

SECTION 3, CHAPTER 2

LATHES

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Introduction

1. The lathe is the one machine tool of which even the non-technical person will probably have heard. In its simplest form it was in use centuries ago, initially for wood turning. Removal of material from revolving work is still the main purpose of a lathe, but modern versions have been so developed that they can be used for many other jobs.

Principle

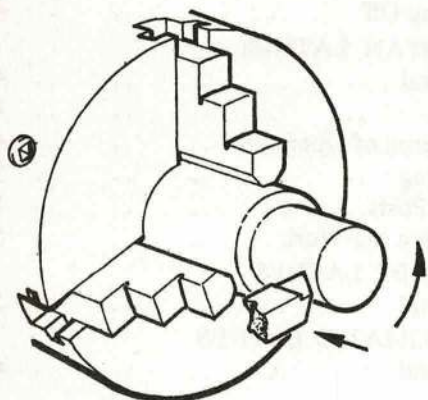
2. The metal to be machined is held between two rigid supports known as **centres**, or by means of a **chuck** or **face plate** screwed or secured to the **spindle**. The spindle is rotated and carries the work with it whilst the **cutting tool**, fixed in the **tool post**, is caused to travel in the direction which will produce the required surface. If the movement of the tool

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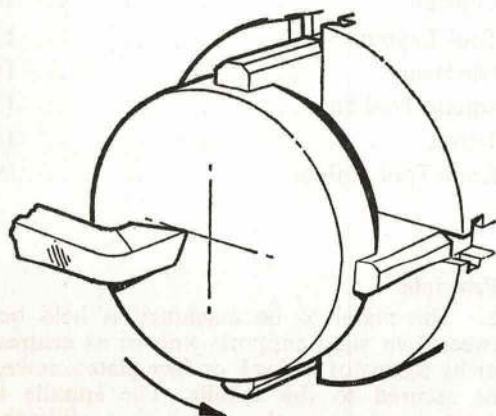
is parallel to the axis of rotation of the work a cylindrical surface will be produced (Fig. 1 upper). A flat surface will be produced when the movement of the tool is perpendicular to the axis of rotation of the work (Fig. 1 lower).

Size

3. In this country lathes are designated by the height of the centres above the flat of the bed and the length of the bed. For example a 5 in. $\times$ 6 ft. lathe would have a spindle with its centre 5 in. above the bed and the bed



PARALLEL TURNING



FACING

Fig. 1. BASIC SURFACE FORMS

would be 6 ft. long. Such a lathe would accommodate work of up to 10 in. diameter over the bed, but the work would have to be less than this diameter when required to clear the carriage. This lathe would be referred to in America as a 10 in. swing, swing being specified in place of height of centres used in this country.

4. The length of the bed includes the lengths of the headstock and tailstock. Therefore the maximum length of the work which can be supported between the centres is somewhat less than the bed length, possibly something in the region of 3ft. 6 in. for a lathe having a 6 ft. bed.

Types

5. Lathes generally can be classified into four main groups:—

- (a) Centre.
- (b) Capstan.
- (c) Turret.
- (d) Automatic.

STANDARD CENTRE LATHE

General

6. There are many types of lathe in group (a) which also vary greatly in size from the small watch-maker's lathe, for example, to the very large tube-boring lathes. Information on all these types is far beyond the scope of these notes, thus the standard centre lathe, which is able to deal with a variety of work and permits a reasonably wide range of operations to be performed, is taken as being a typical example.

7. The standard centre lathe is the type commonly used by machinists for general turning work and therefore it will almost invariably be found in any machine shop. It may be adapted to perform a variety of operations such as:—

- (a) Cylindrical turning between centres.
- (b) Turning, facing, drilling and boring in the chuck.
- (c) Turning, boring and facing work held on the face plate.
- (d) Boring work held on the carriage using a boring bar held in the spindle.

