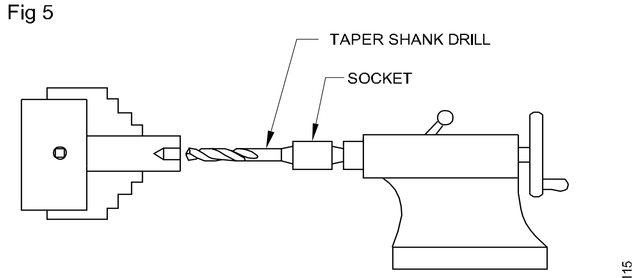
Fig 4



HOLDING TAPER SHANK DRILL USING SLEEVE

- By using drill socket (Fig 5)

Fig 5



HOLDING TAPER SHANK DRILL USING SOCKET

Boring & boring tools

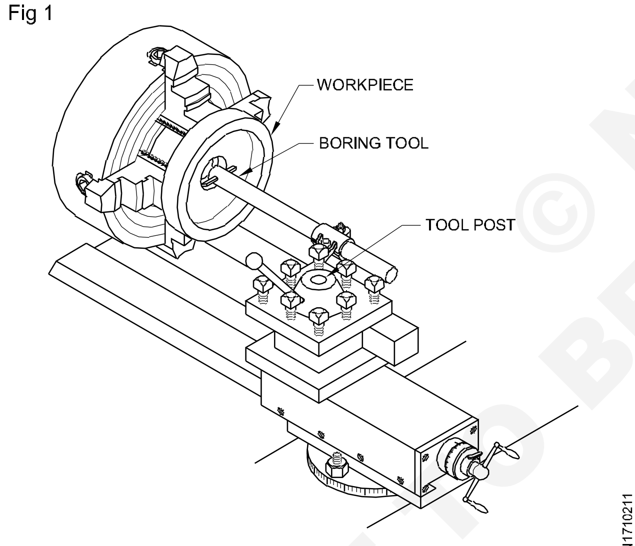
Objectives: At the end of this lesson you shall be able to
- **state the operation boring**
- **state the different types of boring tools.**

Boring

Boring is the operation of enlarging and truing a hole produced by drilling, punching, casting or forging. Boring cannot originate a hole. Boring is similar to the external turning operation and can be performed in a lathe by the following two methods.

The work is revolved in a chuck or a face plate and the tool which is fitted to the tool post is fed into the work. This method is adopted for boring small sized works. A solid forged tool is used for boring small holes, whereas a boring bar with a tool bit attached to it is suitable for machining a large hole. The depth of cut is given by the cross-slide screw and the feed is effected by the longitudinal travel of the carriage. (Fig 1)

Fig 1



BORING OPERATION

Types of boring tools

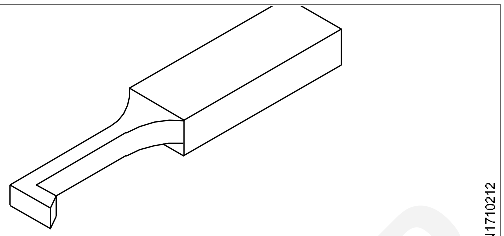
Solid forged tools

Solid forged boring tool is made from HSS with the end forged and ground. It resembles a left hand turning tool and the operation is performed from right to left. There are two types, solid boring tool (Fig 2) and solid forged bar in a tool-holder (Fig 3). They are used for light duty and on small diameter holes.

Advantages

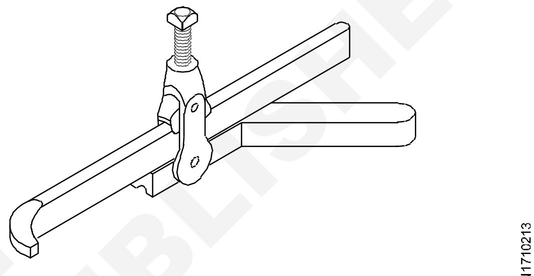
- Regrinding is easy.
- Alignment is easy.
- Mounting and removal is easy.

Fig 2



SOLID BORING TOOL

Fig 3



A SOLID FORGED BAR IN A TOOL HOLDER

Boring bars with inserted bits

Square and round tool bits made from HSS are inserted and fixed in the boring bar. The inserts can be set at an angle of 30°, 45° or 90° in the bar. It is used for heavier cuts than those made by the solid boring tool.

For plain boring, the inserts are set square to the axis of the bar. For facing the shoulder, or threading up to the shoulder, the inserts are set at an angle.

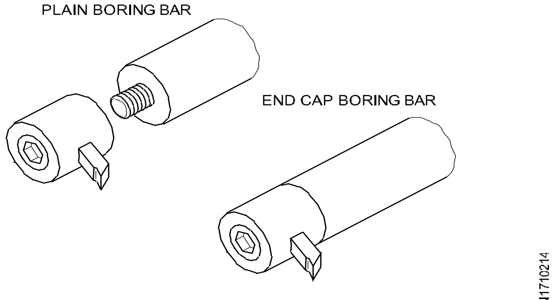
Boring bars used are of two types. (Fig 4)

- Plain boring bar
- End cap boring bar

Advantages

- Used for heavy duty boring operations.
- Tool changing is faster.
- Low cost
- Boring tools can either be set square or at an angle quickly.

Fig 4



BORING BARS

Tool setting

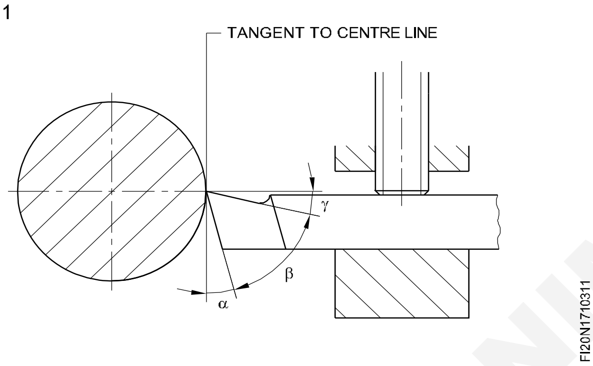
Objective: At the end of this lesson you shall be able to
- **set the tool in the tool post for performing the operation.**

For optimum cutting, the effective rake angle and clearance angle of the clamped tool must be equal to the ground angles of the tool. This requires clamping of the tool to have its axis perpendicular to the lathe axis, with the tool tip at the workpiece centre. (Fig 1)

It is difficult to determine the effective angles of the tool when it is not set to the centre height.

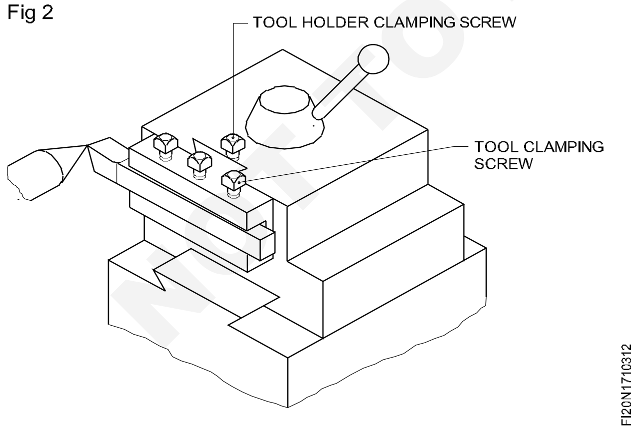
The tool nose can be set to the work centre by means of a tool-holder with adjustable height. (Fig 1)

Fig 1



The tool nose can be set to the exact centre height by placing the tool in the tool post on the shims or packing strips. These packing strips should be preferably a little less in width than the wideth of the tool but should never be more. The length of these strips should be according to the shank length and the tool seating face of the tool post. (Fig 2)

Fig 2



The procedure to follow is given below.

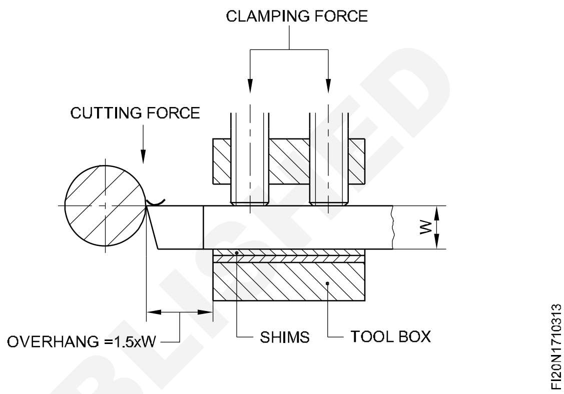
Clean the tool post seating face, and place the shims on the seating face.

Use a minimum number of shims for height adjustment.

Shims must be flushed with the edge of the seating face.

Place the tool in the tool post on the shims, with the rear butting against the wall of the seating face. (Fig 3)

Fig 3

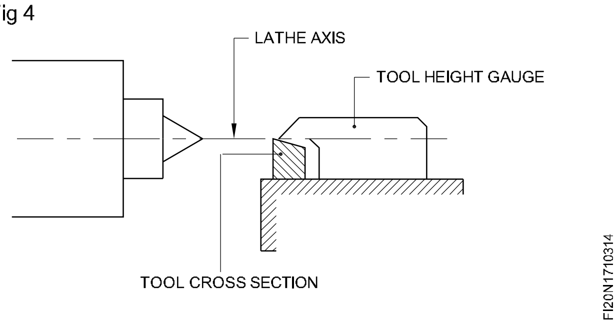


The unsupported length of the overhanging end of the turning tool should be kept to a minimum. As a rule, the overhanging length of tool is equal to the tool shank width x 1.5.

Tighten the tool with the centre screw of the tool post.

Check the centre height with a height setting gauge. (Fig 4)

Fig 4



Remove or add shims and check the height when the tool is tightened by the centre screw.

Tighten the other two tool-holding screw alternate applying the same amount of pressure.

When both the screws have a full gripping pressure, tighten the centre screw fully.

Check once again with a tool height setting gauge.

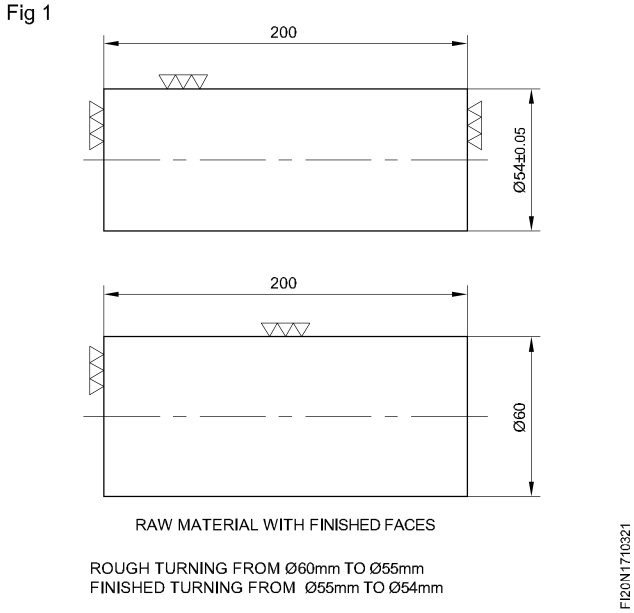
Note: The gauge should be made according to the size of the machine. If a gauge is not available, use a surface gauge and set the pointer tip to the dead centre height fixed in the tailstock. Use this as the height to which the tool is to be set.

Parallel or straight turning

Objectives: At the end of this lesson you shall be able to
- **define plain turning**
- **distinguish between the two stages of plain turning.**

Plain turning (Parallel turning) (Fig 1)

Fig 1

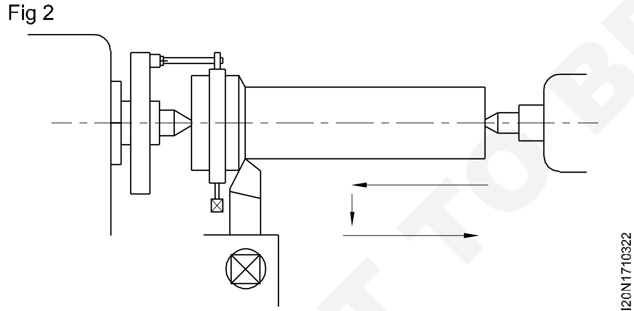


This operation involves removal of metal from the work and it has a cylinder for the full travel of the tool on the work, keeping the same diameter throughout the length.

Plain turning is done in two stages.

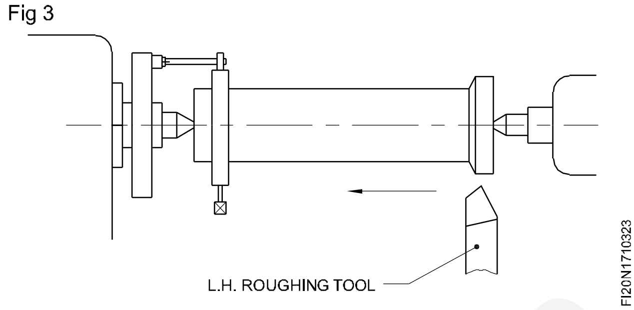
- Rough turning, using roughing tool or knife tool. (Fig 2)

Fig 2



The spindle speed is calculated according to the material being turned, the tool material and the recommended cutting speed.

Fig 3



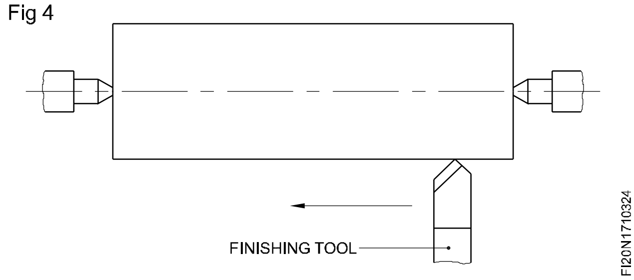
Rough turning: By rough turning the maximum amount of material is removed and the job is brought close to the required size, leaving sufficient metal for finishing. Surface finish and accuracy are not good. While rough turning, the spindle speed is less and the feed is more. A roughing tool or a knife tool is used.

While plain turning for roughing or finishing, long jobs are held between centres. It is necessary to change the ends to obtain a true parallel surface throughout the length. (Fig 3)

Finish turning: It is done, after the rough turning is completed to bring the size of the work to the required accuracy and good surface finish by removing the rough marks produced by the rough turning. For finish turning, the speed is higher (1 to 2 times more than for rough turning) and the feed is very less. A round nose finish turning tool or a knife with a larger nose radius than normal is used for finish turning.

- Finish turning using a finishing tool. (Fig 4)

Fig 4



Step turning

Objective: At the end of this lesson you shall be able to
- **define step turning**

Step turning

It is an operation of producing various steps of different diameters in the work piece as shown in Fig 1 & 2. This operation is carried out in the similar way as plain turning.

Fig 1

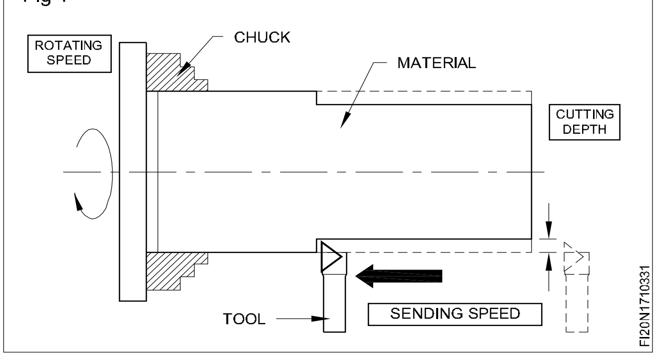
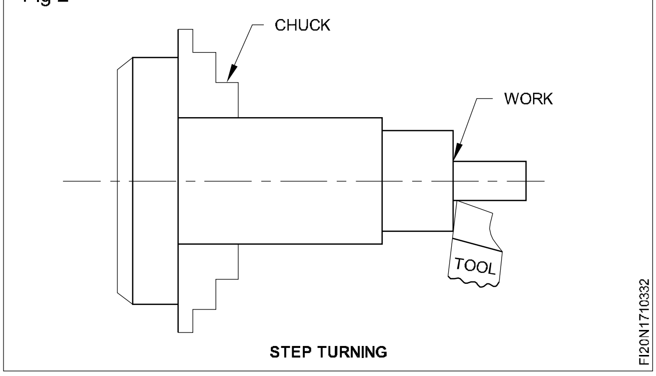


Fig 2



Grooving

Objectives: At the end of this lesson you shall be able to
- **state what is grooving**
- **name the types of grooves**
- **state the specific uses of each type of groove.**

Grooving

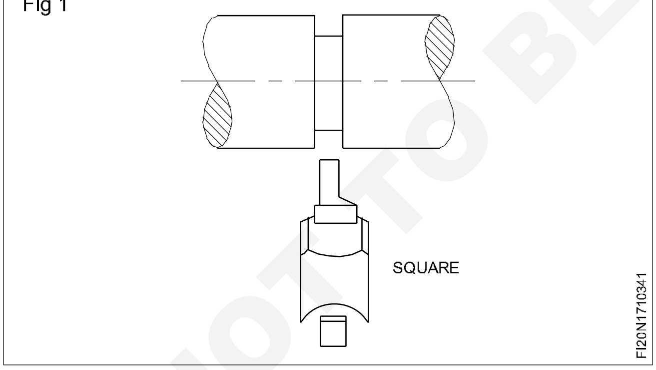
Grooving is the process of turning a grooved form or channel on a cylindrically turned workpiece. The shape of the cutting tool and the depth to which it is fed determine the shape of the groove.

Types of grooves

Square grooves

Square grooves are frequently cut at the end of a section to be threaded in order to provide a channel into which a threading tool may run. A square groove cut against a shoulder allows a matching part to fit squarely against the shoulder. (Fig 1)

Fig 1



When a diameter is to be finished to size by grinding, a groove is generally cut against the shoulder to provide clearance for the grinding wheel and to ensure a square corner.

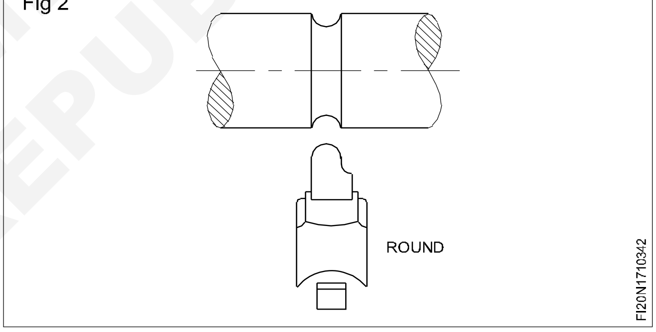
Square grooves are cut with a tool bit ground to the width of the square groove to be formed.

A square groove also serves the purpose of providing space for forks of shift levers in sliding gear assemblies.

Round groove

Round grooves serve the same purpose as square grooves. They are generally used on parts subjected to stress. The round groove eliminates the sharpness of the square corners and strengthens the part at the point where it tends to fracture. A tool bit with a round nose ground to the required radius is used to cut round grooves. (Fig 2)

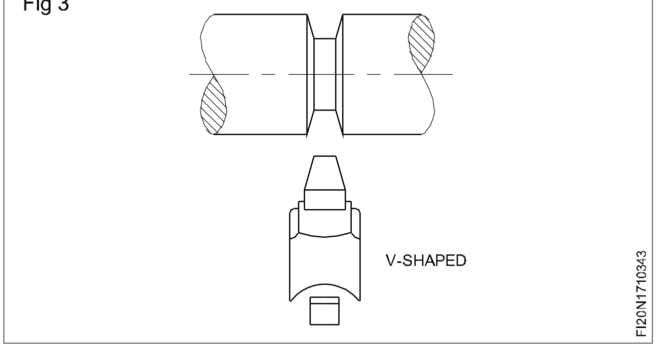
Fig 2



'V' shaped groove

'V' shaped grooves are most commonly found on pulleys driven by 'V belts. The 'V shaped groove eliminates much of the slip which occurs in the other forms of the belt drive. A 'V groove may also be cut at the end of a thread to provide a channel into which the threading tool may run. (Fig 3)

Fig 3



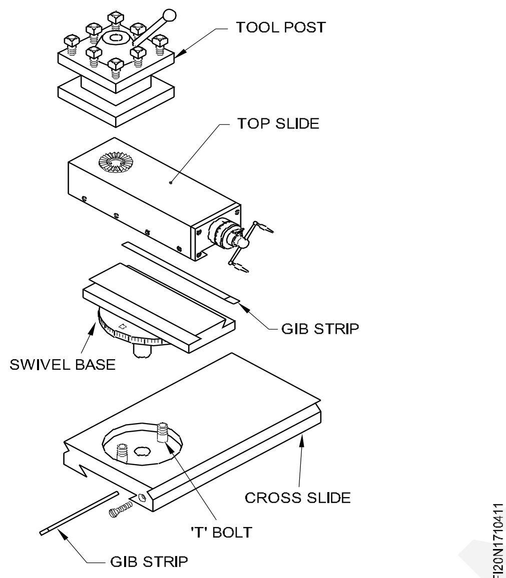
A tool bit ground to the desired angle is used to cut a shallow 'V' groove. Larger 'V' grooves such as those found on pulleys should be cut with the lathe compound rest to form each face of the groove individually.

Tool post

Objectives: At the end of this lesson you shall be able to
- **name the commonly used types of tool posts**
- **compare the features of different types of tool posts.**

The tool post holds and firmly supports the tool or tools. The tool post is fitted on the top slide. (Fig 1)

Fig 1



The commonly used types of tool posts are:

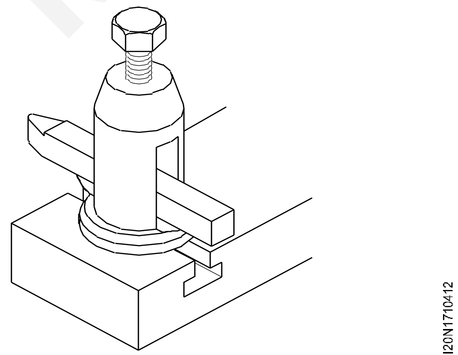
- American type tool post or single way tool post.
- Indexing type tool post or square tool post.
- Quick change tool post.

Single way tool post (Fig 2)

It consists of a circular tool post body and a pillar with a slot for accommodating the tool or tool-holder. A ring base, a rocker arm (boat piece) and a tool clamping screw complete the assembly of this type of tool post.

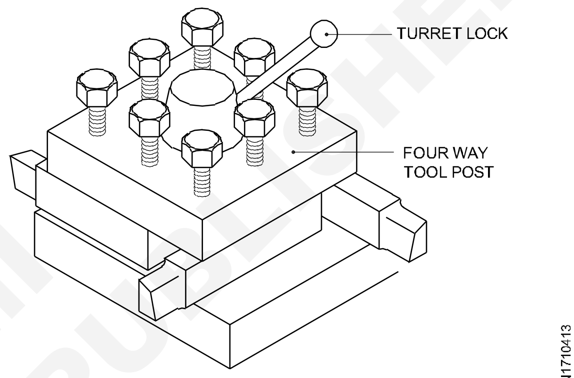
The tool is positioned on the boat piece and clamped. The centre height of the tool tip can be adjusted with the help of the rocker arm and the ring base. Only one tool can be fixed in this type of tool post. The rigidity of the tool is less as it is clamped with only one bolt.

Fig 2



Indexing type tool post (Fig 3): It is also called as square tool post or a four-way tool post. Four tools can be fixed in this type of tool posts, and any one can be brought into the operating position, and the square head is clamped with the help of the handle lever. By loosening the handle lever, the next tool can be indexed and brought in to the operating position. The indexing is manually.

Fig 3



INDEXING TYPE TOOL POST

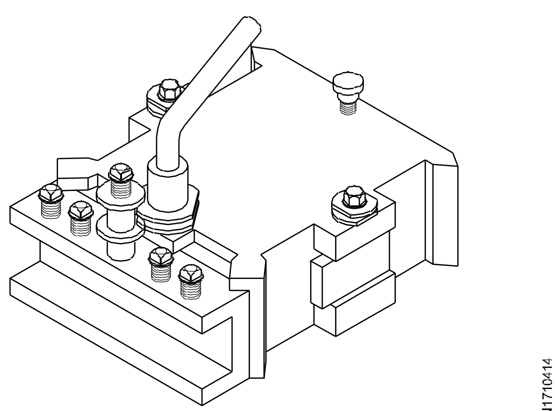
The advantages are as follows: Each tool is secured in the tool post by more than one bolt, and, therefore, the rigidity is more.

Frequent changing of the tool for different operations need not be done as all the four tools can be clamped at the same time.

The disadvantage is that skill is required to set the tools, and it takes more time to set to the centre height.

Quick change tool post (Fig 4): Modern lathes are provided with this type of tool posts. Instead of changing the tools, the tool holder is changed in which the tool is fixed. This is expensive and requires a number of tool-holders. But it can be set to the centre height easily, and has the best rigidity for the tool.

Fig 4



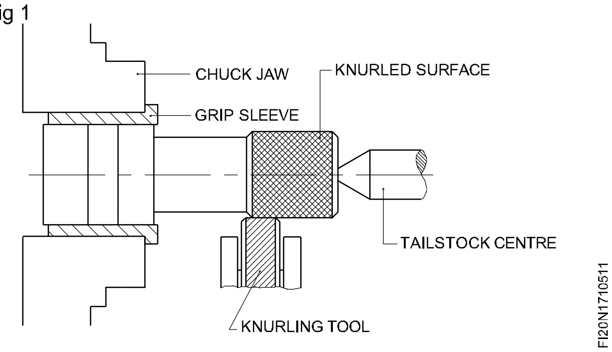
QUICK CHANGE TOOL POST

Lathe operation - Knurling

Objectives: At the end of this lesson you shall be able to
- **define knurling operation**
- **state the purpose of knurling**
- **list the different types of knurls and knurling patterns**
- **name the grades of knurls**
- **distinguish between the various types of knurling tool-holders.**

Knurling (Fig 1)

Fig 1



It is the operation of producing straight lined, diamond shaped pattern or cross lined pattern on a cylindrical external surface by pressing a tool called knurling tool. Knurling is not a cutting operation but it is a forming operation. Knurling is done at a slow spindle speed (1/3 the turning speed). However speed & feed given for knurling is to be divided according to the job material and the finish required.

Purpose of knurling

The purpose of knurling is to provide:

- A good grip and make for positive handling.
- Good appearance
- For raising the diameter to a small range for assembly to get a press fit.

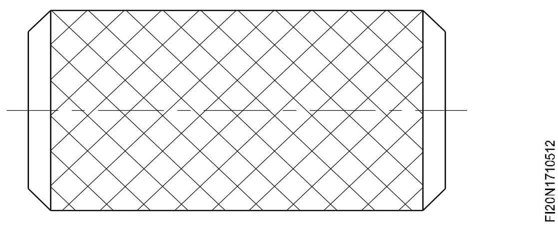
Types of knurls and knurling patterns

The following are the different types of knurling patterns.

Diamond knurling, Straight knurling, Cross knurling, Concave knurling and Convex knurling.

Diamond knurling (Fig 2)

Fig 2



It is a knurling of diamond shaped pattern. It is done by using a set of rolls. One roller has got right hand helical teeth and the other has left hand helical teeth.

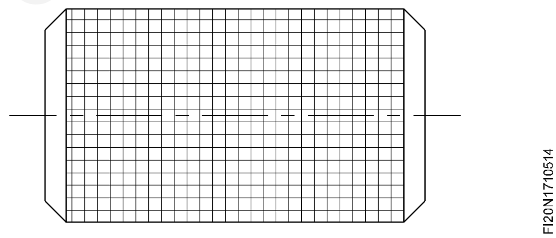
Straight knurling (Fig 3)

Fig 3

It is a knurling of straight lined pattern. This is done by using either a single roller or a double roller with straight teeth.

Cross knurling (Fig 4)

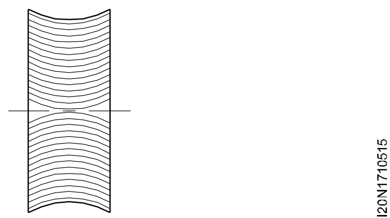
Fig 4



It is a knurling having a square shaped pattern. It is done by a set of rollers, one having straight teeth the other having teeth at right angles to the axis of knurl.

Concave knurling (Fig 5)

Fig 5



This is done by a convex knurl on a concave surface. This is done only by plunging the tool. The tool should not be moved longitudinally. The length of the knurling is limited to the width of the roller.

Convex knurling (Fig 6)

This is done by using a concave knurl on a convex surface. This is also done by plunging the tool.

Grades of knurling (Fig 7)

Fig 6

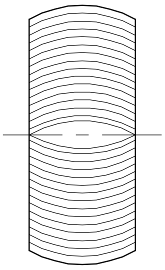
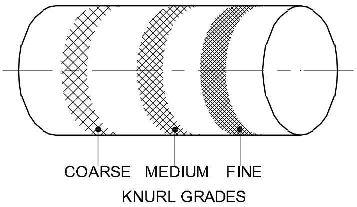


Fig 7



Knurling can be done in three grades.

Coarse knurling, Medium knurling and Fine knurling

Coarse knurling is done by using coarse pitched knurls of 1.75 mm pitch. (14 TPI)

Medium knurling is done by using medium pitched knurls of 1.25 mm pitch. (21 TPI)

Fine knurling is done by using fine pitched knurls of 0.75 mm pitch. (33 TPI)

Types of knurling tool-holders

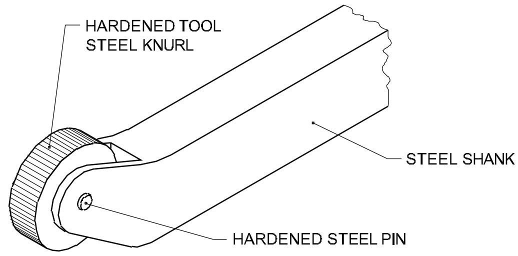
The different types of knurling tool-holders are:

- Single roller knurling tool-holders (parallel knurling tool-holders)
- Knuckle joint type knurling tool-holders
- Revolving type knurling tool-holders (universal knurling tool-holders).

A knurling tool-holder has a heat-treated steel shank and hardened tool steel knurls. The knurls rotate freely on hardened steel pins.

Single roller knurling tool-holder (Fig 8)

Fig 8

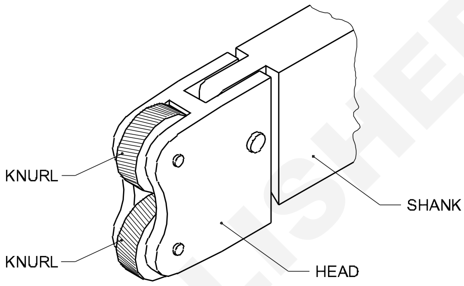


SINGLE ROLLER TYPE

It has only one single roller which produces a straight lined pattern.

Knuckle joint type knurling tool-holders (Fig 9)

Fig 9

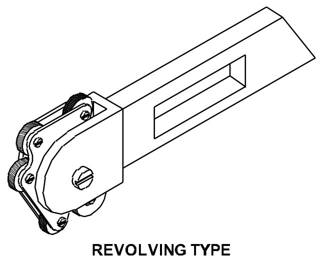


KNUCKLE TYPE

This tool holder has a set of two rollers of the same knurling pitch. The rollers may be of straight teeth or helical teeth. It is self-centering.

Revolving head knurling tool (Fig 10)

Fig 10



REVOLVING TYPE

This tool-holder is also called a universal knurling tool-holder. It is fitted with 3 pairs of rollers having coarse, medium and fine pitches. These are mounted on a revolving head which pivots on a hardened steel pin. It is also self-centering.

Difference between different types of knurling tool-holders

Single roller	Knuckle joint	Revolving type
Only one roller is used	A pair of rollers are used	Three pairs of rollers are used
Only one pattern of knurling can be produced with this type of knurling tool-holder	Cross of diamond knurling pattern can be produced	Knurling patterns of different pitches can be produced
It is not self-centering	It is self-centering	It is self-centering

Knurling - Speed and Feed

The tables shown be used as a guide for determining the amount of end-feed or in-feed per revolution of the work. The rate of the feed for diamond pattern knurling is slower than that for straight or diagonal knurling.

Straight or Diagonal
End - FEED KNURLING
Approximate
FEED per REVOLUTION

T.P.I	Alum Brass	Mild Steel	Alloy Steel
12	.008"	.006"	.004"
16 - 20	.010"	.008"	.005"
25 - 35	.013"	.010"	.007"
40 - 80	.017"	.012"	.009"

Straight or Diagonal
IN - FEED KNURLING
Approximate
REVOLUTION

T.P.I	Alum Bras	Mild Steel	Alloy Steel
12	12	15	25
16-20	10	13	22
25-35	8	11	20
40-80	6	9	18

Standard tapers

Objectives: At the end of this lesson you shall be able to
- **define a taper**
- **state the uses of tapers**
- **state the method of expressing tapers**
- **state the methods to be adopted while specifying tapers**
- **distinguish between the features of self-holding and self-releasing tapers**
- **name the different types of self-holding tapers and state their features**
- **state the features of self-releasing tapers**
- **state the features of pin taper and keyway taper.**

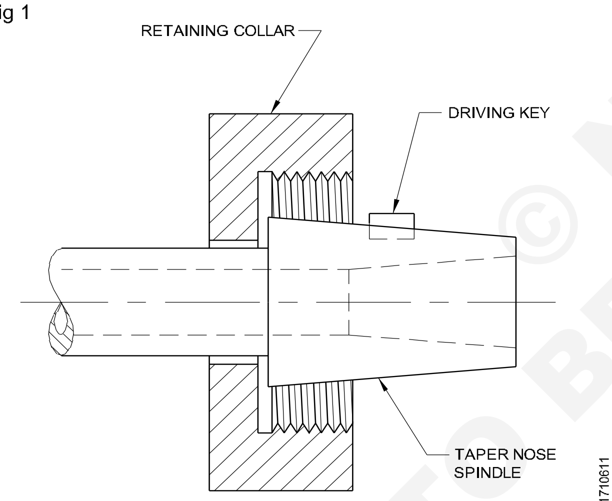
Definition of Taper: Taper is a gradual increase or decrease in the dimention along its length of the job.

Tapers are used for:

- Self-alignment/location of components in an assembly.
- Assembling and dismantling parts easily.
- Transmitting drive through assembly.

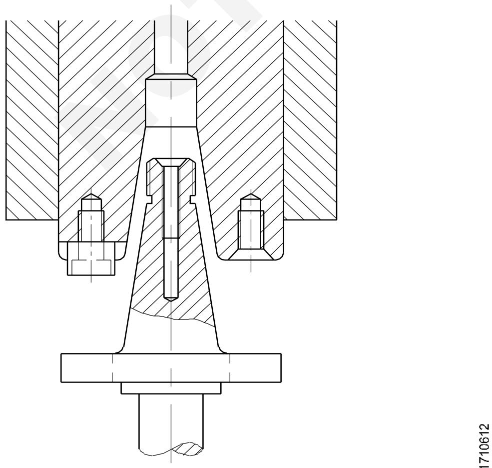
Tapers have a variety of applications in engineering assembly work.(Figs 1,2 & 3)

Fig 1



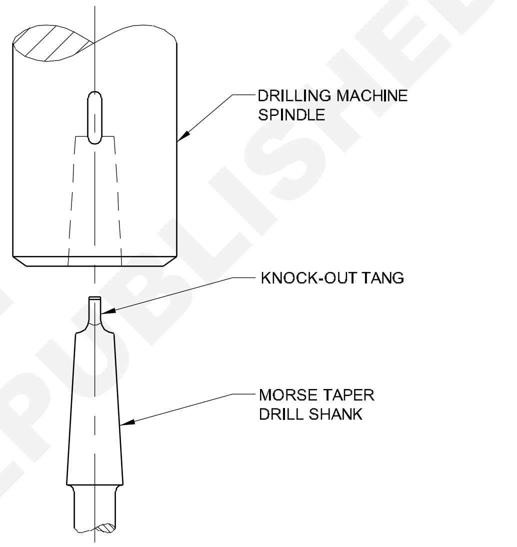
LATHE-TAPER NOSE SPINDLE

Fig 2



MILLING MACHINE SPINDLE

Fig 3

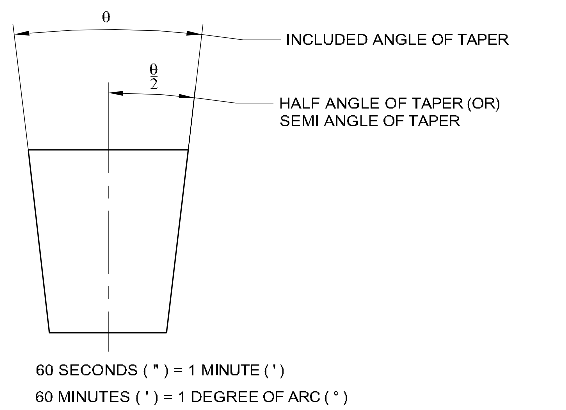


DRILLING MACHINE SPINDLE AND DRILL WITH TAPER SHANK

Tapers of components are expressed in two ways.

- Degree of arc (Fig 4)

Fig 4



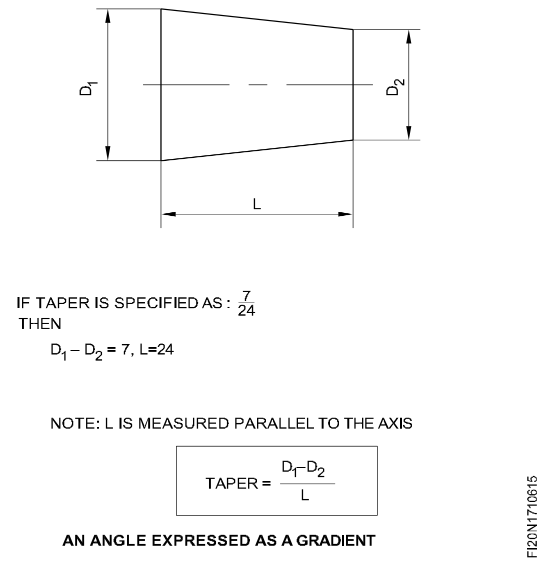
AN ANGLE EXPRESSED IN DEGREES OF ARC

- Gradient (Fig 5)

The method adopted for expressing tapers depends on:

- The steepness of the tapers
- The method adopted for measuring.

Fig 5



Specification of tapers

While specifying taper in drawings it should indicate the:

- Angle of the taper
- Size of the component. (Figs 6,7, 8 & 9)

Fig 6

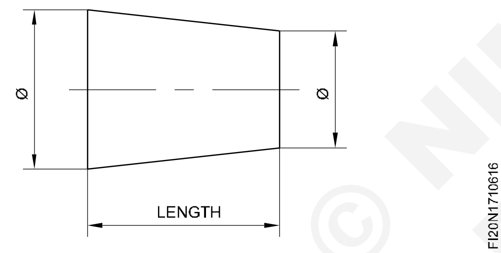


Fig 7

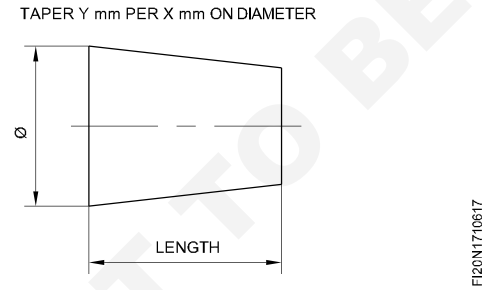


Fig 8

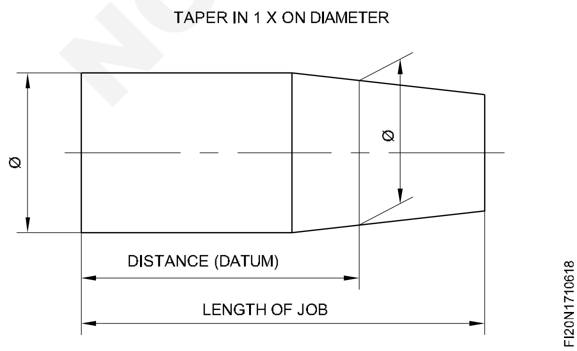
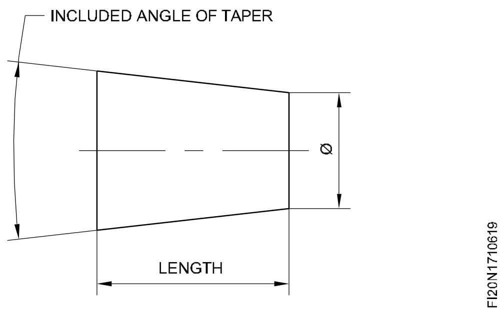


Fig 9



Standard tapers

Tapers for tool-holding

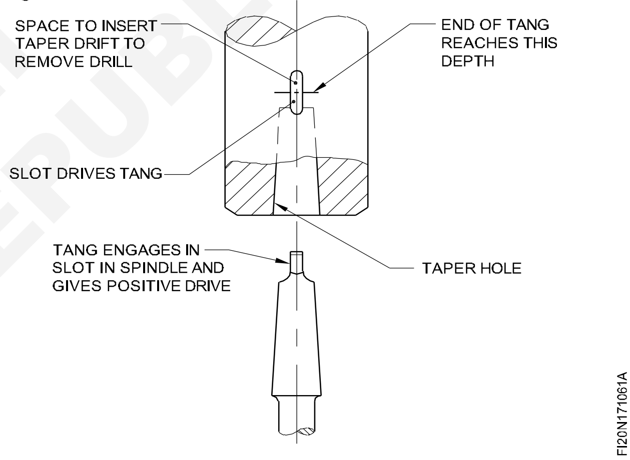
Two types of tapers are used for tool-holding on machines.

- Self-holding tapers
- Self-releasing tapers

Self-holding tapers

Self-holding tapers have less taper angle. These are used for holding and driving cutting tools like drills, reamers etc. without any locking device. (Fig 10)

Fig 10



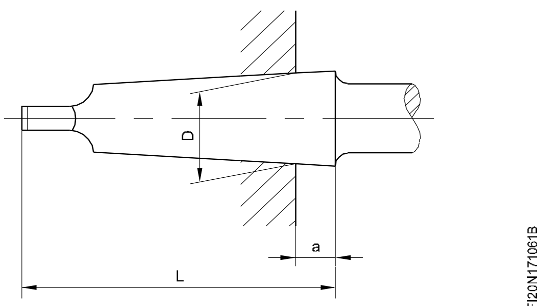
The standard tapers used for this are:

- The metric taper
- The morse taper.

Metric taper

The taper on diameter is 1:20. The commonly used shank sizes in metric tapers are metric 4, 6, 80, 100, 120, 160 and 200. The shank size indicating the metric taper is the diameter at D. (Fig 11)

Fig 11



Morse taper

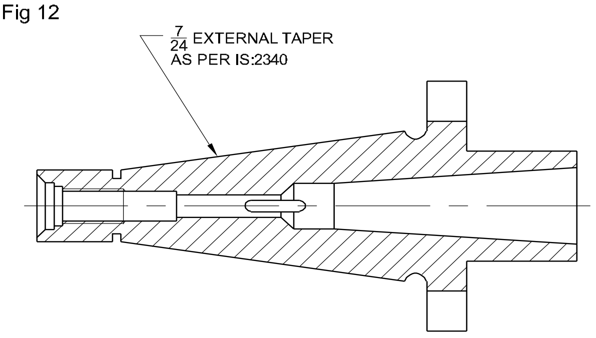
The commonly used taper shank sizes are:

0, 1, 2, 3, 4, 5 and 6.