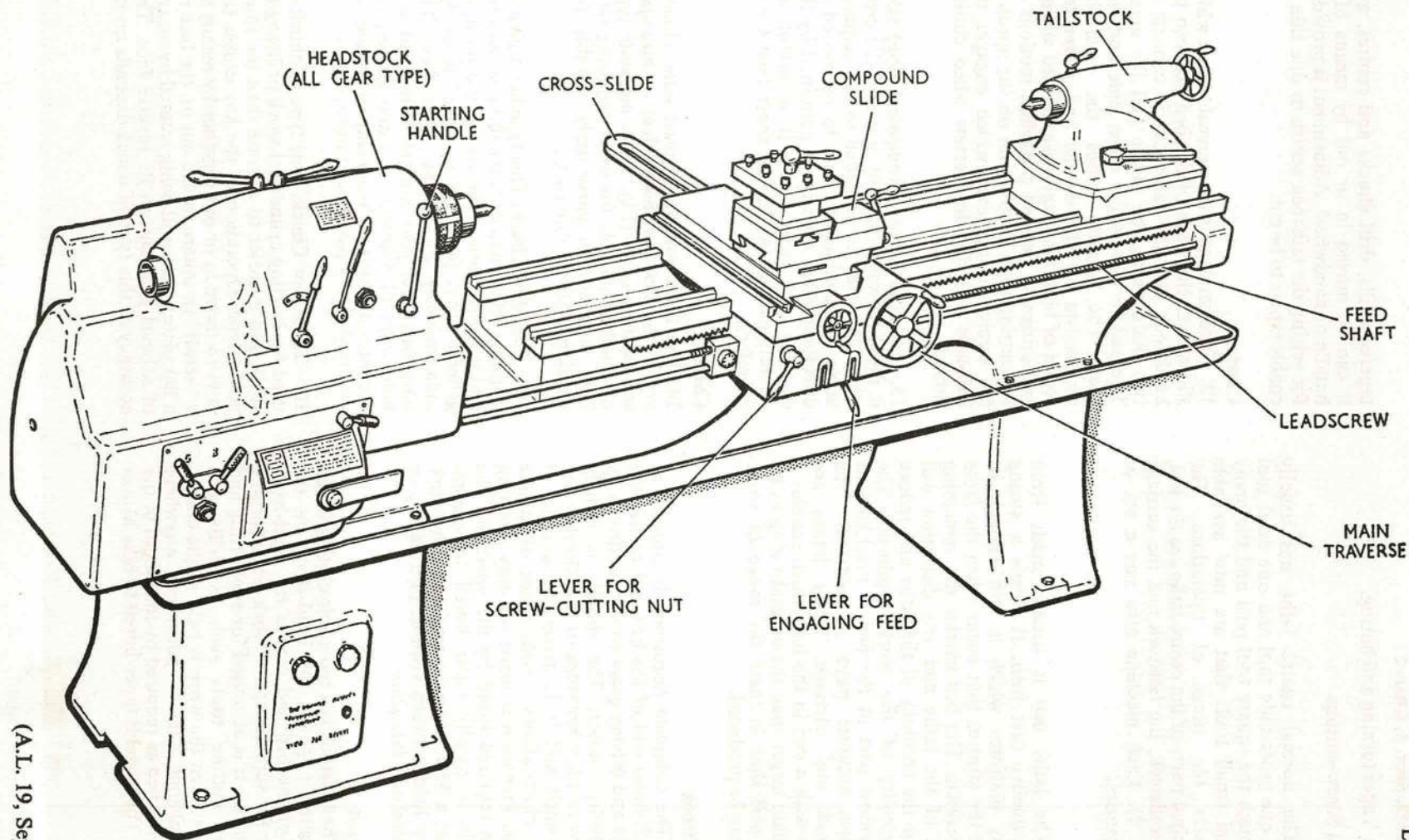


Fig. 2. CENTRE LATHE

(e) Taper turning and boring.

(f) Screw-cutting.