The taper is varying according to the size of the Morse taper. It varies from 1:19.002 to 1:20.047.

Self-releasing 7/24 taper (Fig 12)

Fig 12



Spindle noses and arbors used on milling machines are usually provided with self-releasing tapers. The standard self-releasing taper is 7/24. This is a steep taper which helps in the correct location and release of the components in the assembly. This taper does not drive the mating component in the assembly. For the purpose of driving, additional features are provided.

The commonly used 7/24 taper sizes are: 30,40,45,50 and 60.

The taper of a 7/24 taper of No.30 will have a maximum diameter of (D) 31.75 mm and No.60, 107.950 mm. All other sizes fall within this range.

Tapers used in other assembly work

A variety of tapers are used in engineering assembly work. The most common ones are:

- pin taper
- key and keyway taper.

Pin taper

This is the taper used for taper pins used in assembly. (Fig 13)

The taper is 1:50.

The diameter of taper pins is specified by the small diameter.

Taper pins help in assembling and dismantling of components without disturbing the location.

Key and keyway tapers

This taper is 1:100. This taper is used on keys and keyways. (Figs 14 and 15)

> **Note: For further information about the tapers used for special application refer to: IS: 3458 - 1981.**

Fig 13

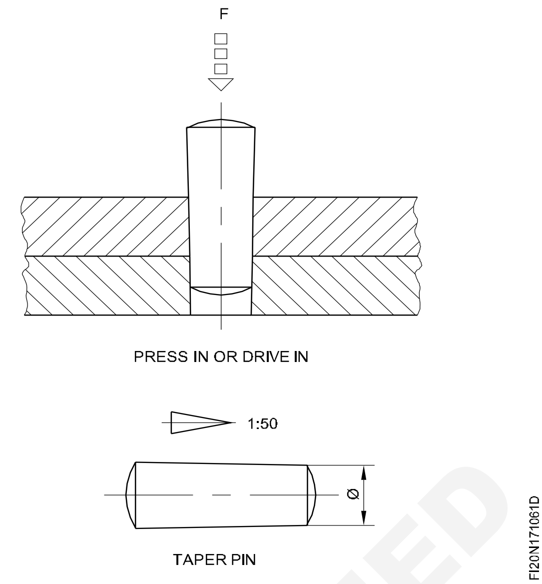


Fig 14

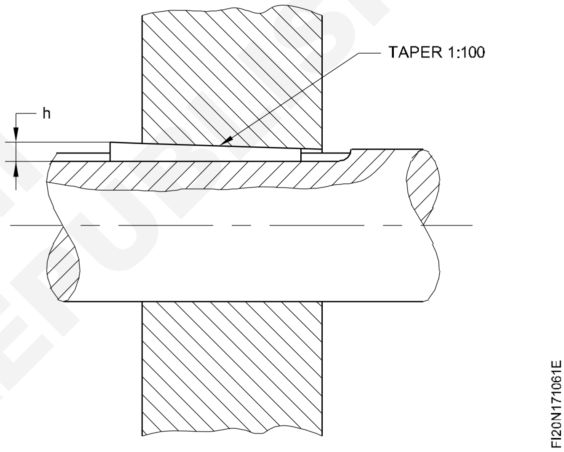
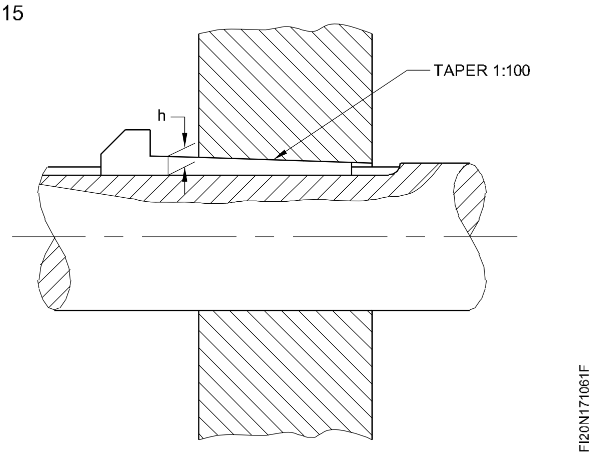


Fig 15



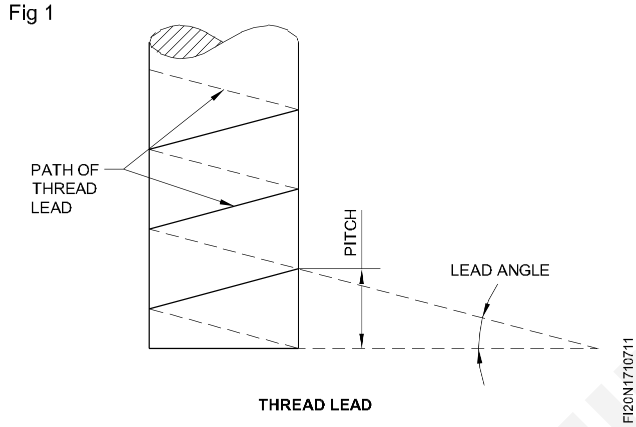
Screw thread

Objectives: At the end of this lesson you shall be able to
- **define screw thread**
- **state the use of screw thread.**

Definition

Thread is a ridge of uniform cross-section which follows the path of a helix around the cylinder or cone, either externally or internally. (Fig 1)

Fig 1



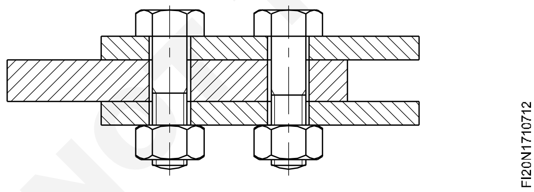
Helix is a type of curve generated by a point which is moving at a uniform speed around the cylinder or cone and at the same time, moves at a uniform speed parallel to the axis. (Fig 1)

Uses of Screw threads

Screw threads are used

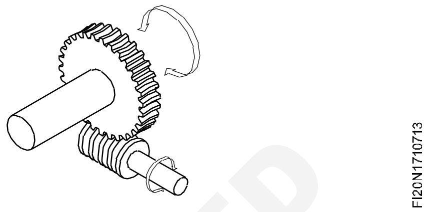
- As fasteners to hold together and dismantle components when needed. (Fig 2)

Fig 2



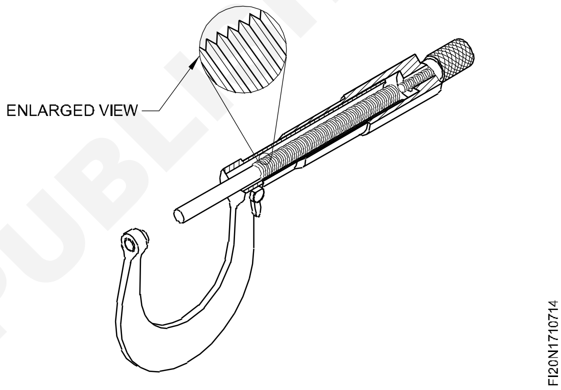
- To transmit motion on machines from one unit to another. (Fig 3)

Fig 3



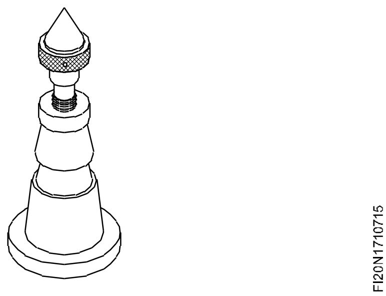
- To make accurate measurements. (Fig 4)

Fig 4



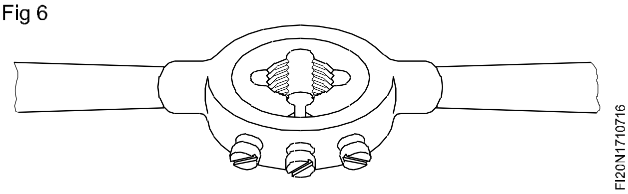
- To apply pressure. (Fig 5)

Fig 5



- To make adjustments. (Fig 6)

Fig 6



Square, worm, buttress and acme threads

Objectives: At the end of this lesson you shall be able to
- **identify square thread and specify its uses**
- **state the relationship between the pitch and the other elements of square threads**
- **identify the modified square thread and its applications**
- **identify the different forms of trapezoidal threads and their uses**
- **state the relationship between the pitch and the other elements of all the different forms of trapezoidal threads.**

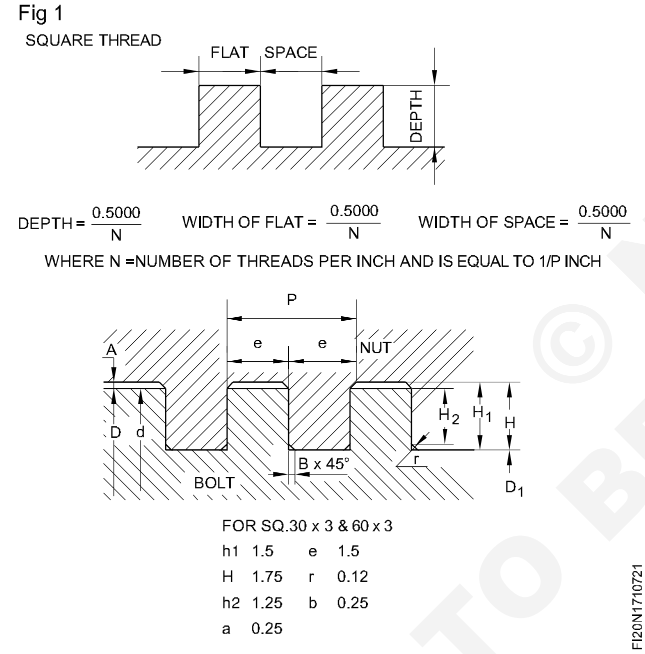
Square and trapezoidal threads

Square and trapezoidal threads have more cross-sectional area than 'V' threads. They are more suitable to transmit motion or power than 'V' threads. They are not used for fastening purposes.

Square thread

In this thread the flanks are perpendicular to the axis of the thread. The relationship between the pitch and the other elements is shown in Fig 1.

Fig 1



Square threads are used for transmitting motion or power. Eg. screw jack, vice handles, cross-slide and compound slide, activating screwed shafts.

Designation

A square thread of nominal dia. 60mm and pitch 9mm shall be designated as Sq. 60 x 9 IS: 4694-1968. The dimensions a, b, e, p, H_1, h_1, h_2 & d_1 are changed as per thread series (fine, normal & coarse).

Modified square thread

Modified square threads are similar to ordinary square threads except for the depth of the thread. The depth of thread is less than half pitch of the thread. The depth varies according to the application. The crest of the thread is chamfered at both ends to 45° to avoid the formation of burrs. These threads are used where quick motion is required.

Trapezoidal threads

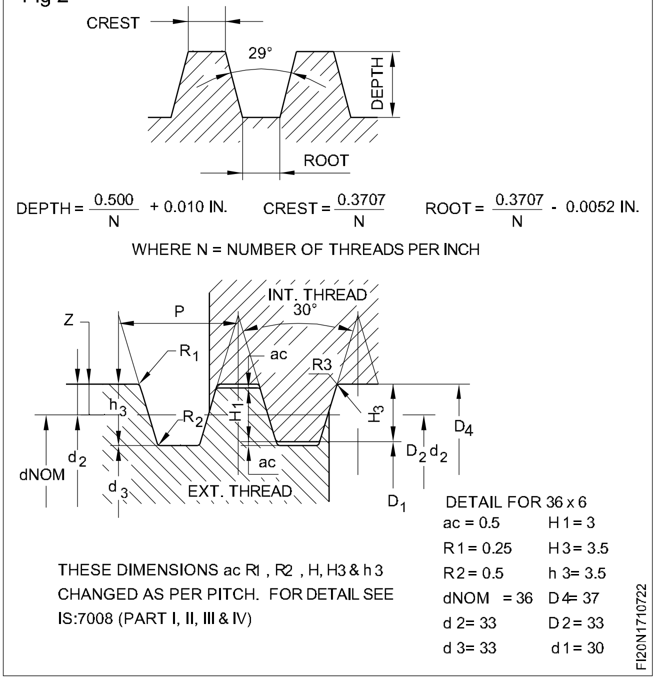
These threads have a profile which is neither square nor 'V' thread form and have a form of trapezoid. They are used to transmit motion or power. The different forms of trapezoidal threads are:

- Acme thread
- Buttress thread
- Saw-tooth thread
- Worm thread.

Acme thread (Fig 2)

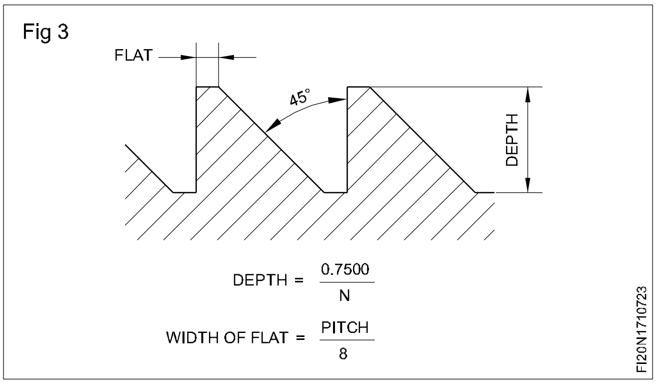
This thread is a modification of the square thread. It has an included angle of 29°. It is preferred for many jobs because it is fairly easy to machine.

Fig 2



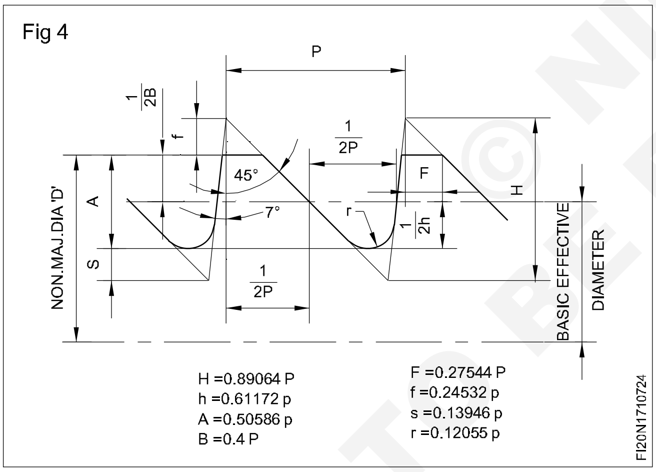
Acme threads are used in lathe lead screws. This form of thread enables the easy engagement of the half nut. The metric acme thread has an included angle of 30°. The relationship between the pitch and the various elements is shown in the figure.

Buttress thread (Fig 3)



In buttress thread one flank is perpendicular to the axis of the thread and the other flank is at 45°. These threads are used on the parts where pressure acts at one flank of the thread during transmission. Figure 3 shows the various elements of a buttress thread. These threads are used in power press, carpentry vices, gun breeches, ratchets etc.

Buttress thread as per B.I.S. (Fig 4)

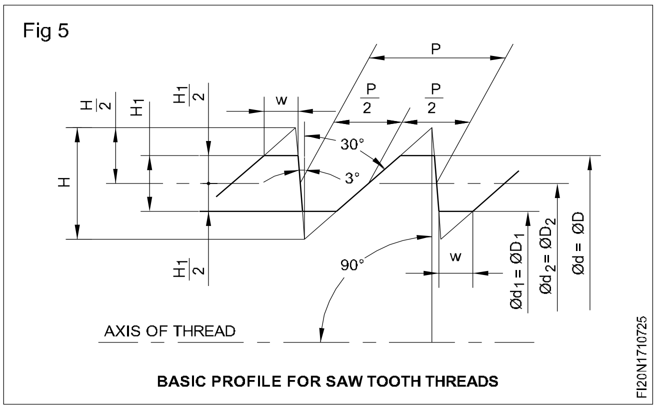


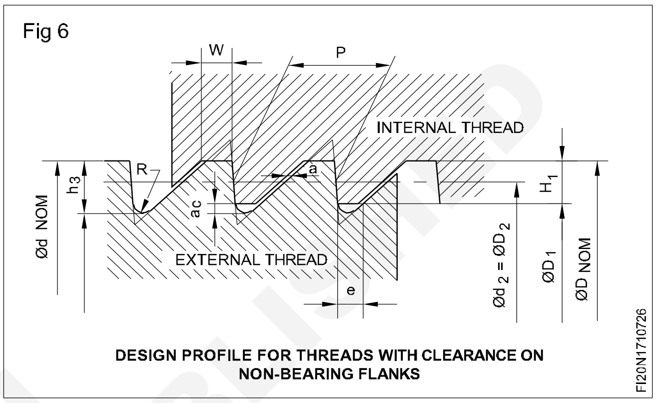
This is a modified form of the buttress thread. Figure 4 shows the various elements of the buttress thread. The bearing flank is inclined by 7° as per B.I.S. and the other flank has a 45° inclination.

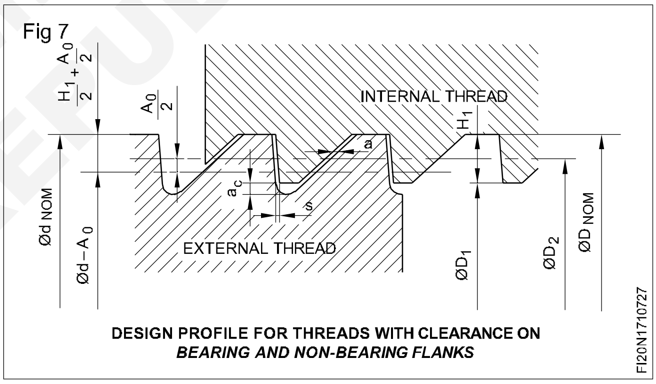
Saw-tooth thread as per B.I.S. 4696

This is a modified form of buttress thread. In this thread, the flank taking the load is inclined at an angle of 3°, whereas the other flank is inclined at 30°. The basic profile of the thread illustrates this phenomenon. (Fig 5) The proportionate values of the dimensions with respect to the pitch are shown in Figs 6 and 7.

The equations associated with the dimensions indicated in the two figures (Figs 6 and 7) are given below.







$H_1 = 0.75\ P$

$h_3 = H_1 + a_c = 0.867\ 77\ P$

$a = 0.1\ \overline{P}$ (axial play)

$a_c = 0.117\ 77\ P$

$W = 0.263\ 84\ P$

e = 0.263 84 P - 0.1 Ö P = W - a

$R = 0.124\ 27\ P$

$D_1 = d - 2\ H_1 = d - 1.5\ P$

$d_3 = d - 2\ h_3$

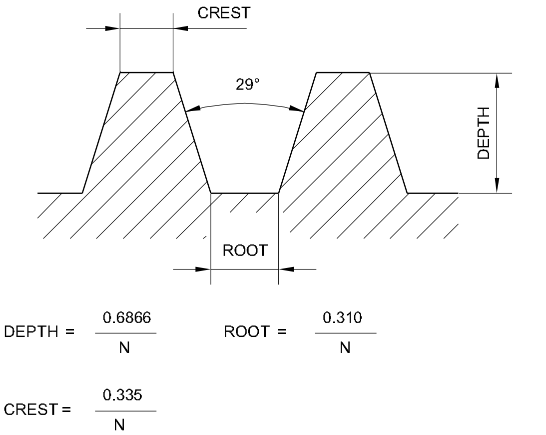
$d_2 = D_2 = d - 0.75\ P$

S = 0.314 99 A_o, where A_o = basic deviation (= upper deviation) for external thread in the pitch diameter.

Worm thread

This is similar to acme thread in shape but the depth of thread is more than that of acme thread. This thread is cut on the worm shaft which engages with the worm wheel. Figure 8 shows the elements of a worm thread.

Fig 8



WORM THREAD

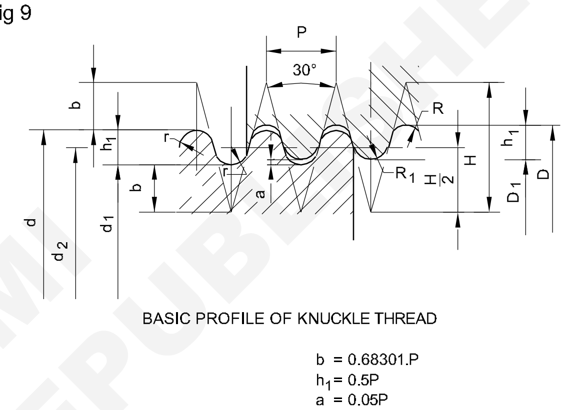
The worm wheel and worm shaft are used in places where motion is to be transmitted between shafts at right angles. It also gives a high rate of speed reduction. The worm wheel is generally cut by diametral pitch (D.P) or module pitch cutters. Diametral pitch (D.P) is the ratio between the number of teeth to the pitch diameter (P.D.) of the gear. Module is the ratio between the pitch diameter of the gear and the number of teeth of the gear.

The linear pitch of the worm thread must be equal to the circular pitch of the worm gear. When the worm gear is of D.P. then the linear pitch of the worm thread in mesh is equal to p/DP. When the worm gear is of module teeth, then the linear pitch of the worm thread is equal to module x p. In some of the lathes, a chart illustrates the position of levers of the quick change gearbox together with the change gear connections for cutting D.P. or module worm threads.

Knuckle threads

The shape of the knuckle thread is not trapezoidal but it has a rounded shape. It has limited application. The figure shows the form of knuckle thread. It is not sensitive against damage as it is rounded. It is used for valve spindles, railway carriage couplings, hose connections etc. (Fig 9)

Fig 9



DESIGNATION:- A KNUCKLE THREAD OF DIAMETER 60 mm & PITCH 4.233mm SHALL BE DESIGNATED AS k60x4.233 IS:4695

Principle of cutting screw thread in centre lathe

Objectives: At the end of this lesson you shall be able to
- **state the principle of thread cutting by a single point tool**
- **list the parts involved in the thread cutting mechanism and state their functions**
- **derive formula for change gear calculation.**

Principle of thread cutting

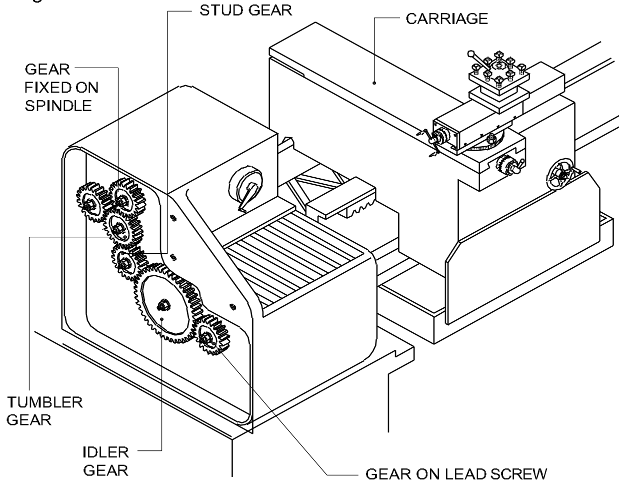
The principle of thread cutting involves producing a uniform helical groove on a cylindrical or conical surface by rotating the job at a constant speed, and moving the tool longitudinally at a rate equal to the pitch of the thread, per revolution of the job.

The cutting tool moves with the lathe carriage by the engagement of a half nut with the lead screw. The shape of the thread profile on the work is the same as that of the tool ground. The direction of rotation of the lead screw determines the hand of the thread being cut.

Parts involved in thread cutting

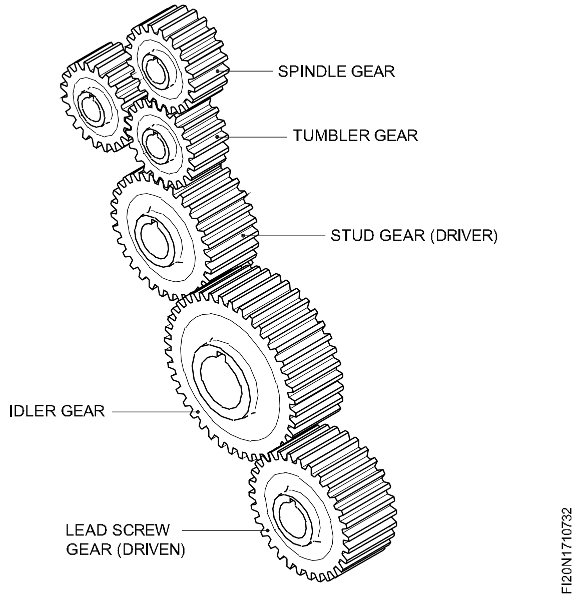
Figures 1 & 2 illustrate how the drive is transmitted from the spindle to the lead screw through a change gear arrangement. From the lead screw the motion is transmitted to the carriage by engaging the half nut with the lead screw.

Fig 1



TRANSMITTING MOTION FROM SPINDLE TO CARRIAGE

Fig 2



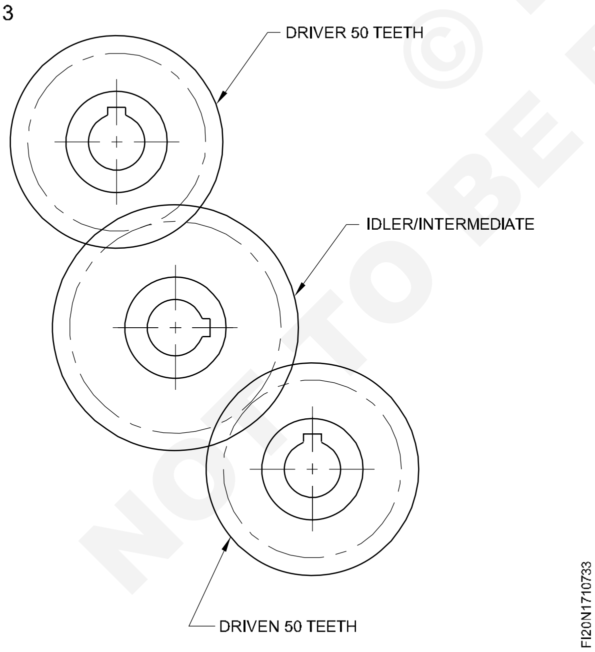
Derivation of the formula for change gears

Example

CASE 1 : To cut 4 mm pitch (lead) thread on the job in a lathe having a lead screw of 4 mm pitch.

When the job rotates once, the lead screw should make one revolution to move the tool by 4 mm. Hence, if the stud gear (Driver) has a 50 teeth wheel, the lead screw should be fixed with a gear of 50 teeth (Driven) to get the same number of revolutions as the spindle. (Fig 3)

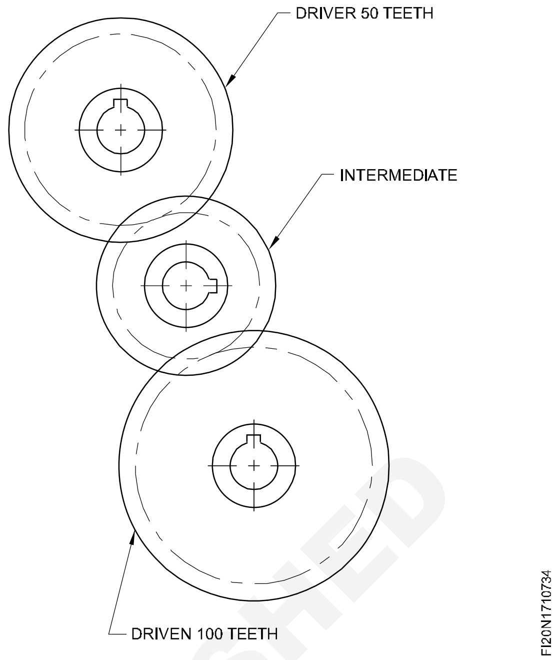
Fig 3



CASE 2 : To cut 2 mm pitch threads instead of 4 mm in the same lathe.

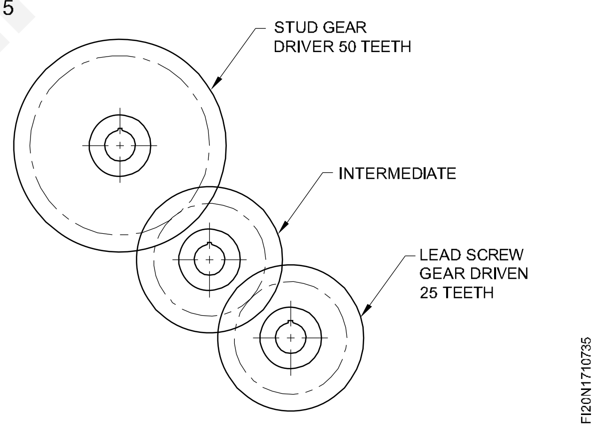
When the job makes one rotation, the lead screw should rotate 1/2 revolution so that the lead screw rotation is slower. Therefore, the driven wheel (lead screw gear) should be of 100 teeth if the driver (stud gear) is of 50 teeth. (Fig 4)

Fig 4



CASE 3 : If we have to cut a 8 mm pitch thread on a job, with a 4mm lead screw pitch, the tool should move 8 mm per revolution of the job. The lead screw should rotate 2 revolutions when the job makes one rotation, making the L S to run twice as fast as the spindle. So the driven wheel (lead screw gear) should be of 25 teeth if the driver wheel is of 50 teeth. (Fig 5)

Fig 5



Let us compare the above three examples.

Examples :	Case 1	Case 2	Case 3
Pitch(Lead)of job	4	2	8
Pitch(Lead) of L.S	4	4	4
Driver	50	50	50
Driven	50	100	25

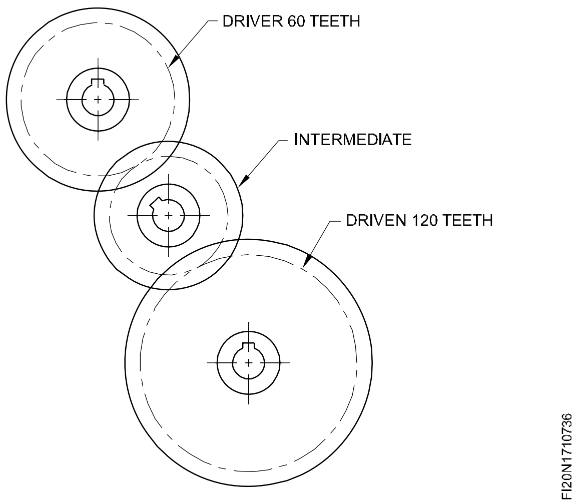
Stating the above in a formula,

$$\text{The gear ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of lead screw}}$$

Solved examples

1 Find the change gears required to cut a 3 mm pitch on a job in a lathe, having a lead screw of 6 mm pitch. (Fig 6)

Fig 6



Ratio = Driver = Lead of work

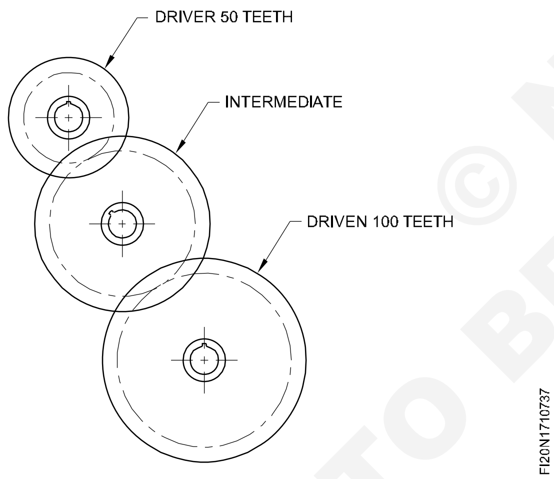
$$\text{The gear ratio} = \frac{3}{6} = \frac{3 \times 20}{6 \times 20} = \frac{60}{120}$$

Driver = 60 teeth

Driven = 120 teeth

2 Find the change gears required to cut a 2.5 mm pitch in a lathe, having a lead screw of 5 mm pitch. (Fig 7)

Fig 7



$$\text{Ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of lead Screw}}$$

$$= \frac{2.5}{5} = \frac{2.5 \times 20}{5 \times 20}$$

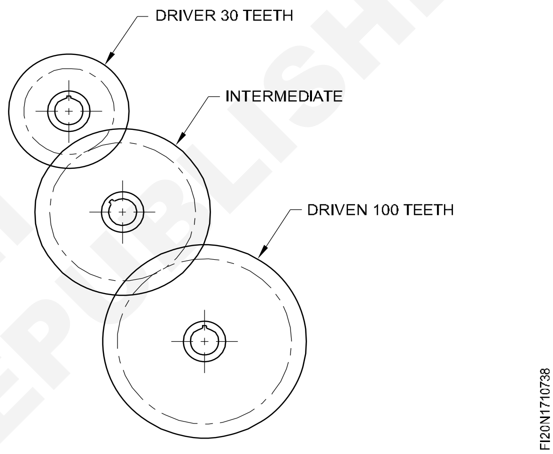
$$= \frac{50\ (\text{Driver})}{100\ (\text{Driven})}$$

3 Calculate the gears required to cut a 1.5 mm pitch in a lathe having a lead screw of 5 mm pitch. (Fig 8)

$$= \frac{1.5}{5} = \frac{3}{10} = \frac{3 \times 10}{10 \times 10}$$

$$= \frac{30\ (\text{Driver})}{100\ (\text{Driven})}$$

Fig 8



Principle of chasing screw thread

Objectives: At the end of this lesson you shall be able to
- **state the necessity of a thread chasing dial**
- **state the constructional details of a British thread chasing dial**
- **state the functional features of a British thread chasing dial.**

Thread chasing dial

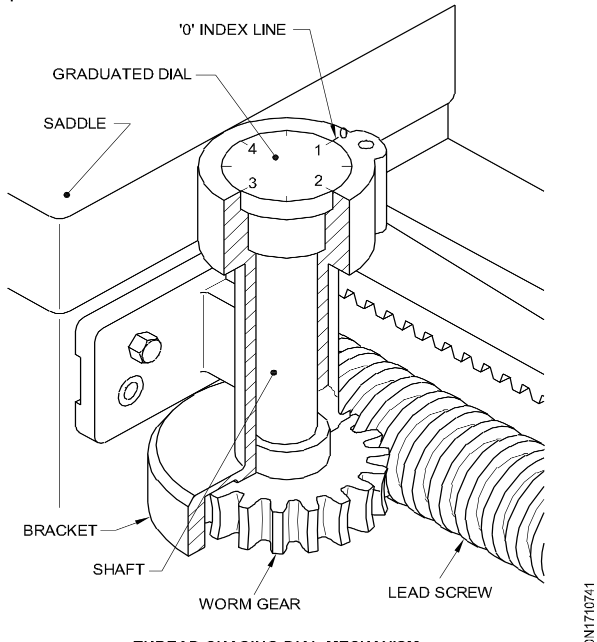
To catch the thread quickly and to save manual labour, use of a chasing dial is very common during thread cutting by a single point cutting tool. A thread chasing dial is an accessory.

Constructional details (Fig 1)

The figure shows constructional details of a British thread chasing dial. It consists of a vertical shaft with a worm wheel made out of brass or bronze, attached to the shaft at the bottom. On the top, it has a graduated dial. The shaft is carried on a bracket in bearing (bush) which is fixed to the carriage. The worm wheel can be brought into an engaged or disengaged position with the lead screw as needed. When the lead screw rotates it drives the worm wheel which causes the dial to rotate. The movement of the dial is with reference to the fixed mark ('O' index line).

The face of the dial is usually graduated into eight (8) divisions, having 4 numbered main divisions and 4 unnumbered subdivisions in between.

Fig 1



THREAD CHASING DIAL MECHANISM

The number of teeth on the worm gear is the product of the number of threads per inch on the lead screw and the number of numbered divisions on the dial.

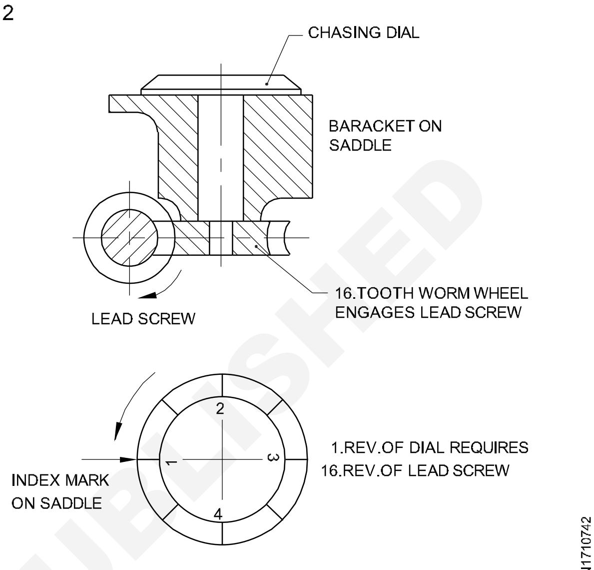
Each numbered division represents 1 inch travel of the carriage.

Let the worm wheel have 16 teeth, and the lead screw 4 TPI. The number of numbered graduations and unnumbered graduations are 4 each.

The half nut can be engaged 8 times for one revolution of the graduated dial. The movement of the carriage for one complete revolution of the dial is 4". (Fig 2) Since the dial is having totally 8 graduations marked, each graduation represents 1/2" travel of the carriage.

The chart given here shows the positions at which the half nut is to be engaged when cutting different threads per inch, when a British thread chasing dial with the above data is fitted to the lathe.

Fig 2



THREAD CHASING DIAL CHART

Threads per inch to be cut	Dial graduation at which the half nut can be engaged to catch the thread	Reading on the dial illustrated
Threads which are a multiple of the number of threads per inch of the lead screw.	Engage at any position the half nut meshes.	Use of dial unnecessary.

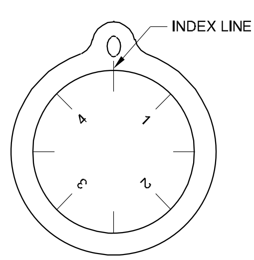
Example T.P.I. to be cut - 8

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I to be cut}} = \frac{4}{8} = \frac{1}{2}$$

Predetermined travel $= 1 \times \frac{1"}{4} = \frac{1"}{4}$

The predetermined travel of 1/4" is represented by the dial position in the exact middle between any numbered division and adjacent un-numbered division. The half nut engagement can be done at any position at which it can be engaged (ie. 16 positions).

Referring to the dial is not necessary.

Even number of threads	Engage at any graduation on the dial. 8 positions	1 1 1/2 2 2 1/2 3 3 1/2 4 4 1/2	

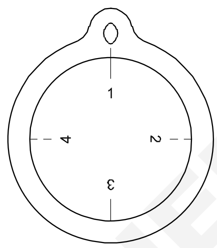
Example T.P.I. to be cut - 6

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I to be cut}} = \frac{4}{6} = \frac{2}{3}$$

Predetermined travel $= 2 \times \frac{1''}{4} = \frac{1''}{2}$

The predetermined travel of 1/2" is represented by dial movement from any numbered division to the next adjacent unnumbered division. The half nut can be engaged when any numbered or unnumbered graduation coincides with the zero line (8 positions).

Odd number of threads	Engage at any main division. 4 positions	1 2 3 4



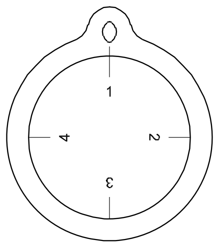
Example T.P.I. to be cut - 5

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} = \frac{4}{5} = \frac{4}{5}$$

Predetermined travel $= 4 \times \frac{1''}{4} = 1''$

The predetermined travel of 1" is represented by the dial movement from any numbered division to the next numbered division or from any unnumbered division to the next unnumbered division. Therefore, if the first cut is taken when a numbered division of the dial coincides with zero, then the half nut engagement for successive cuts can be done when any numbered division coincides with the zero mark. If the first cut is taken when an unnumbered division coincides with the zero, then the half nut for successive cuts, is engaged when any unnumbered division coincides with the zero. (4 positions)

Half fractional number of threads	Engage at every other main division. 2 positions	1 & 3 or 2 & 4



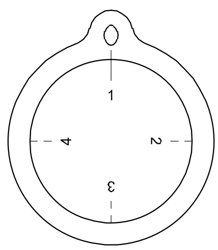
Example T.P.I. to be cut - 3 1/2

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} = \frac{4}{3\,1/2} = \frac{8}{7}$$

Predetermined travel $= 8 \times \frac{1''}{4} = 2''$

The half nut can be engaged only at opposite numbered or unnumbered graduations (2 positions).

Quarter fractional number of threads	Engage at the same main division. 1 position	1 or 2 or 3 or 4



Example T.P.I. to be cut - 2 3/4

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} = \frac{4}{2\ 3/4} = \frac{16}{11}$$

Predetermined travel $= 16 \times \frac{1"}{4} = 4"$

The half nut can be engaged to catch the thread only when the same numbered or unnumbered graduated line, at which the first cut is taken, coincides with the zero line (1 position only).

Example T.P.I. to be cut - 1 3/8

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} = \frac{4}{1\ 3/8} = \frac{32}{11}$$

Predetermined travel $= 16 \times \frac{1"}{4} = 4"$

The half nut engaged for the first cut should remain at the engaged position till thread cutting is completed and the machine is reversed as it takes a long time to cover the predetermined travel arrived at by calculation.

Example T.P.I. to be cut - 1 3/8

$$\frac{DR}{DN} = \frac{\text{T.P.I. on lead screw}}{\text{T.P.I. to be cut}} = \frac{4}{1\ 3/8} = \frac{32}{11}$$

Predetermined travel $= 32 \times \frac{1"}{4} = 8"$

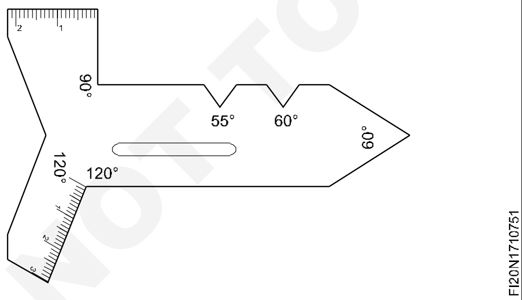
The half nut engaged for the first cut should remain at the engaged position till thread cutting is completed and the machine is reversed as it takes a long time to cover the predetermined travel arrived at by calculation.

Centre gauge

Objectives: At the end of this lesson you shall be able to
- **define centre gauge**
- **write the uses of centre gauge.**

Centre gauge: (Fig 1)

Fig 1



Centre gauges and fish tail gauges are gauges used in lathe work for checking the angles when grinding the profiles of single point screw cutting tool bits and centers. In the image, the gauge on the left is called a fishtail gauge or centre gauge, and the one on the right is another style of center gauge.

These gauges are most commonly used when hand grinding threading tool bits on a bench grinder, although they may be used with tool and cutter grinders.

When the tool bit has been ground to the correct angle, they may then be used to set the tool perpendicular to the workpiece.