8. The normal centre lathe has usually only one cross-slide tool and one axial tool although the square tool post and the many special small tools that are now available increase the range of operations. The principal parts of the **centre lathe** are the **bed**, the **headstock**, the **tailstock** and the **carriage** (Fig. 2). Each machine also has a set of accessories.

Bed

9. The lathe bed is usually made from good-quality cast iron. It forms a strong sturdy platform which is stiff enough to resist the stresses that occur when the lathe is operated. The bed carries the remaining parts of the lathe and any distortion will impair the accuracy of the lathe and reduce the quality of the work produced. The uppermost part of the bed is machined to produce accurate **ways** or **guides** for the tailstock and carriage. Many lathes are made with a gap in the bed which enables a faceplate larger than the normal swing to be used and thus increase the range of work that can be produced.

Headstock

10. The complete headstock is situated at the left-hand end of the bed and carries the **spindle** and **driving gears** which are driven by an electric motor. The spindle is usually hollow to allow **bar stock** to pass through the head-stock and it is driven by a train of gears which allows a wide range of spindle speeds. Provision is made for easy selection of the required speed by the operator. The spindle is usually taper bored to accommodate a **Morse tapered centre** and the work can be held between **centres**, in a **chuck**, or mounted on a **face plate**.

Tailstock

11. The tailstock is a moveable casting which is located opposite the head-stock on the ways of the bed and carries the right-hand centre for supporting the work when turning on centres. It is also used for supporting and feeding cutting tools such as drills and reamers when the work is held in the chuck. The tailstock can be positioned anywhere along the bed as required by the length of the work. The **barrel** is taper-bored to take Morse

tapered drills, drill chucks and centres, and it can be moved in or out by means of a handle or handwheel. Adjustment is provided for setting the tailstock centre to one side to enable tapers to be cut.

Carriage

12. The carriage is the moveable part which slides over the ways of the bed between the headstock and the tailstock. It consists of two main parts, the **saddle** and the **apron**. The saddle carries the **cross slide** and **tool post**. The apron houses the operating mechanism for the **manual** and **power traverses** of both the lengthwise (termed **sliding**) and crosswise (termed **surfacing**) motions of the cutting tool. Also found on the apron is the screw cutting lever which engages the **half-nuts** with the **lead screw** when cutting threads.

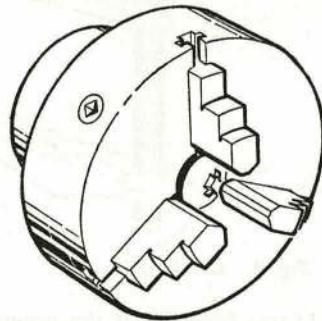
13. On most lathes a **compound (top) slide** is fitted between the tool post and the cross slide. This may be swivelled to any required angle and enables the tool to be moved in directions other than those permitted by the carriage and cross slide. It is useful for operations such as boring short tapers and chamfers.

Chucks

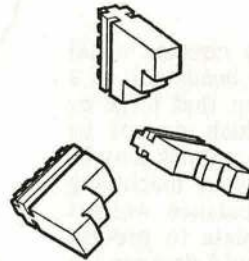
14. The most commonly used lathe chucks are of the **four-jaw independent** or **three-jaw self-centring** types (Fig. 3). A **magnetic** type of chuck is suitable for work requiring only light cuts and is particularly suitable for holding relatively thin parts.

15. **Four Jaw Chuck.** This type has a greater gripping effect than does the three-jawed type and it is therefore preferred for use on most general work. Each jaw is moved in or out independently by means of a **key**. The hardened steel jaws are reversible and will hold work of different sizes and shapes, the accuracy of "set-up" being entirely dependent on the skill and patience of the operator.