They can incorporate a range of sizes and types on the one gauge, the two most common being metric or UNS at 60^0, and BSW at 55^0. Gauges also exist for the acme thread form.

Tool setting - external thread

Objective: At the end of this lesson you shall be able to
- **tool setting to cut external thread by half angle method.**

Check the diameter of the workpiece to be threaded by referring to the drawing.

To provide thread clearance, it is good practice to turn the diameter of the workpiece undersize depending upon the requrired.

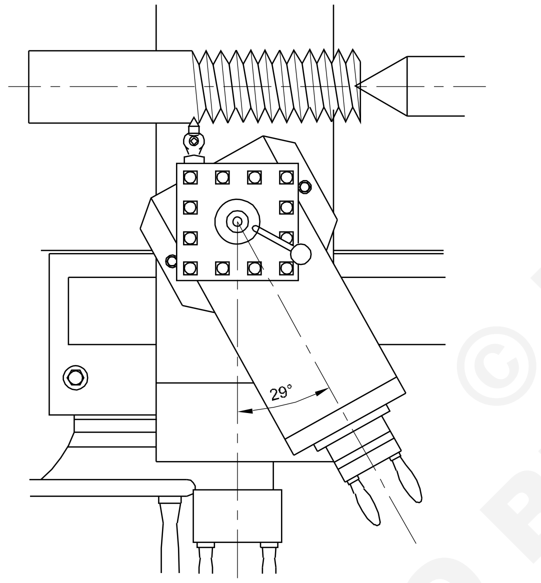
Set the lathe spindle speed to about one fourth of the turning speed.

Set the gerarbox according to the pitch of thread to be cut.

Swivel the compound slide to 90° from the horizontal position to bring it in line with the cross-slide.

Swivel to the right 1° less than the half included angle of the thread it is a right hand thread. (Fig 1)

Fig 1



COMPOUND REST SET AT 29° TO THE RIGHT TO CUT A 60° INCLUDED ANGLE RIGHT HAND THREAD

The angle to which the compound rest is set affects the cutting action of the cutting tool by producing a shearing action on the trailing edge of the tool. This produces a smooth cut.

Set the tool in the tool post with a minimum overhand perpendicular to the axis and also set with a centre gauge. (Fig 2)

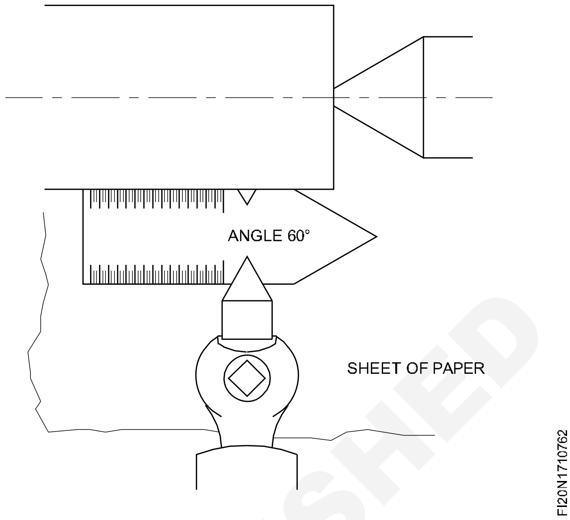
Mark out the length of the workpiece to be threaded.

Chamfer the end of the workpiece surface with the leading edge of the cutting tool to a depth, just greater than the minor diameter of the thread to be cut.

Advance the cutting tool to the work surface by operating the cross-slide hand wheel.

When the tip of the tool just touches the work surface, stop further advancement and set the cross-slide and compound slide graduated collars to zero.

Fig 2



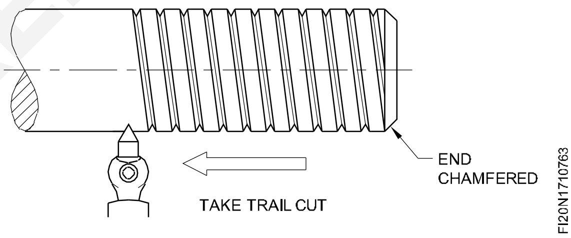
Move the carriage to the right until the end of the tool clears the work.

Feed the tool in about 0.1 mm using the top slide hand wheel.

Engage the half nut referring to be chasing dial.

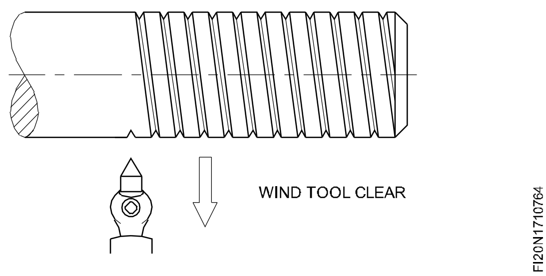
Take a trial cut along the workpiece to be threaded. (Fig 3)

Fig 3



At the end of the trial cut, withdraw the tool immediately, winding it clear off the workpiece by operating the cross slide hand wheel and simultaneously reversing the machine. (Fig 4)

Fig 4



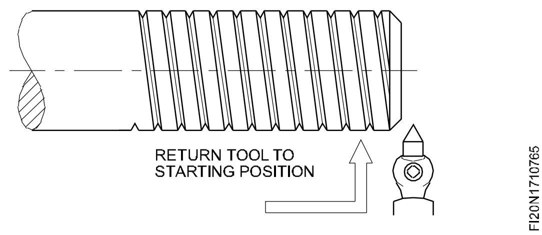
Allow the carriage to move to the right till it is cleared from the end of the work, and stop the machine. (Fig 5)

Check the thread formation with a pitch gauge.

Advance the tool by the cross-slide hand wheel toll zero position.

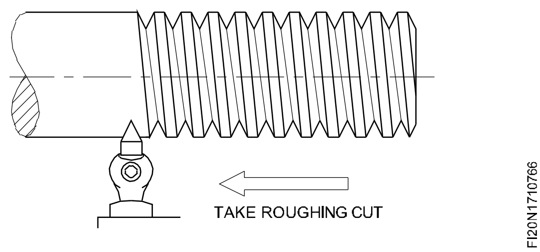
Give depth of cut with the top slide handle.

Fig 5



Start the machine and allow the tool to cut the thread. (Fig 6)

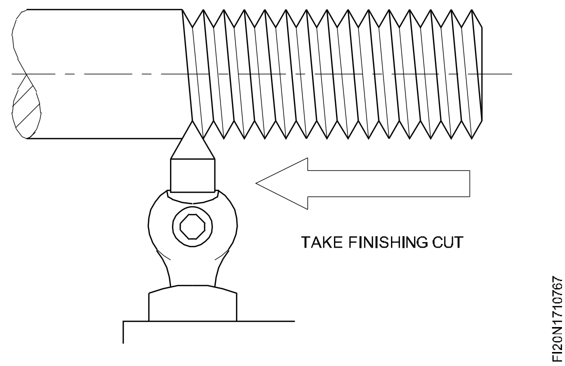
Fig 6



Use plenty of coolant during threading.

Repeat the steps till the required depth is reached. (Fig 7)

Fig 7



Note: At the end of each cut, the tool is withdrawn from the work by the cross-slide hand wheel and the carriage is brought to the starting point. The cross-slide hand wheel is brought to zero position and a depth of cut is given by the top slide.

Cutting an internal thread

Objectives: At the end of this lesson you shall be able to
- **tool setting to cut an internal thread.**

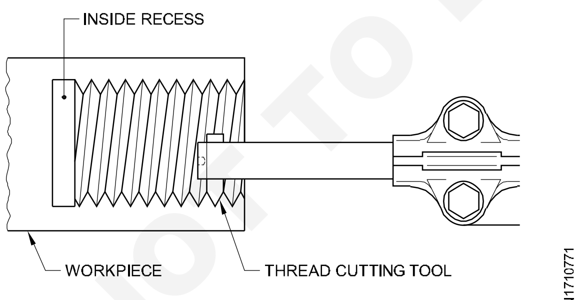
Mount the job on four jaw chick/three jaw chuck/ collect.

Drill and bore the job to the core diameter of the thread to required length/through hole.

For a blind hole, cut a recess at the end of the bore enough to permit the cutting tool to clear thread.

The recess must be larger than the major diameter of the thread. (Fig 1)

Fig 1



CUTTING AN INTERNAL THREAD

Chamfer the front end to 2x45°.

Set the compound rest at 29° to cut 60° included angle as shown in Fig 2.

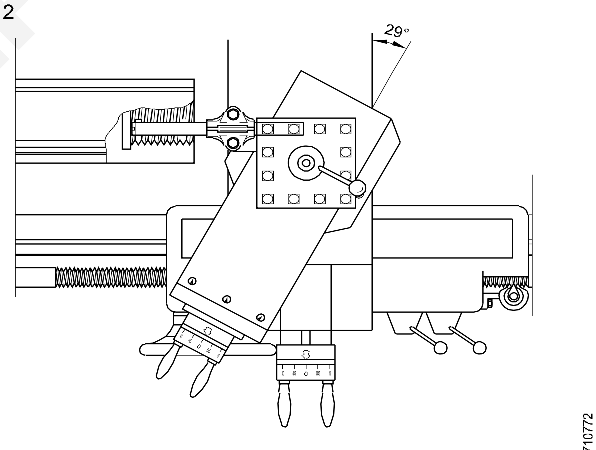
Set the gear box levers to the required pitch.

Fix the correctly ground threading tool in a boring bar.

Fix the boring bar parallel to the lathe centre line and set the point of the cutting tool to lie on the centre.

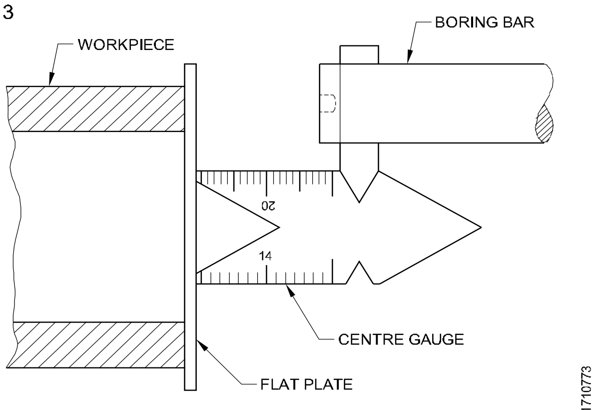
Align the cutting tool with a help of centre gauge as shown in Fig 3.

Fig 2



COMPOUND REST SET AT 29° TO THE LEFT TO CUT A 60° INCLUDED ANGLE INTERNAL THREAD

Fig 3



ALIGNING THE CUTTING TOOL WITH A CENTRE GAUGE

Mark the boring bar to indicate the required depth to entry into the bore.

Ensure that the boring bar does not foul anywhere on the job.

Reverse the cross slide until the tool point just touches the bore.

Set the cross-slide and compound slide graduated collars to zero.

Withdraw the cutting tool from the bore.

Set the spindle speed to 1/3 of the calculated r.p.m.

Start the machine.

Adjust the depth of cut to 0.1 mm.

Engage the half nut.

At the end of the cut, simultaneously reverse the chunk and clear the tool just away from the thread.

Ensure that the tool should not touch the thread in both side of the bore.

When cutting tool comes out of the bore stop the machine.

Give the depth of cut and run the machine in forward direction. Similarly finish the thread until final depth is achieved.

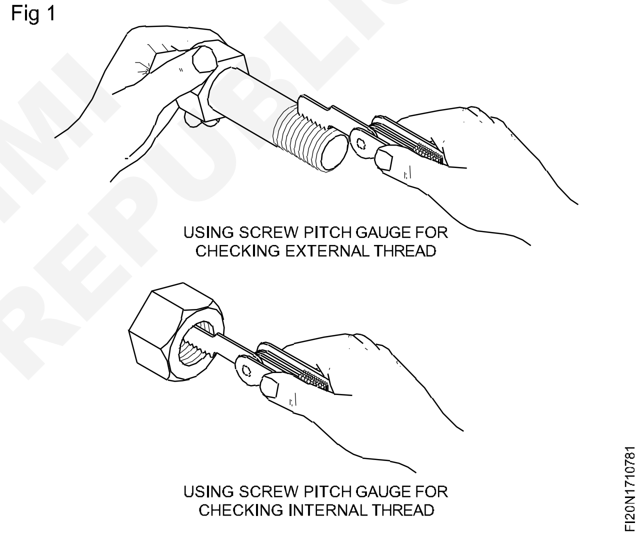
Check the finished thread with a thread plug gauge or a threaded bolt.

Screw pitch gauge

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a screw pitch gauge**
- **state the features of a screw pitch gauge.**

For obtaining accurate results while using the screw pitch gauge, the full length of the blade should be placed on the threads. (Fig 1)

Fig 1



Total productive maintenance

Objectives: At the end of this lesson you shall be able to
- **explain the concept of TPM**
- **state advantages of TPM**
- **explain the concept of OEE**
- **describe the components of OEE and their effects.**

Total Productive Maintenance(TPM) concepts

TPM aims to maximize overall equipment effectiveness. Establishes a complete system of productive maintenance for the machines/equipments entire lifespan is implemented by various departments. [Engineering, Operations, Maintenance, Quality and Administration]

TPM can be considered as the medical science of machines.

TPM involves every single employee, from top management to all the operators on the shop floor. TPM raises and implements productive maintenance based on autonomous small group activities.

TPM is a maintenance program which involves a newly defined concept for maintaining plants and equipments.

The goal of TPM is to an extent increase production while, at the same time, increasing employee morale and job satisfaction.

TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity.

Downtime for maintenance is scheduled as a part of the manufacturing day. In some cases as an integral part of the production process.

The goal of TPM is to stop the emergency and unscheduled maintenance.

Form different teams to reduce defects and self maintenance.

Advantages of TPM

- Avoids wastage in quickly changing economic environment.
- Produces goods without reducing product quality.
- Reduces maintenance cost.
- Produces a low batch quantity at the earliest possible time.
- Ensures the non defective goods to the customers.
- Reduce customers complaints.
- Reduce accidents.
- Follow pollution control measures.
- Favourable change in the attitude of the operator.

Overall equipment effectiveness (OEE)

Overall equipment effectiveness (OEE) is a concept utilized in a lean manufacturing implementation. OEE is described as one such performance measurement tool that measures different types of production loses and indicate areas of process development. The OEE concept normally measures the effectiveness of a machine center or process line, but can be utilized in non-manufacturing operation also.

The high level formula for the lean manfacturing OEE is

OEE = Availability x Productivity x Quality

Availability

The availability is part of the above equation measures the percentage of time the machine/equipment of operation was running compared to the available time. For example if the machine was available to run 20 hours but was only run for 15, then the availability is 75 percent 15/20. The five hours when the machine didn't run would be set up time, breakdown or other downtime. The 4 hours the company did not plan to run the machine is rarely used in the calculation.

Performance

The performace part of the equation measures the running speed of the operation compared to its maximum capability often called the rated sppe. For example, if a machine produced 80 pieces per hour while running, but the capability of the machine is 100, then the performance is 80% (80/100). The concept can be used multiple ways depending on the capability number. For example, the machine might be capable of producing 100 pieces per hour with the perfect part, but only 85 on that particular order. When the capability of 100 is used for the calculation, the result is more a measure of facility OEE.

Quality

The third portion of the equation measures the number of good parts produced compared to the total number of parts made. For example if 100 parts are made and 95 of them are good, the quality is 95% (95/100).

Combining the above example into the OEE equation the OEE is

OEE = 75% x 80% x 95% = 57%

Autonomous Maintenance

Autonomous Maintenance put simply is the restoration and preventionof accelerated deterioration and has a major positive effect on OEE. It is a step by step improvement process, rather than production teams taking on maintenance tasks.

- Understanding the equipment functions and safety risks.

The seven steps of Autonomous Maintenance

1 Initial cleaning (Initial inspection & registration)	- Detect problem of the lives and restore the original state. - Start managing the line autonomously (5s, Minor stops, quality) autonomously - Create & perform temporary “cleaning/lubrication produces”
2 Source of contamination & Hard-to-reach areas	Solve “sources of contamination” and hard to reach clear (Cleaning, Inspection lubrication)
3 Standard of cleaning & lubrication	Develop tentaive standards for cleaning lubrication and inspection.
4 General Inspection	Provide training on their equipments, products and materials, inspection skills and other Am skills.
5 Autonomous Inspection	Develop a routine maintenance standard by operations.
6 Standadize autonomous maintenance operation	Standadize routine operation related to work place management such as quality inspection of products, life cycle of jigs, tools, set up operation and safety
7 Autonomous management	Autonomous team working.

Routine maintenance

Objectives: At the end of this lesson you shall be able to
- **state the need for routine maintenance**
- **describe the functions of routine maintenance**
- **state the advantages of routine maintenance.**

Routine Maintenance

- In order to get trouble free service from productive equipment.
- Following activities is necessary to carry out.
  - i Lubrication
  - ii Periodic inspection
  - iii Adjustments of various parts
  - iv Cleaning

All the above maintenance operations are carried out while the machine is running or during pre-planned shutdowns.

This type of maintenance may prevent breakdown of equipment.

Routine maintenance should not interfere with production schedules.

Planned preventive maintenance (PPM), more commonly referred to as simply planned maintenance (PM) or scheduled maintenance, is any variety of scheduled maintenance to an object or item of equipment. Specifically, planned maintenance is a scheduled service visit carried out by a competent and suitable agent, to ensure that an item of equipment is operating correctly and to therefore avoid any unscheduled breakdown and downtime.

Along with condition based maintenance planned maintenance comprises preventive maintenance, in which the maintenance event is preplanned, and all future maintenance is preprogrammed. Planned maintenance is created for every item separately according to manufacturers recommendation or legislation. Plans can be date-based, based on equipment running hours, or on the distance travelled by the vehicle. A good example of planned maintenance program is car maintenance, where time and distance determine fluid change requirements. A good example of condition based maintenance is the oil pressure warning light that provides notification that you should stop the vehicle because engine lubrication has stopped and failure will occur.

Planned maintenance has some advantages over condition-based maintenance (CBM), such as:

- Easier planning of maintenance and ordering spares.
- Costs are distributed more evenly.
- No initial costs for instruments used for supervision of equipment.

Disadvantages are:

- Less reliable than equipment with fault reporting associated with CBM.
- More expensive due to more frequent parts change.
- Requires training investment and on going labour costs.

Parts that have scheduled maintenance at fixed intervals, usually due to wear out or a fixed shelf life, are sometimes known as time-change interval or TCI items.

Maintenance schedule

Objective: At the end of this lesson you shall be able to
- **describe the normal procedure followed in machine tool maintenance in shop floor.**

Any kind of action or activity there should be some procedure and sequence likewise maintenance also has some normal procedure to execute the maintenance activity without any confusion. If maintenance is not followed any procedure there will be time loss and the machine and equipment could not be ready in time. The procedure guides the maintenance people how to start, execute, where to inpect and how to complete the maintenance in time. The maintenance is carried out with the following procedure.

- Initial cleanup
- Identification of fault
- Dismantling
- Inspection
- Identification of cause for defect
- Inspection and replacement/ Repair of spares
- Reassembling
- Trial run
- Inspection with standards
- Maintaining records

Initial cleanup

Main machine, connected accessories, lubrication system, panels and adjacent parts are to be cleaned first.

Identification of fault

The fault of the machine is to be identified by visual inspection and getting information from the complaint and justified the same.

Dismantling

The fault area is dismantled with the referring to the manual and all the spares are kept seperate in a tray and preserved safely.

Inspection

All the dismantled parts such as gear, bearing, shaft, key, etc. are cleaned and inspected for any damages. Any damages/breakage is recorded in the maintenance checklist.

Identification of cause for defect

The defect in spare parts thoroughly examined and analysed the causes for damage and the same has to be rectified.

Inspection and replacement/ repair of spares

The damaged or broken spares are procured from stores/ repaired and the same is inspected to the standards.

Reassembling

The next course of action is assembling the parts in reverse manner of dismantling order.

Trial run

After completion of assembling the machine is to run first manually and all the lubrication, electrical connection to be given. Finally the machine should run on is trial run for some time and observed for any unusual sound from the machine.

Inspection with standards

The machine is finally checked/inspected for geometry accuracy safety hazards etc., according to the manufacturer standard any other recommended standard as required by the nature of maintenance work carried.

Maintaining records

All the activities related to fault attended, spares changed, etc. to be recorded in the inspection report/maintenance record, machine history cards suitably for future reference.

Retrieval data from machine manuals:

Information Retrieval (IR) in computing and information science is the process of information system resources that are relevant to an information need from a collection of those resources. Automated Information retrieval systems are used to reduce what has been called information overload.

"Classification tasks that are well suited to machine learning" in many cases, tasks that untill recently had to be accomplished manually install. Learning algorithms use examples, attributes and values, which information retrieval systems can supply in abundance.

Preventive maintenance

Objectives: At the end of this lesson you shall be able to
- **state the need for preventive maintenance**
- **describe the functions of the P M department**
- **state the advantages of P M**
- **state the advantages of maintenance records and periodic inspection of machines.**

Need for Preventive maintenance

The machine tools are of high precision, and are sensitive and expensive.

They must be handled and maintained carefully in order to give good and long service.

The basic function of the maintenance department is the upkeep of the machines and equipment in good operating condition.

Earlier the maintenance of the equipment used to receive attention only when the equipment suffered some set-back or breakdown as a result of some minor/major fault. Such breakdowns not only brought a serious production hold-up but also used to upset the production flow of the industry where the other equipment also had to stand idle. This resulted in a more cautious approach to the maintenance of the equipment and this brought up the more scientific way of tackling the maintenance problem, through preventive maintenance. (P M)

Preventive maintenance

Preventive maintenance consists of a few engineering activities which help to maintain the machine tools in good working order.