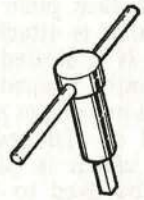
16. **Three Jaw Chuck.** This type of chuck is used for holding cylindrical work or hexagon stock and is easier to operate than the four-jawed type. Operation of the **key** causes the jaws to move in or out together by means of a "scroll" (a square thread cut on the face of a flat plate), the scroll being rotated by means of a bevel gear cut on its reverse face. The accuracy of this type of chuck depends on its



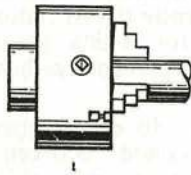
THREE JAW CHUCK



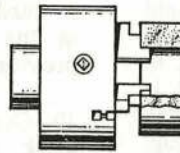
ALTERNATIVE JAWS



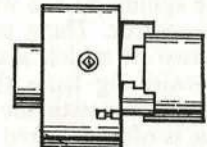
KEY



1

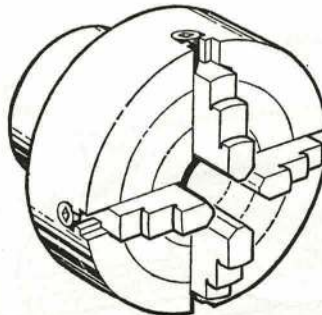


2



3

USE OF BOTH SETS OF JAWS



FOUR JAW CHUCK

Fig. 3. CHUCKS

mechanical condition and any eccentricity must be overcome by repair or replacement of faulty components. The jaws are not reversible and therefore two sets must be provided with each chuck.

Face Plate

17. A face plate is a large circular metal plate that is attached to the headstock of a lathe. It is slotted radially so that large or irregularly shaped work which cannot be turned on centres nor held in a chuck may be bolted or clamped to it. When machining work which is off-centre, balance weights must be fixed to the face plate to prevent excessive vibration which would damage the bearings and give a poor surface finish.

Driving Plate

18. This is a round metal plate that is attached to the headstock and, in conjunction with a **lathe carrier** and in some cases a **projecting pin**, is used to transmit power from the lathe spindle to the work when it is held between centres. There are several types of carrier, two of which are shown at Fig. 4. A pin projecting from the driving plate is required for use with the straight type. The bent type is often referred to as a **driving dog**.

Centres

19. Two plain solid centres are issued for use with each machine. The shanks are

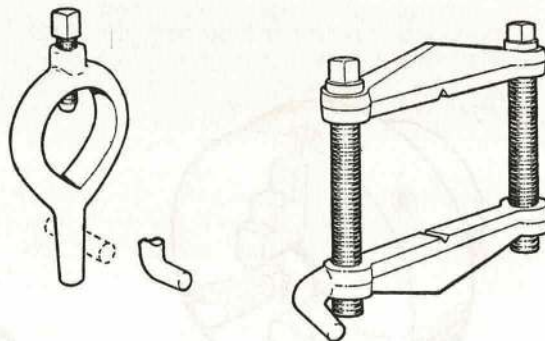


Fig. 4. CARRIERS

finished to a Morse taper to fit the tapers in the headstock and the tailstock and the points made to an included angle of 60° . A tapered sleeve is used to accommodate the centre in the headstock and, because this centre rotates with the spindle, it is often referred to as the **"live" centre**. The live centre may be hardened and ground but it does not need to be nearly so hard as the **"dead" centre** that is stationary in the tailstock and for which grease is provided as a lubricant to prevent overheating.

20. Care must be taken to ensure that the work is correctly mounted between the centres before turning commences (Fig. 5). The centres must be clean and undamaged and the live centre should be checked for truth when running. If the work does not

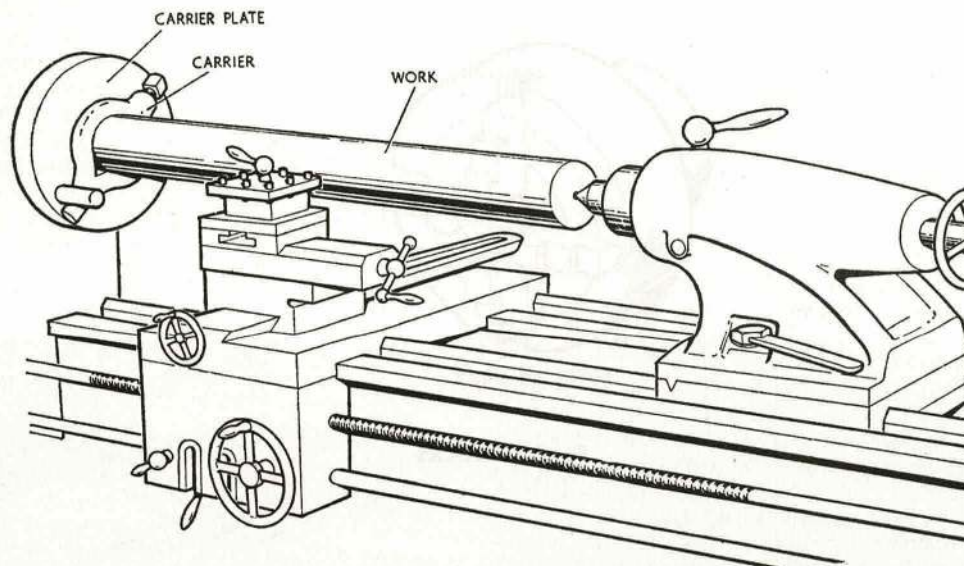


Fig. 5. WORK MOUNTED BETWEEN CENTRES

run true, it will be found that when it is reversed in order to finish the part previously covered by the lathe carrier, a step is formed where the two turned portions meet. The work must be held firmly but not too tightly on the live and dead centres. Also, when a bent type of lathe carrier is used, there must be clearance between the leg and the bottom of the slot or else the work will be pulled away from the centres and revolve eccentrically.

21. **Half Centre.** This is similar to a solid centre but the bearing end is ground away to just over half the thickness (Fig. 6). This type of centre is required when the ends of work held between centres have to be faced.

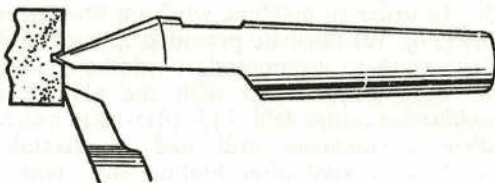


Fig. 6. HALF CENTRE

22. **Square Centre.** This type is also similar to the solid centre but it has the tapered end ground with four flats to form four cutting edges (Fig. 7). It is used to repair worn or damaged centre holes.



FIG. 7. SQUARE CENTRE

23. **Rotating Centre.** There are several types of rotating centres varying in design from the plain metal-to-metal bearing as used in the pipe centre (Fig. 8) to the three bearing type used for high speed mass-production work. The latter type has a ball thrust race and two ball or roller races to support axial loads. The point of the normal rotating centre is ground to an included angle of 60° but the pipe centre is ground to an angle of 90° or 120° to prevent belling of the pipe. Because this type is designed for use on large bore pipes the tip is usually truncated.

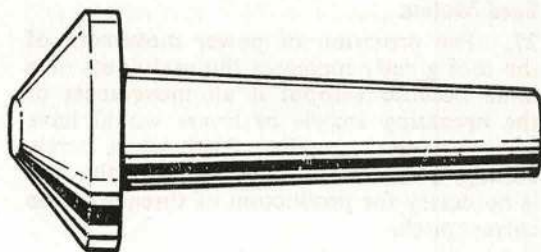


Fig. 8. PIPE CENTRE

Steadies

24. There are two types of steadies provided with each lathe, **fixed** and **travelling**.

25. **Fixed Steady.** A fixed steady (Fig. 9) is used to support the end of lengthy work when it is not possible to use a tailstock centre for this purpose. It is also used to support the centre of long slender work when the work is held between centres. More than one steady may be used if necessary. This type is bolted to the bed of the lathe and usually has three phosphor-bronze fingers, although in some cases the fingers or jaws are fitted with rollers. Normally, before the steady is mounted, the work is skimmed up true where the support is required. The steady is then mounted and the fingers are adjusted to hold the work securely but not so tightly as to cause excessive friction.