The basic activities of preventive maintenance are the:

- Periodic inspection of machines and equipment to uncover conditions leading to production breakdowns or harmful depreciation
- Upkeep of machines and equipment to avoid such conditions or to adjust, repair or replace them while they are still in the initial stages.

Advantages of preventive maintenance system

- Less down time in production.
- Improves quantity and quality of product.
- Standby equipment is not needed which saves capital investment.
- Lower unit cost of manufacture.
- Reduces major and repetitive repairs of machines.
- P.M. helps in prolonging the life of the machines and reduction in un-expected breakdowns.

Functions of preventive maintenance department

- Periodic inspection of machines and equipment as per the 'Check- lists'. (Annexure I)
- Lubrication of machines and equipment as per the manufacturer's instruction manuals.
- Servicing and overhauling of machine and equipment as per the P M schedule.
- Keeping basic records of each machine and equipment. (Annexure II)
- Analysis of inspection reports and systematic review of reports of machines and equipment.

Periodic inspection of machines and equipment as per the check-list

The check-list items for the inspector about all the points to be checked on individual machines. While preparing the check-list of the machine, make sure that no machine part or item that is omitted needs attention. The inspection of machine tools like lathe and drilling machine includes the following.

- Driving system and feeding system
- Lubricating and coolant system
- Slides and wedges and gibs
- Belts, bearings, clutch, brake and operating controls
- Guideways, lead screws and their mating parts

After inspection of each machine, the inspector has to make out the list of parts which need repairs or spares for replacement.

Frequency of inspection

The frequency of inspection depends on the age, kind of machine and its operating conditions. Frequent inspection of machines and equipment may be expensive and frequency with long intervals may result in more breakdowns. A good balance is needed to bring optimum savings.

Lubrication of machines and equipment

The length of time a machine will retain its accuracy and give satisfactory service depends on the lubrication and care it receives. It is essential that lubrication of machines should be carried out systematically at regular intervals as recommended in the service manual supplied by the machine manufacturer.

The manufacturer's manual contains all the necessary details like grade of oil, grease, oiling and greasing points and also indicates the time intervals of lubrication.

Maintenance records (Annexure III)

Keep a detailed record of faults, failures, repairs and replacements done for machines. It is useful to analyses Keep a detailed record of faults, failures, repairs and replacements done for machines. It is useful to analyses the cause of a fault and rectification.

Maintenance records analysis

Systematic review and regular analysis of the equipment records will help to:

- Re-design the weak part which gives repetitive trouble
- Substitute with better material for high cost items
- Minimise frequent breakdowns
- Reduce the cost of production.

Preventive Maintenance Programme

Name of the Machine : Location of the machine :

Machine Number :

Model No. & Make :

Annexure I

CHECK-LIST FOR MACHINE INSPECTION

Inspect the following items and tick in the appropriate column and list the remedial measures for the defective items.

Items to be checked	Good working/satisfactory	Defective	Remedial measures
Level of the machine			
Belt and its tension			
Bearing sound			
Driving clutch and brake			
Exposed gears			
Working in all the speeds			
Working in all feeds			
Lubrication system			
Coolant system			
Carriage & its travel			
Cross-slide & its movement			
Compound slide & its travel			
Tailstock's parallel movement			
Electrical controls			
Safety guards			

Inspected by

Signature

Name :

Date :

Signature of in-charge

EQUIPMENT RECORD **Annexure II**

History sheet of machinery & equipment

Description of equipment:	
Manufacturers' address:	
Supplier's address:	
Order No. and date:	
Date on which received:	
Date on which installed and placed:	
Date of commissioning:	
Size: Length X Width X Height	
Weight:	
Cost:	
Motor particulars:	Watts: r.p.m: Phase: Volts
Bearings/Spares record:	
Belt specification:	
Lubrication details:	
Major repairs and overhauls carried out with dates.	

Annexure III

MAINTENANCE RECORDS

Sl.No	Name of the machine	Nature of fault rectified	Date	Signature of in-charge

Difference between breakdown maintenance and preventive maintenance

Sl.No.	Breakdown Maintenance	Preventive Maintenance
1	Maintenance is undertaken only after breakdown	Maintenance is undertaken only before breakdown
2	No attempt is made to prevent breakdown	Maintenance is made to prevent breakdown
3	This is unpredictable activity	Predictable activity
4	Maintenance cost less	Cost of maintenance is high
5	Not suitable for equipments like cranes, hoists, pressure vessels	Can be applied to all types of equipments
6	Results in production loss and more "Down time"	Such disadvantages are eliminated

Reactive Maintenance

The oldest maintenance approach is reactive. Equipment is not repaired or replaced until it breaks. In this maintenance equipment fails with little or no warning so this could be down until replacement parts arrive, resulting in income loss. In this maintenance cost and down time increased and also create safety issues. Reactive maintenance can be suitable in some situation such as for non critical and low cost equipment with little or no risk of capital loss or production loss.

Importance of breakdown maintenance and preventive maintenance in productivity

The importance of an effective maintenance program cannot be overlooked because it plays such an important role in the effectiveness of lean manufacturing. As in personal health care insurance, maintenance may be considered the health care of our manufacturing operation, business or service operation. The cost of routine maintenance is very small when its compared to the cost of a major breakdown at which time there is no production.

Purpose of maintenance

The importance use of routine maintenance is to ensure that all equipment required for production is operating at 100% efficiency at all times. Through short daily inspections, cleaning, lubricating and making small adjustment small problems can be detected and corrected before they become major problem that can shutdown a production line. A good maintenance program requires company wide participation and support by everyone ranging from the top executive to the shop floor personel.

Inspection, types of inspection and gadgets for inspection

Objectives: At the end of this lesson you shall be able to
- **retrieval of data from machine manual**
- **state the need of inspection**
- **state the function of inspection**
- **list out the type of inspection**
- **discuss the each type of inspection**
- **list out the gadgets used for inspection.**

Retrieval of data from machine manual

Manual is one of the integral and necessary literary part that the operator has to know before handling and operating the machine. It will be provided by true manufacturer along with the supply of the machine.

Manual furnish all information about the machine like size of the machine, foundation and errection method, safety procedure to be followed, operating procedure and periodical maintenance required.

The machine manual will also provide about the required power supply, safety precaution grade of lubrication oil to be used etc., availability of suitable spare parts and details of dealer/supplier has to be provided in the manual otherwise use of any other parts will not suit and the machine will get damaged.

We have to refer and follow manual if any problem/defects arises during operation of the machine.

The manual will also provide the brand and type of tools that can be used, time period/life of the tools to be replaced based on the usage and periodical inspection to be carried out.

In general manual to provide information right from starting of the machine, operating method of machine and stopping the machine, incase of emergency to stop the machine.

Inspection

Inspection is necessary for any machine/equipment where remarkable risk to health and safety may arise from wrong installation, re-installation or any other circumstances. The purpose of inspection is to find whether machine can be operated, adjusted and maintained safely. The need for inspection and inspection intervals to be determined through risk assessment.

The summary of inspection should be recorded and same should be kept atleast until the next inspection of that machine. Machine/equipment that required inspection should not be used unless the machine has been inspected.

If the machine/equipment obtained from any other source (eg. hired). One should be ensure that physical evidence of last inspection is accompanied with the machine, such as inspection report, some form of tagging, labelling system or colour coding.

Function of Inspection in maintenance

1 Periodic inspection of machines and equipments as per checklist (Annexure 1)

2 Keeping basic records of each machine & equipments.

3 Preparation of list which need for repairs (or) spare for replacements.

4 Analysis of inspection report and systematic review of reports of machines/equipments.

5 Assigning of frequency of inspection.

The following Annexure 1,2 and 3 are the formats used in maintenance inspection.

Annexure I

INSPECTION CHECK-LIST			
Name of the machine : Machine No : Model No : Inspect the following items and tick in the appropriate column and list the measures for the defective items.			Location of the machine :
Item to be checked	**Good working/Satisfactory/Status**	**Defective**	**Remedial measures**
Availability of machine manual			
Safety guards			
Installation			
Level of the machine			
Belt and its tension			
Bearing sound			
Driving clutch and brake			
Exposed gears			
Working in all the speeds			
Working in all the feeds			
Lubrication system			
Coolant system			
Sliding part and its travel			
Safety and limit switches			
Electrical controls			
Proper lighting			
Emergency stop			
Alarm specialty			
Condition of work holding devices			
Condition of tool holding devices			
Condition of accessories and attachments			
Chip collection and disposal			

Conclusion of inspection

Recommendations

Inspected by

Signature

Name :

Date :

Signature of incharge

Annexure II

EQUIPMENT RECORD

History sheet of machinery & Equipment

Description of equipment	
Manufacturer's address	
Supplier's address	
Order No. and date	
Date on which received	
Date on which installed and placed	
Date of commissioning	
Size: Length x Width x Height	
Weight	
Cost	
Motor particulars	Watts/H.P./ r.p.m: Phase: Volts:
Bearings/ spares/ record	
Belt specification	
Lubrication details	
Major repairs and overhauls carried out with dates	

Maintenance - Installation, Maintenance and overhaul of machinery and engineering equipment

Objectives: At the end of this lesson you shall be able to
- **how to install the machinery in the new place**
- **what is the procedure followed installation of new machinery**
- **what are the types of maintenance activities followed in the newly installed machinery**
- **state the procedure for overhauling in a machinery.**

Installation means, it is the stage at which machinery is unpacked, reassembled, realigned connected to essential services and then tested exhaustively to ensure & works at peak operating efficiency when it finally goes into production.

General Procedure of Machine Installation: Installation procedure of a machine involves a series of activities are follows:

a Location and layout

- Once the location is finalized, the work of laying out the foundation plan is to be undertaken.
- Laying out means marking of the foundation plan. It may be done with the help of chalk on a concrete floor and by a string with a number of pegs.
- The general procedure is to indicate the outlines as per specification of the machine.
- The axis lines are to be drawn both longitudinally and crosswise to locate the center of foundation.
- Excavation of soil may be started only when the layout is completed as per the requirement.

b Positioning of machines;

- Equipment may have the weight of a few tons. But it is to be loaded or unloaded, to be moved vertically or horizontally to bring it at the site and to place it on the foundation as well.
- Different types of lifting devices like pulley blocks, chain hoists, and overhead cranes may be used as per the availability and requirement.
- When the load is light, rope pulley blocks are widely used and chain pulley blocks may be useful, but for a very heavy load, electric cranes are generally employed.
- However, the slinging should be done with much care to avoid any impact shock, to avoid formation of any scratches and breakages, etc.

c Foundation;

- The shapes and sizes of the foundation differ according to the type and size of the machines.
- They are also dependent on the property of the subsoil and the dynamic loads of the machine during operation.
- If the weight of the installed machine is not too much or if the dynamic loads are insignificant, the size of the foundation may be finalized on the basis of design considerations.
- But when the dynamic loads predominant, the foundation should also serve the purpose to protect the machine from external vibration and to lower down the frequency of natural vibration by increasing its total mass.

a Ground Condition

o The nature of soil is obviously a vital criterion. For a hard soil or for a normal soil, the construction of a concrete bed does not entangle too many complicacies. It is rather most straightforward to consider the foundation plan supplied by the manufacturer. But, for soft and loose soil, a large surface area with proper depth is needed for the foundation of a machine.

b Vibration Consideration

- To avoid transmission of vibration to adjoining parts of buildings or other foundations, it is necessary to provide a suitable isolation between the equipment foundation and the joining structure.
- Usually a gap is maintained all around the foundation, and is filled by sand to avoid such transmission of vibration. Any vibration isolating material, other than sand, such as rubber, lead sheet, felt etc. may also be used.
- As a rule, the equipment foundation shall not be allowed to serve as support for other structures or for machineries not related to the particular equipment.
- The impact type machines, like stamping press, drop and forging hammer, need special care during foundation. The depth of the foundation becomes very large to make the foundation heavy.

c Foundation Bolts

- To install the machineries, foundation bolts will be specified and supplied by the manufacturers. Some of the foundation bolts become rigid on pouring concrete and some may be removable and adjustable bolts.

Example: Eye foundation bolts, Rag bolt, Lewis bolt, Cotter bolt, Split end bolts

- The machine tool is placed on the foundation with the help of spacers or pads, leveling wedges, etc.

- Foundation plates are also supported similarly, for different machines etc. At this time, a gap (minimum 50 to 70mm) depending on the type of the machine is maintained between the top of the foundation block and the bottom of the machine or base plate.
- The foundation bolts are positioned before positioning the machine and the exact location of the machine is guided by the insertion of the projected foundation-bolt ends through the holes, provided at the machine footings or base plate.
- The bolt-ends should remain sufficiently projected to accommodate the washers and nuts as well.

d Leveling and alignment

- The leveling is performed with leveling wedges, shoes etc. as stated before.
- The horizontal and slight vertical movement of the heavy mass of machine is performed by pipes, rollers.
- Straight edge, spiral level, dial indicator etc., are generally useful instruments to level the machine.
- The leveling is to be checked in the both, longitudinal and transverse direction.
- When leveling is completed, the foundation bolt cavity along with the bolt may be made concreted. Pouring of cement concrete is generally made through the gap provided at the top of the foundation.

e Grouting

- Grouting is a procedure of connecting the machine with the foundation by a concrete mixture of plastic consistency or cement mortar. It is extensively used in installing most of the machines.
- Generally, quick setting cement is used to perform grouting. The top of the foundation block is made roughened, made moistened with water and wooden partitions are placed all around the machine.
- The heights of such wooden boards are kept much higher than the gap between the top or the foundation and the bottom of the machine.
- Quick setting cement is then poured within the boundary with care to eliminate any air gap within it.
- Once started, the pouring should be completed continuously and the machine must be felt undisturbed for a few days after grouting to provide it time to set.

f Fitting of other parts, accessories, piping etc.,

- When the machine is erected, the other accessories may be joined accordingly.
- But, while laying out the foundation plan, the overall requirement should be kept in mind.
- The auxiliary structures e.g. in case of a heavy duty diesel engine foundation, the structures for outer bearing pedestal, water pump blocks etc. should be planned at a time.
- This will minimize the problem of internal fittings.

g Final leveling and test runs

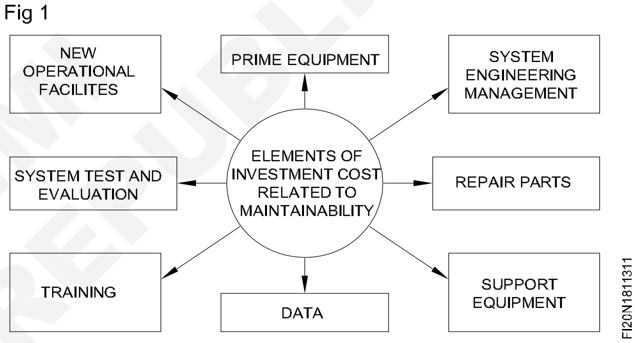
- Accurate leveling can be carried out only when the grouting has set in after a few days.
- The machine is to be made cleaned and leveled then. Such leveling involves minor adjustments.
- Whenever provided, the leveling screws and may be operated to achieve the final level. Everything should now be made ready to carry the test run. The style of testing will differ from machine to machine.
- The accuracy shown in the chart will be re obtained only if the machine is correctly erected and leveled.

Maintenance

Machine maintenance is the work that keeps mechanical assets running with minimal downtime. Machine maintenance can include regularly scheduled service, routine checks, and both scheduled and emergency repairs. It also includes replacement or realignment of parts that are worn, damaged, or misaligned. These Maintenance activities are explained in the following Fig 1.

How we can maintain the heavy machines and extend their longevity.

Fig 1



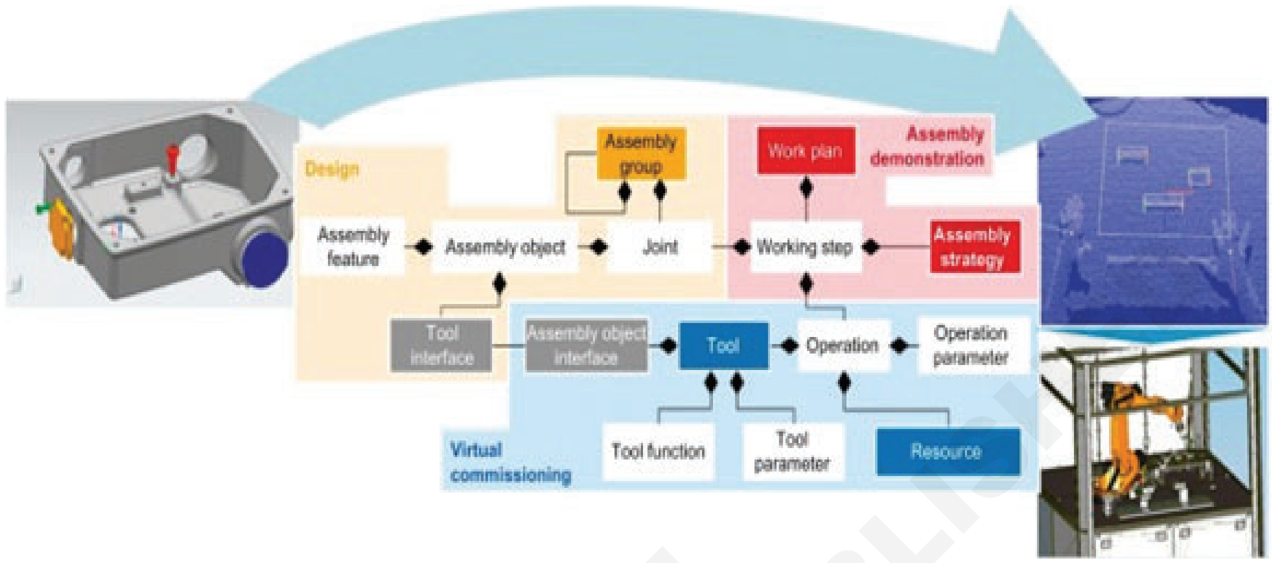
- Clean the Machines Thoroughly and ensure cleaning and lubricating of moving parts
- Check the Machinery for Wear and Tear.
- Ensure all moving parts working properly otherwise replaced.
- Ensure that all bolts and nuts including point machine mounting bolts are tight and split pins are opened properly, during every maintenance visit.
- Check that electrical wire connections inside the cable termination box and inside the machine are tight and the wiring is laced properly.
- Check the rodding connections for tightness and friction free movement. o Lubricate the slide chair plates frequently for smooth working of points.
- Ensure that the rodent entry points in the point machine and CTB etc. if any are properly plugged.
- Lubricate all moving parts with lubricating oil/grease as per manufacture's specifications.
- Avoid Exceeding Performance Specifications; train the operator to short out these problems.

- Document Your Preventive Maintenance and Servicing in Detail.

Over hauling

Overhaul maintenance (OM) is a comprehensive examination and restoration of a system, or a major part thereof, to an acceptable standard of performance. It could involve reconditioning, refitting, rebuilding, or total replacement of subassemblies of the system. The goal of overhauling is to keep the system in serviceable condition (Fig 3). Machinery overhaul is usually performed by companies offering maintenance services.

Fig 2



Overhauling usually involves the following stages:

Inspection: First of all, the machine will be thoroughly inspected. Experienced maintenance crews perform an inspection on the overhauled machine under production conditions. It means, the machine's performance is monitored while the machine is in use. Such a procedure allows allocating any issues and performing the troubleshooting more effectively.

Dismantle: After the initial inspection, the piece of equipment should be taken apart. Disassembly is crucial for further check and the next steps of the overhauling process, such as repair. A skilled maintenance worker is capable of putting the machine down efficiently, indicating which parts of the equipment needs to be replaced or repaired.

Repair: Depending on the issue, the machine is either repaired or certain damaged parts are replaced. This step once again proves how effective overhauling is as opposed to replacing the whole piece of equipment at once. Replacement of parts might take longer than a simple repair, as the spare parts might need to be ordered from a manufacturer.

Reassembly: Following the successful replacement of spare parts, reassembly of the whole mechanism is performed. Being one of the final steps, the reassembly is crucial for the functioning of the equipment. Certain skill is surely needed to perform reassembly, so it's best handled by professionals.

Testing: The final step that concludes the overhauling process. Without testing it is naturally impossible to identify if the performed repair was effective. During testing the retrofit is either proclaimed successful or less frequently the process goes back to the starting point.

Causes for assembly failures and remedies

Objectives: At the end of this lesson you shall be able to
- **state the poor assembly**
- **list out poor service conditions**
- **state the cost of operation.**

Poor assembling: Error in assembly can result due to various reasons such as ambiguous, insufficient or inappropriate assembly procedure, misalignment, poor workmanship. Sometimes, failures are also caused by the inadvertent error performed by the workers during the assembly. For example, failure of nut and stud assembly (used for holding the car wheel) by fatigue can occur owing to lack of information regarding sequence of tightening the nuts and torque to be used for tightening purpose; under such conditions any sort of loosening of nut which is subjected to external load will lead to fatigue failure.

Poor service conditions: Failure of an engineering component can occur due to abnormal service condition experienced by them for which they are not designed. These abnormal service conditions may appear in the form of exposure of component to excessively high rate of loading, unfavorable oxidative, corrosive, erosive environment at high or low temperature conditions for which it has not been designed. The contribution of any abnormality in Service conditions on the failure can only be established after thorough investigation regarding compatibility of the design manufacturing (such as heat treatment) and material of the failed components with condition experienced by them during the service.

Weight of raw material: Calculate theoretically weight of material, calculate volume of material and multiply with density of material. It gives you exact weight of raw material required.

While calculating weight do not consider final dimension always consider plus size for machining and other operation.