26. **Travelling Steady.** This type is used to eliminate bow or vibration when machining long slender work. This type of steady is bolted to the saddle opposite the cutting tool and usually slightly behind it so that the steady and the tool move together along the bed. It has a V-shaped bearing pad which is adjustable and made of phosphor bronze.

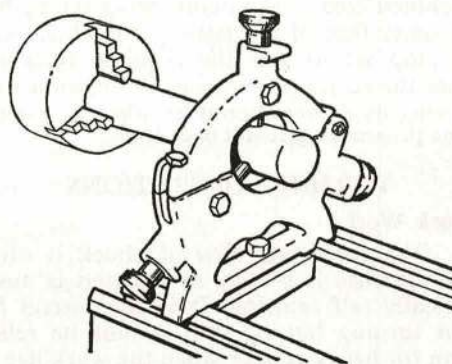


Fig. 9. FIXED STEADY

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Feed Motion

27. The provision of power movement of the tool greatly increases the usefulness of a lathe because without it all movements of the operating wheels or levers would have to be done manually. Also when screw cutting, accurate mechanical feed of the tool is necessary for production of threads of the correct pitch.

28. The **main spindle** drives gearing where means are provided to obtain different rates of feed either by a **gear box** or by fitting different **gears**. A **tumbler gear** arrangement is generally fitted in order to reverse the direction of rotation of the **feed shaft** or lead screw. The gearing transmits the drive to the **feed shaft** or **lead screw**, as applicable, the motion then being transmitted to the **carriage** and **cross slide** by mechanism contained in the **apron**.

Graduated Sleeves

29. Movement of the compound and cross slides is obtained through the engagement of a screw with a nut that is attached to the slide, the screw generally being a square or acme thread. The screw is turned by means of a hand lever, wheel or knob. Fitted on the cross slide screw and often on the compound slide is a graduated sleeve which is used to measure accurately the movement of the slide.

Stops

30. When a number of the same article have to be produced much time can be saved by the elimination of repetitive checking and the extra care necessary to prevent the removal of too much metal. This is achieved on many lathes by the provision of stops for the carriage and cross slide, the previously machined face of the blank being set against the inner face of the jaws of the chuck and the stop set to give the required thickness when the carriage is against it. When a stop is being used care should be taken to use the same pressure against it each time.

TURNING OPERATIONS

Chuck Work

31. The three jaw type of chuck is often used because it is easy to use and is automatically self centring. It is very useful for light turning but its grip cannot be relied upon for heavy cuts or when the work has to be held on a short length.

32. When setting work in a four jaw chuck, the rings on the front of the chuck should be used as a guide and will enable the work to be set to within approximately $\frac{1}{16}$ in. of centre. Hold a piece of chalk steady at about centre height and run the lathe until the high side of the work is marked. The jaw (or jaws) opposite the chalk mark should be loosened slightly and tightened on the side of the mark. This process is repeated until the work runs true and the chalk line is continuous. When setting work true on both the diameter and the face, set the diameter true, lightly tighten and then lightly tap with a hammer to set the face true; finally tighten all jaws evenly.

Centre Turning

33. In order to machine work on centres, a hole (Fig. 10) must be provided at each end of the work to accommodate a lathe centre. The hole is produced with the aid of a **combination centre drill** (Fig. 10) which is also called a **combined drill and countersink**. This tool is used after finding and centre-punching the actual centre of the work.