Cost of operation: Decide each operation to be performed on flanges like Drilling, matchinig and boring. While selecting the process do take care of sequence of operation as it matters a lot on costing.

You need to allot time required for particular operation considering all factors of machine. On their basis of price of machine, depreciation and cost of electricity consumed you need to finalise cost of machine running per hour.

Now multiply time required for particular operation and machine running cost/hour

Tools Cost

- **Cost of Labour:** For each piece calculate total working time consumed and calculate total cost need to pay to labour.
- **Accidental/Risk/Rejection cost:** As manufacturing of flange is a manual process, there may be chances of rejection of material, so this cost should be considered.

The simple method is add 1 piece's rate if manufacturing 100 qty in bulk

- Packaging and handling cost: Generally 2% of basic cost
- Profit: Approx 5 to 15% to basic cost
- Admin and depreciation cost

Assembly techniques

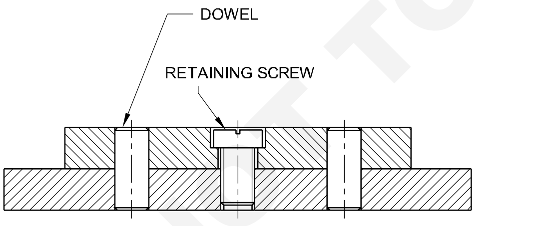
Objectives: At the end of this lesson you shall be able to
- **name the common techniques used for assembling components**
- **distinguish between the application of dowelling, pinning, staking, brazing and use of adhesives for assembling components.**

In machine shop assembly various methods are used for securing components together. A few of the common methods are:

- Dowelling
- Pinning
- Staking
- Brazing/Hard soldering
- Using of adhesives

Dowelling (Fig 1)

Fig 1



This is used for accurate positioning of two or more parts. This allows the parts to be separated and relocated in position. Different types of dowels are used depending on the type of assembly.

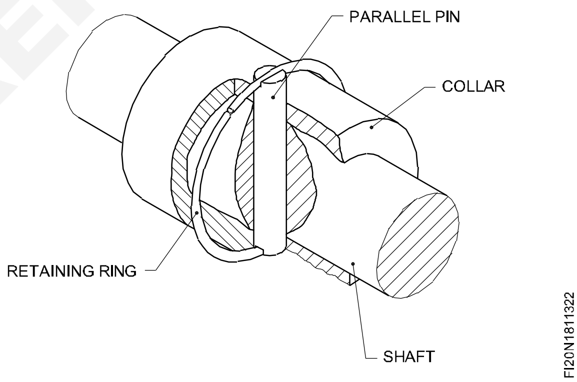
The components dowelled are always fixed with retaining screws in the assembly.

Pinning: This is also a method of locating and securing components together. Pins are of different types.

Parallel pins (Fig 2)

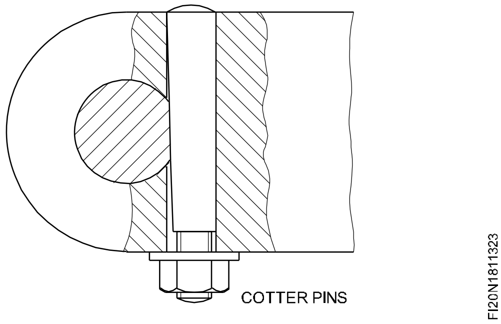
These are fitted like dowels in reamed holes and held in position by a retaining ring.

Fig 2



Cotter pins (Fig 3)

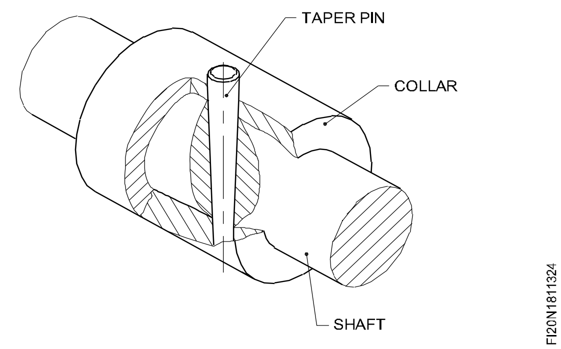
Fig 3



Taper pins (Fig 4)

Taper pins will position parts accurately. The component can be dismantled easily and assembled without any change in location.

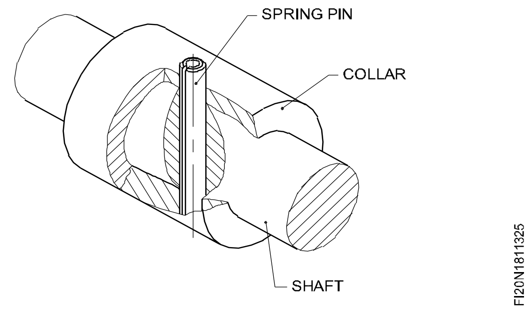
Fig 4



The holes for fitting taper pins are finished using taper pin reamers.

Spring pins (Fig 5)

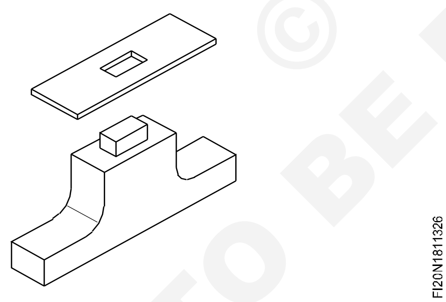
Fig 5



This eliminates the need for drilling and reaming of the assembly together. The spring pin adjusts itself in case of slight misalignment.

Peening (Fig 6)

Fig 6



When parts are to be assembled together this is one method of assembly. Basically this is similar to riveting.

Staking (Figs 7a, b & c)

This is a method of retaining parts in an assembly in which a portion or all of a component is forced to flow on the other component. This increases the efficiency of the fit.

Brazing and hard soldering (Fig 8a & b)

This is a process of joining metals by using layer of non-ferrous metal between the surface to be joined.

The alloy used for brazing is known as spelter (combination of copper and zinc)

Adhesives (Fig 9)

The adhesives commonly used are epoxy adhesives. This adhesive gives a strong bond between materials to be assembled. This is not affected by moderate moisture or heat. It is usually supplied in two containers/tubes. One is resin and the other is the hardener.

Fig 7

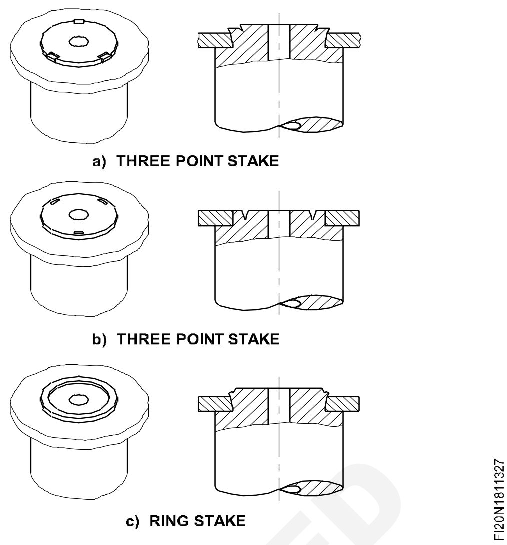


Fig 8

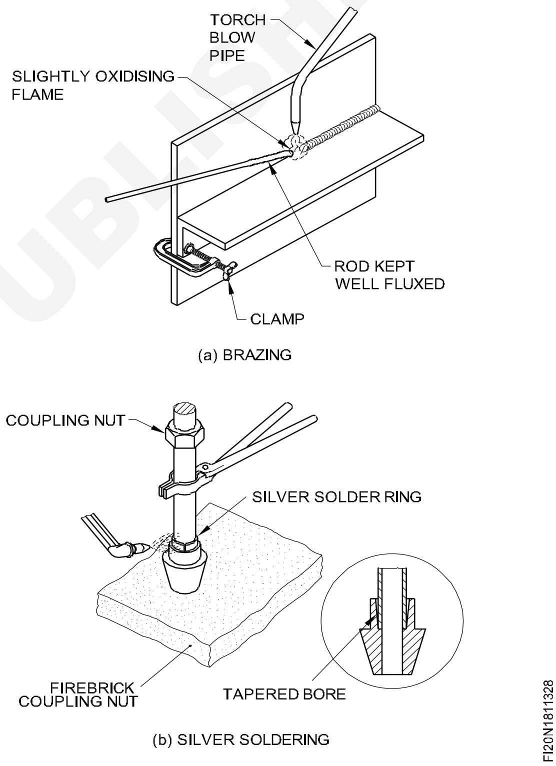
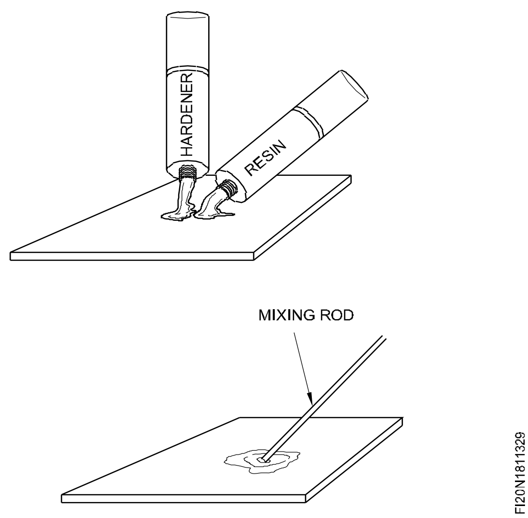


Fig 9

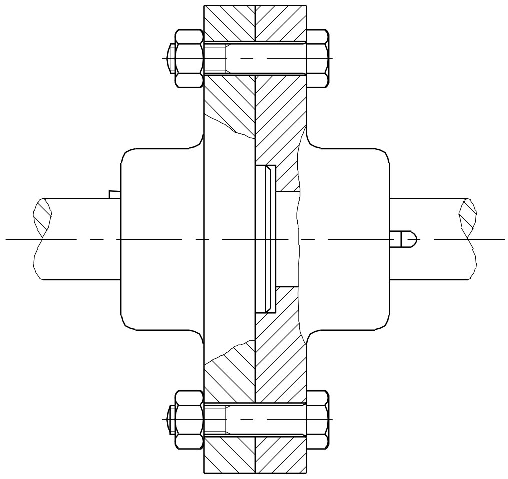


Threaded jointer

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**
- **identify 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)

Fig 1



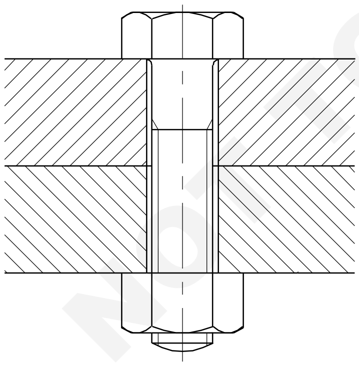
These are generally used to clamp two parts together.

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)

Fig 2

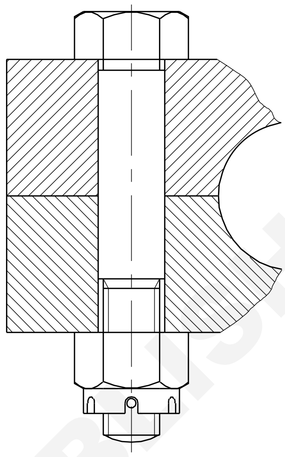


This is the most common type of fastening arrangement using bolts. The size of the hole is slightly larger than the bolt (clearance hole).

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

Body fit bolt (Fig 3)

Fig 3



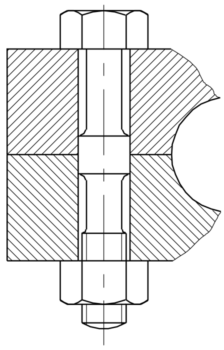
This type of bolt assembly is used when the relative movement between the workpieces has to be prevented.

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

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

Anti-fatigue bolt (Fig 4)

Fig 4

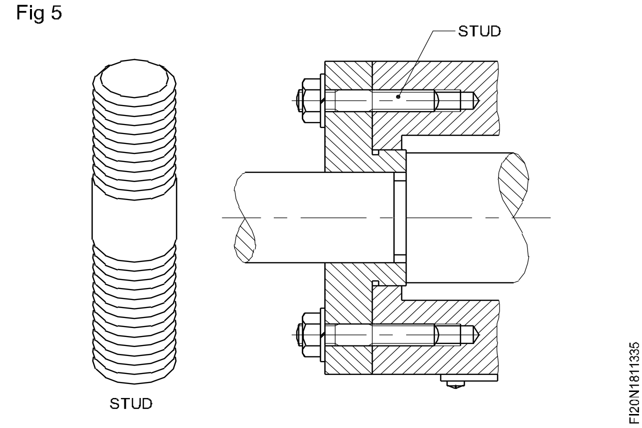


This type of bolt is used when the assembly is subjected to alternating load conditions continuously. Connecting rod big ends in engine assembly are examples of this application.

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

Studs (Fig 5)

Fig 5



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

When excessively tightened, the variation in the thread pitch allows the fine thread or nut end to strip. 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 60 mm and property class 4.8 shall be designated as:

Hexagon head bolt M10 x 60 - 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 = 40 kgf/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 and '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.)

Cylindrical and taper pins

Objectives: At the end of this lesson you shall be able to
- **state the uses of cylindrical and taper pins**
- **specify cylindrical pins**
- **state the features and uses of different types of cylindrical pins**
- **state the advantages of taper pins**
- **state the features and uses of the different types of taper pins**
- **designate standard taper pins**
- **distinguish the features and uses of the different types of taper pins**
- **state the uses of the different types of grooved pins**
- **state the features and uses of spring pins.**

Cylindrical and taper pins

– Locating hole position for assemblies whenever they are dismantled and assembled (Examples - jigs and fixtures, cover plates, machine tool assembly etc.) (Figs 1a and 1b)

– Assembling components. (Examples - wheels, gears, levers, cranks etc. to shafts) (Figs 2a and 2b)

Cylindrical pins are available with different types of:

- Ends
- Tolerances
- Surface quality

Cylindrical pins are also available in un-hardened and hardened conditions.

Un-hardened cylindrical pins are of three types. (Fig 3)

- Chamfered and rounded end
- Chamfered end
- Square end

Fig 1

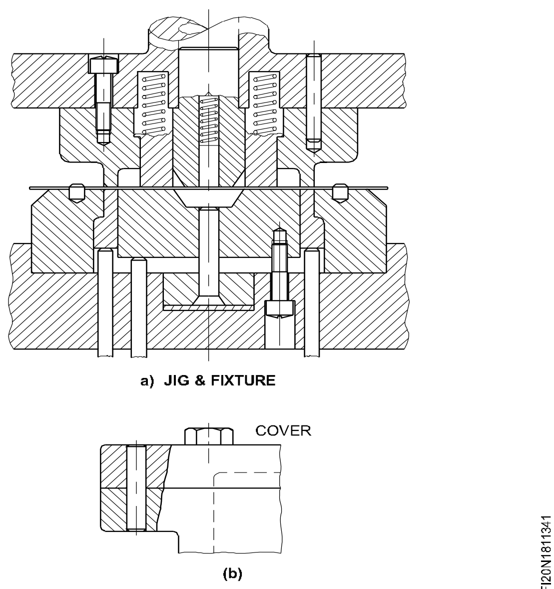


Fig 2

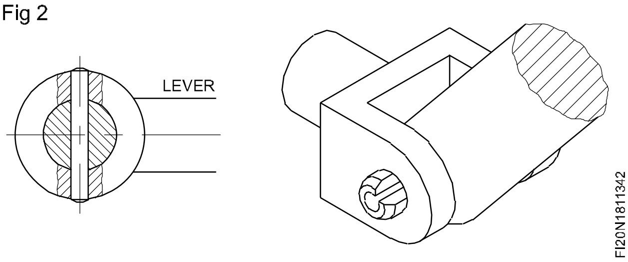
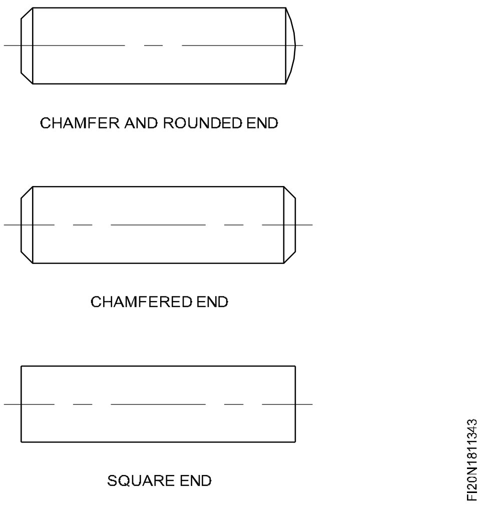


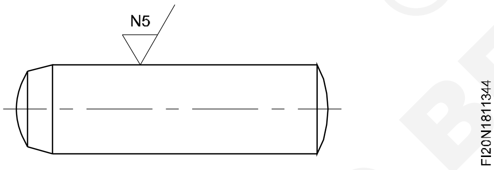
Fig 3



They are useful in general assembly work.

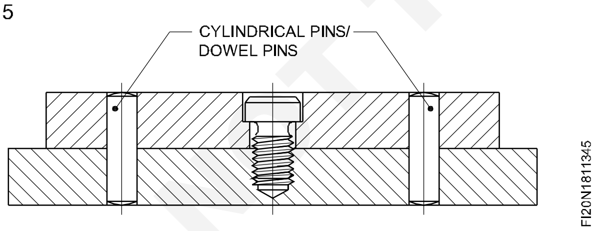
Hardened cylindrical pins are made of high grade steel and are finished by grinding. (Fig 4) These pins can withstand higher shearing force. These pins are used in precision assemblies like jigs and fixtures and other tool making works.

Fig 4



In tool assemblies the parts will be fixed by screws or bolts, (Fig 5) and are located by using cylindrical pins.

Fig 5



Hardened cylindrical pins are available with dimensional tolerance m6.

Un-hardened and hardened cylindrical pins are made to fit in the holes finished by standard reamers.

Cylindrical pins are designated by the name, nominal diameter, tolerance on diameter, nominal length and the number of B.I.S. Standard.

Example: A cylindrical pin of nominal diameter 10 mm, tolerance h8 and nominal length 20 mm shall be designated as-

Cylindrical pin 10h8x20 IS:2393.

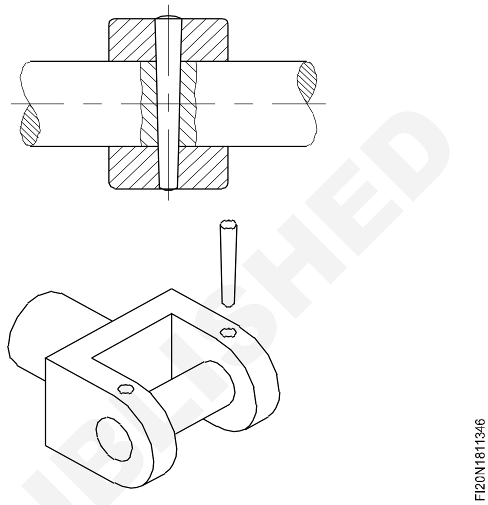
> **Note: The I.S. number refers to un-hardened cylindrical pins. Cylindrical pins are also referred to as dowel pins.**

Taper pins

Taper pins of different types are used in assembly work.

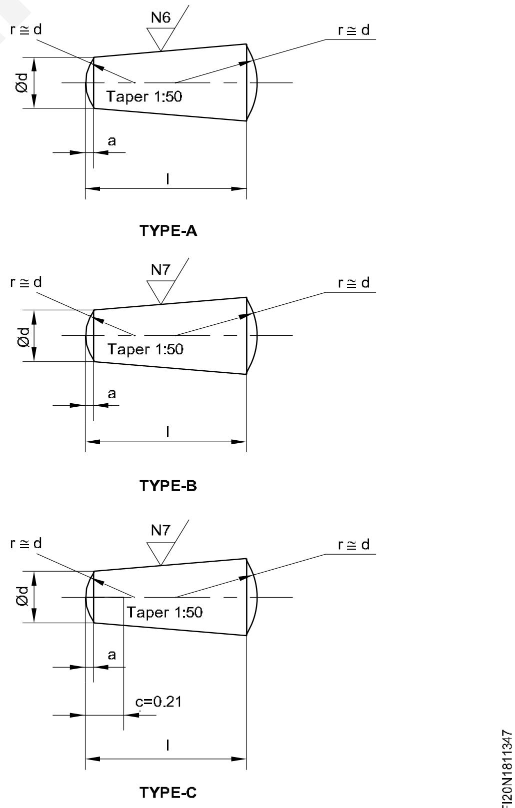
Taper pins allow for frequent dismantling and assembling of components without disturbing the precise nature of location. They are used to transmit small torques. (Fig 6)

Fig 6



Taper pins are of three types. (Fig 7)

Fig 7

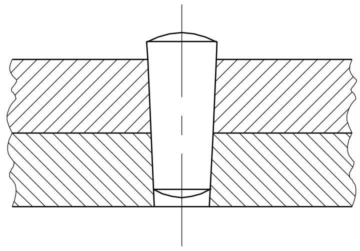


Type A	-	Taper pins with a surface finish of N6.
Type B	-	Taper pins with a surface finish of N7.
Type C	-	Split taper pins with a surface finish of N7.

All taper pins have a taper of 1:50 and are finished within a dimensional tolerance of h10.

Taper pin types A & B assembly is shown in Fig 8 and type C is shown in Fig 9.

Fig 8



PRESSED OR DRIVEN OUT

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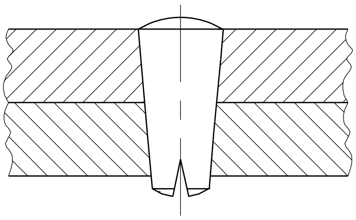
Fig 9



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Split taper pin

In the case of split taper pins the split end can be slightly opened to ensure a more positive locking.