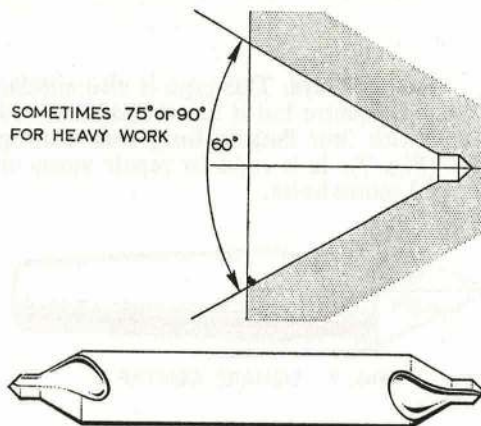


Fig. 10. CENTRE HOLE AND DRILL

34. The driving plate should then be mounted and the projecting pin and carrier or driving dog, as applicable, secured in place. The ends of the work may have been faced during the centring operation; if not, the half centre should be fitted to the tailstock and facing to length carried out.

35. Lubricate the tailstock centre hole and, whilst holding and turning the work, adjust

the tailstock until the grip of the centres can just be felt. The grip should be checked occasionally as heat or wear of the tailstock centre hole may cause it to alter. Tighten the tailstock clamp when the correct adjustment has been obtained.

36. After having faced the ends of the work with a **facing tool** the tool should be replaced in the tool post by a **straight roughing tool**. The cutting angles of this tool should be suitable for the metal being machined, and the tool should be set with the minimum overhang of the tool post and with its nose level with the centre of the work.

37. Measure the work with the aid of calipers and ascertain the amount of metal which is to be removed. The depth of the cut will depend upon the amount of metal to be removed, the type of lathe, and the rigidity of the work. Having put on the required cut and engaged the carriage feed, the cut should proceed as required by the work. This may be up to a shoulder, in which case the cut will be stopped just short of the finished dimension; or when the work is required to be parallel for its whole length, then the cut will be stopped before the tool or some part of the carriage reaches the carrier. Check the diameter of the turned portion and repeat the process until the diameter is approximately within $\frac{1}{16}$ in. of the finished size. The work should then be reversed and the remainder roughed out.

38. **Finishing.** To finish dead to size and with a good surface it may be necessary to change the tool, alter the speed and/or the feed. The same general procedure should be followed as for roughing but more care and attention will have to be paid to the measurements and these may have to be checked with the aid of precision instruments.

39. **Lack of Parallelism.** The work produced will not be parallel if the head and tailstock centres are not on a line parallel with the travel of the carriage. It is important therefore that the work is checked for parallelism whilst there is sufficient metal left for any error to be rectified by adjustment of the tailstock.

Boring

40. There is always the possibility that a drill will "run out" slightly so that drilling

and reaming may produce a hole which is accurate in all ways except that it is not true with the rotational axis of the work and therefore with other faces which may have been machined on the work. A true hole can be bored with a tool set up as shown in Fig. 11, but for large work a **boring bar** in which the separate cutting tool is secured is often used.

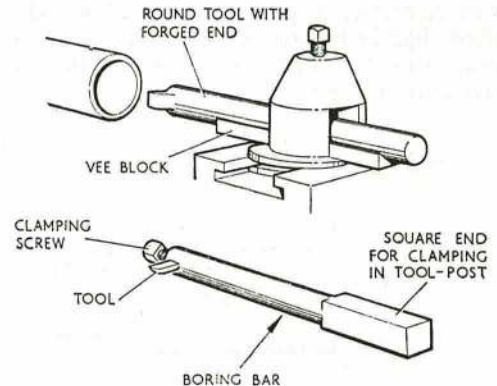


Fig. 11. BORING

Drilling and Reaming

41. Holes are drilled in the opposite way on a lathe to that used on a drilling machine, i.e., the drill is held stationary whilst the work revolves. A chuck fitted into the tailstock is used to hold small drills, but larger drills and tapered-shank reamers can be accommodated in the tailstock by means of a **morse adaptor** and then fed slowly in to the work.

Knurling

42. Knurling tools are used to serrate or cross-hatch the surface of work required to give a grip to the fingers. The knurling tool is forced slowly into the work to a depth of about $\frac{1}{64}$ in. and is fed slowly across the surface of the work, the operation being repeated until the knurling (Fig. 12) is completed. The particular tool used will depend upon whether coarse, medium or fine indentations are required.