Taper pins are designated by name, type (A, B or C) nominal diameter, nominal length and number of the standard.

Examples

i A taper pin of Type A of nominal diameter 10 mm and nominal length 50 mm shall be designated as - Taper pin A10 x 50 IS:6688.

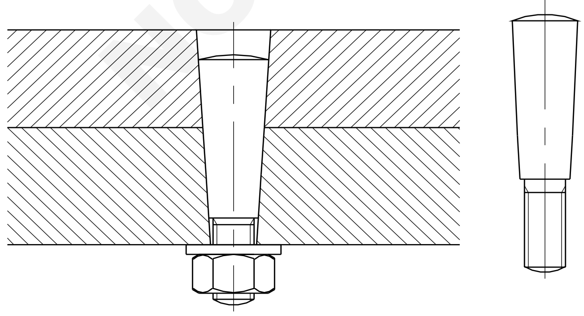
ii A split taper pin of nominal diameter 10 mm and nominal length of 60 mm shall be designated as - Split taper pin C10 x 60 IS: 6688.

The nominal diameter in the case of taper pins is the diameter at the small end of the taper.

Threaded taper pins are available for:

- Locking the pins and preventing loosening due to vibration (Fig 10)

Fig 10

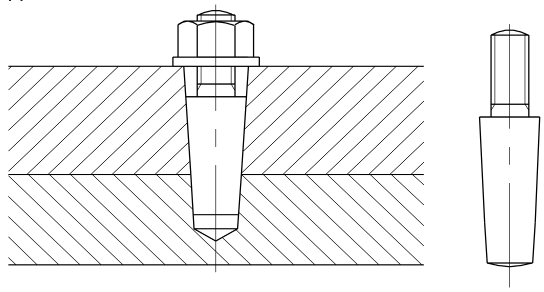


LOCKING

FI20N181134A

- Assisting in drawing the pins out of the blind holes. (Fig 11)

Fig 11



DRAWING OUT

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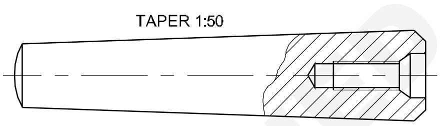
Threaded taper pins with internal threads are also available. (Fig 12)

Fig 12



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Grooved pins: These pins have three slots rolled on the outer surface. The sides of the grooves/slots bulge out. The holes in which slotted pins are used are not finished by reaming. Grooved pins are available as straight pins (Fig 13a), and tapered pins (Fig 13b). These are used in assemblies which are not dismantled frequently and where high accuracy is not required.(Fig 14)

Fig 13

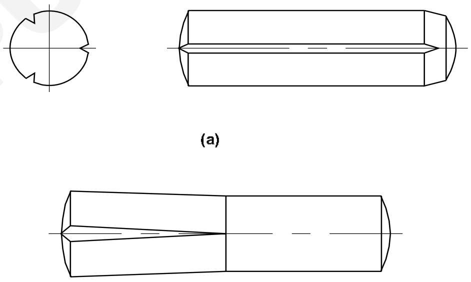

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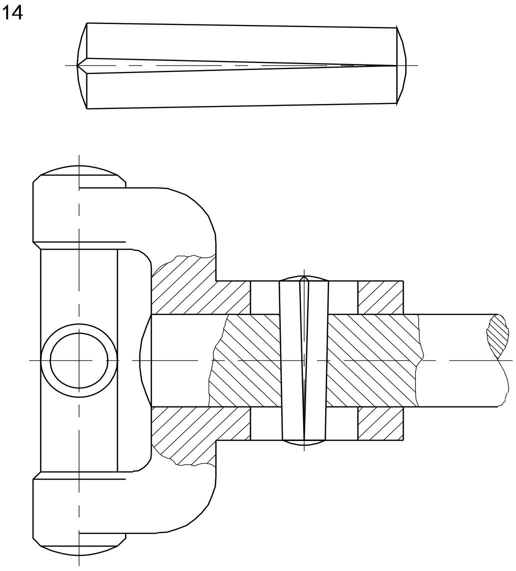
Fig 14



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Grooved pins with head are also used in assembly involving small components. (Fig 15)

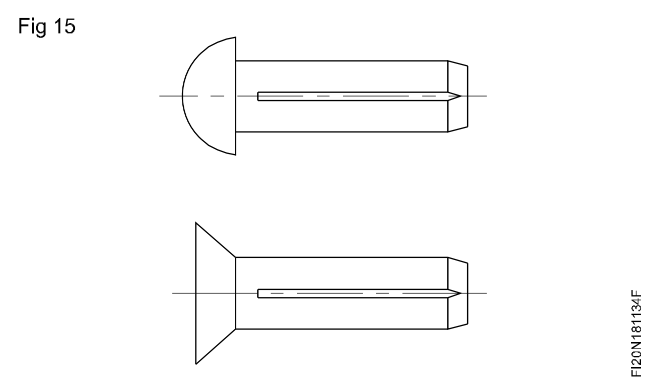


Fig 15

Spring pins (Fig 16)

Spring pins are used for locating assemblies with wide tolerance in the corresponding holes. These pins are manufactured from flat steel bands and rolled to form a cylindrical shape. These springs will stay tight in the fitting hole because of the spring action.

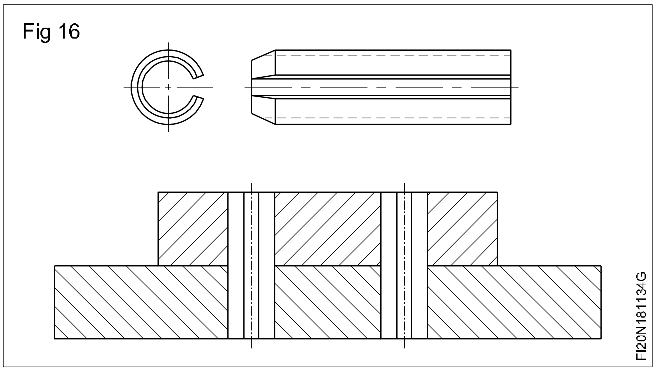


Fig 16

Seal

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a seal**
- **name the material used for static seal**
- **state the types of static seals and their applications**
- **name the materials used for dynamic seals**
- **state the types of dynamic seals and their applications.**

Purpose

A seal is used to prevent leakage.

It prevents dust, dirt and foreign particles from entering into the system.

Any machining process leaves behind a little imperfection of the surfaces of the mating components. A seal fills up the gap to prevent leakage from the system.

Types

- Static
- Dynamic

Static seal

It is used for sealing the contact areas between the surfaces where there is relative movement, eg. Gasket 'O' ring, bellows, etc.,

Materials used for gaskets

Static seal

- Compressed cork
- Oil-proof paper
- Graphite-impregnated cloth
- Asbestos with copper covering
- PTFE (Poly-tetrafluroethylene)
- Copper
- Steel

Types of static seals

Compressed cork gasket (Fig 1)

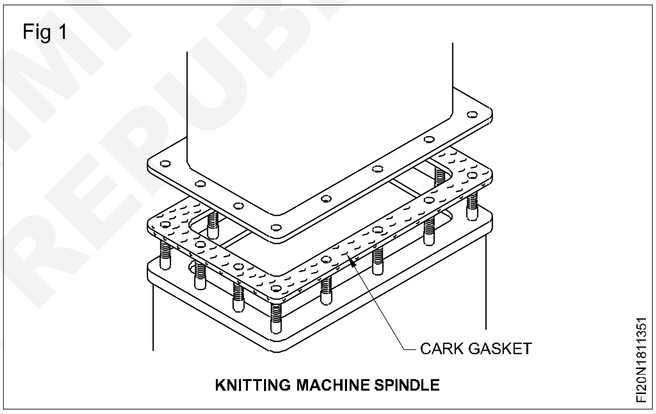


Fig 1

This is used for sealing between mating surfaces which are not having good surface finish. Compressed cork can be obtained in several thicknesses.

Paper (Fig 2)

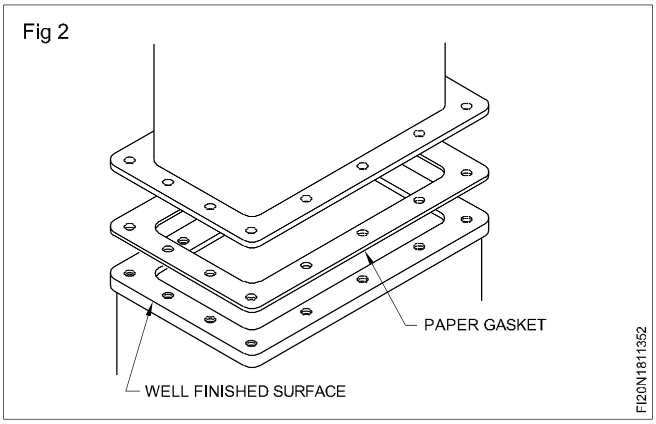
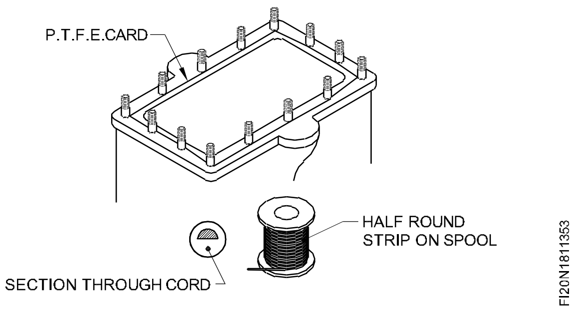


Fig 2

This is used between smooth and accurately finished joint surfaces. It can vary in thickness from thin paper to card and may be grease-proofed.

PTFE cord sealing (Fig 3)

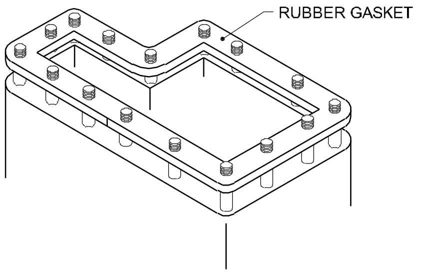
Fig 3



This is suitable for use at very low temperature applications. The material is chemically inert and can be made into soft flexible strips and used to make either flat seals or gland packings.

Rubber gaskets (Fig 4)

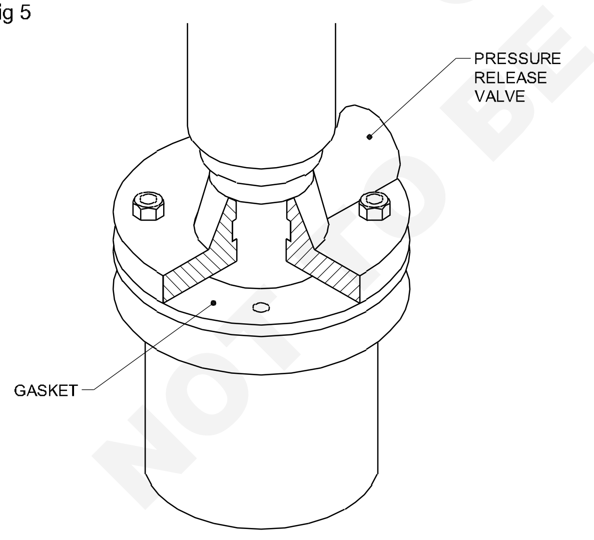
Fig 4



They are the good for sealing flanges of cold water connections. They are not suitable where oil comes in contact.

Graphite impregnated cloth (Fig 5)

Fig 5



This is a suitable material for hot water and steam joints.

Metallic gaskets (Fig 6)

Hard metallic seals made of steel, copper or beryllium are used for high pressure joints found commonly in hydraulic system.

Asbestos covered with copper sheet gasket (Fig 7)

Fig 6

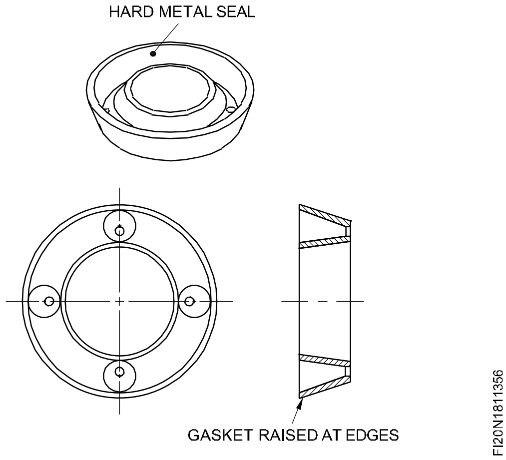
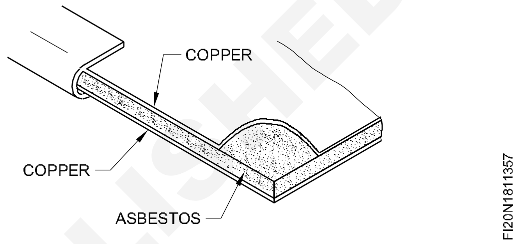


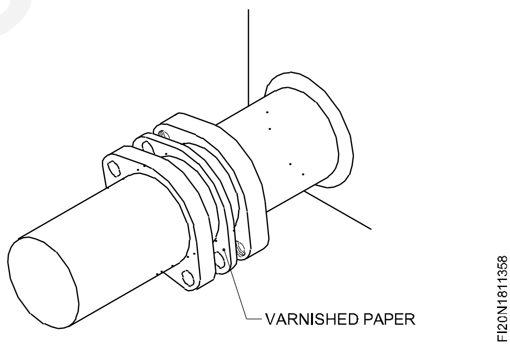
Fig 7



These are suitable for use in high temperature applications.

Varnished paper gasket (Fig 8)

Fig 8



It is suitable for use where liquids would be absorbed into plain paper. The surface of the varnished paper gasket must not be cracked or damaged in any way.

Material used for manufacturing dynamic seal

- Natural rubber
- Nitrile
- Viton
- PTFE plastics
- Flurosilicone
- Butyle
- Neoprene
- Flurocarbon

Table 1 shows the allowable temperature range for different materials.

Table 1

Material	Temp.°C	Material	Temp.°C
Natural rubber	-50 to +80	Flurosilicone	-50 to +100
Nitrile	-30 to +110	Butyle	-40 to +100
Viton	-40 to +180	Neoprene	-40 to +100
PTFE	-85 to +260	Flurocarabon	-20 to +140

Types of dynamic seals

Dynamic seals are required to work under more exacting conditions than static seals because movement lakes place between the surfaces being sealed.

O-ring seal (Figs 9 & 10)

Fig 9

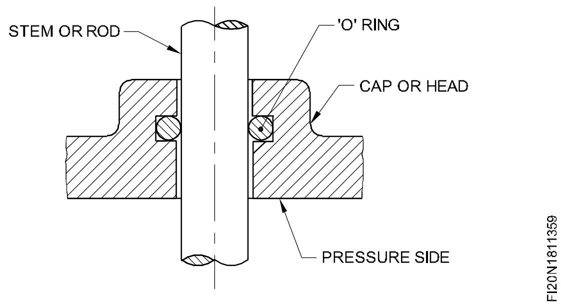
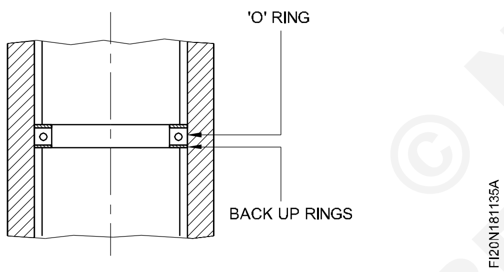


Fig 10



These are the most common types of dynamic seals in use and have many applications. When required to seal against high pressures, they are fitted with back-up rings. There are many similar seals made for special purposes that do not have a circular cross-section.

Radial lip seals

Radial lip seals are used primarily to retain lubricants in equipment with rotating, reciprocating or oscillating shafts. The secondary purpose is to exclude foreign matter.

Non-spring loaded seals

These are used to retain highly viscous materials like grease at shafts less than 600 m/min.

Spring-loaded seals (Fig 11)

They are used to retain low viscosity lubricants such as oils at speeds up to 1000 m/min.

Wiper seal (Fig 12)

These seals are used in rotary and sliding operating conditions and are used to prevent dust or grit entering shaft bearings. The contacting surface of the seal wipes off the particles from the shaft.

Fig 11

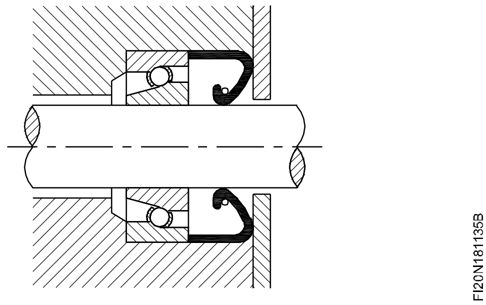
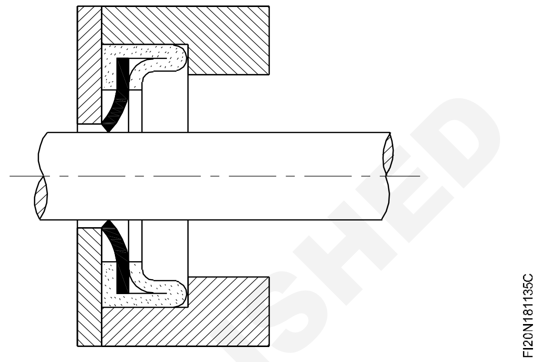
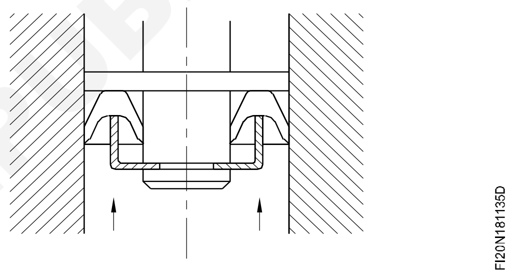


Fig 12



'V' seals (Fig 13)

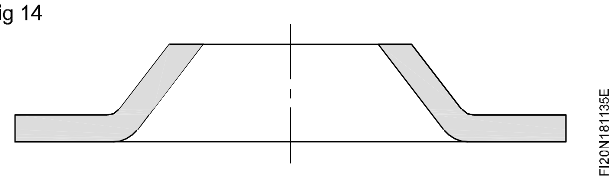
Fig 13



Fabric reinforced or leather seals are suitable for use against high pressure. These seals are available in various forms.

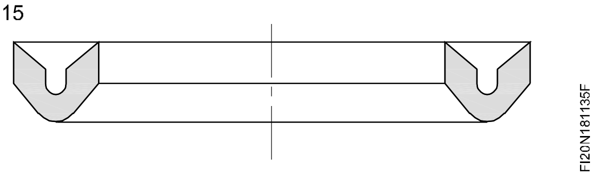
Flange seal (Fig 14)

Fig 14



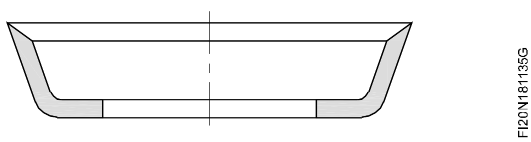
'V' type or Chevron seal (Fig 15)

Fig 15



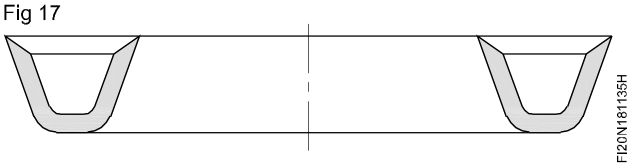
Cup seal (Fig 16)

Fig 16



'U' type seal (Fig 17)

Fig 17

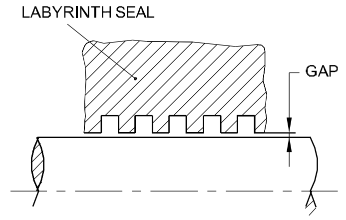


They are often used to form the seal between piston and cylinder assemblies in hydraulic equipment.

Labyrinth seals (Fig 18)

This is a clearance type of seal and it allows some amount of leakage. Labyrinth seals are used primarily to seal gases in compressors and steam turbines. This seal is commonly used in rotary operating conditions. The function of the seal is to provide radial clearance while preventing dust or dirt from entering into the system.

Fig 18



Torqueing

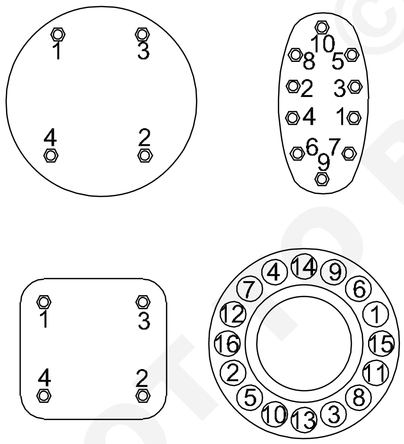
Objectives: At the end of this lesson you shall be able to
- **state torque in assembling**
- **state precautions to be observed during assembling & installation.**

Torqueing: While assembling, threaded fasteners are tightened as per thread manufacturer recommended torque value. If the torque is more than the recommendation, threads may damage on both fasteners and housing and tends to break.

Precautions observed during Assembling and installation

- Tighten the bolts to compress the gasket uniformly. Follow the sequence from side to side around the joint. (Fig 19).

Fig 1



- Use well lubricated fasteners and hardened flat washer.
- All bolts should be tightened in one-third increments, according to proper bolting patterns.
- Make final check pass at the target torque value moving consecutively from bolt to bolt
- Never use liquid or metallic based anti-stick or lubricating compounds on the gaskets. It creates Premature failure.