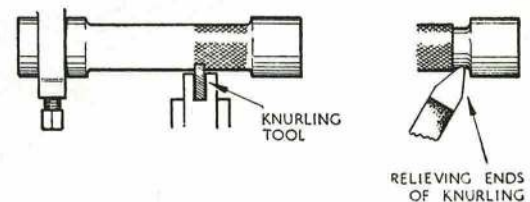


Fig. 12. KNURLING

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Parting-Off

43. Parting-off (Fig. 13) or cutting-off is the operation used to divide the finished article from the stock metal. This is a job that is more difficult than it looks for it needs care and experience to prevent the tool digging in and probably breaking. This tool cuts in one direction only, straight forward. It has less rake than a turning tool for the same material, with clearance angles on both sides and is often slightly tapered in order to cut deeper away from the chuck. The width of the tool varies according to the work.

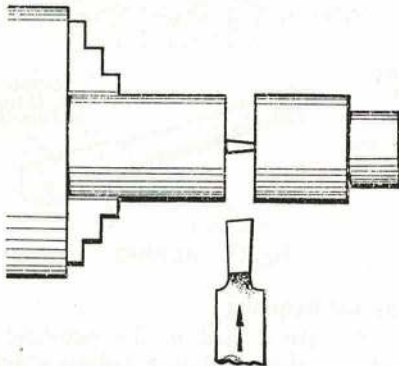


Fig. 13. PARTING-OFF

44. To use the tool, set it slightly below centre and secure it tightly with minimum overhang. Lock the carriage against lengthwise movement and set the compound slide

in line with the bed. Speed should be about $\frac{1}{2}$ that used for normal turning and feed the tool slowly by hand.

CAPSTAN LATHES

General

45. The **capstan lathe** is a development of the centre lathe, the main difference being that the tools required for successive operations are mounted radially in a tool-holder resembling a capstan; by revolving this, each tool in turn may be brought into position in exact location. This results in a saving of the time that is taken normally in changing and setting the tools on a centre lathe.

46. The main visual difference is that the **capstan** has replaced the tailstock. The capstan (Fig. 14) generally resembles a large hexagonal nut with provision on its faces (often known as **stations**) for mounting the various tools. It is mounted on and gets its movement from an **auxiliary slide** that is clamped to the top of the bed and can be moved to any position from the spindle nose as required.

Use

47. Capstan lathes are used extensively for rapid repetition work. It is essential therefore that the sequence of operations required to produce the finished object be predetermined and from this sequence the tool layout can be planned. Unlike the centre lathe, the

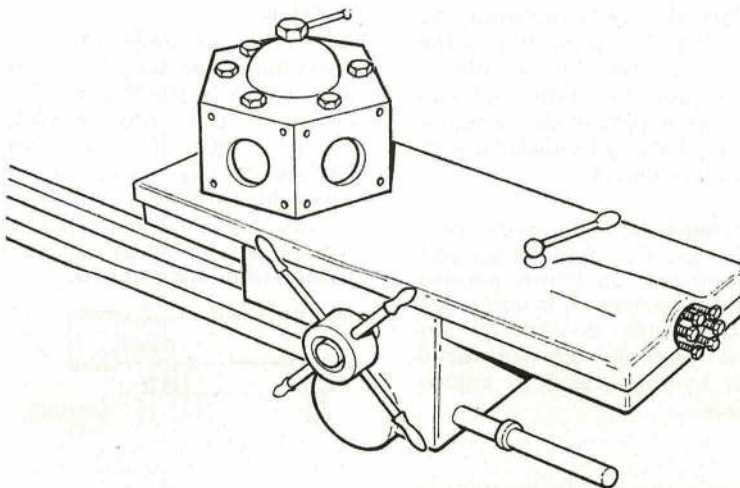


Fig. 14. CAPSTAN

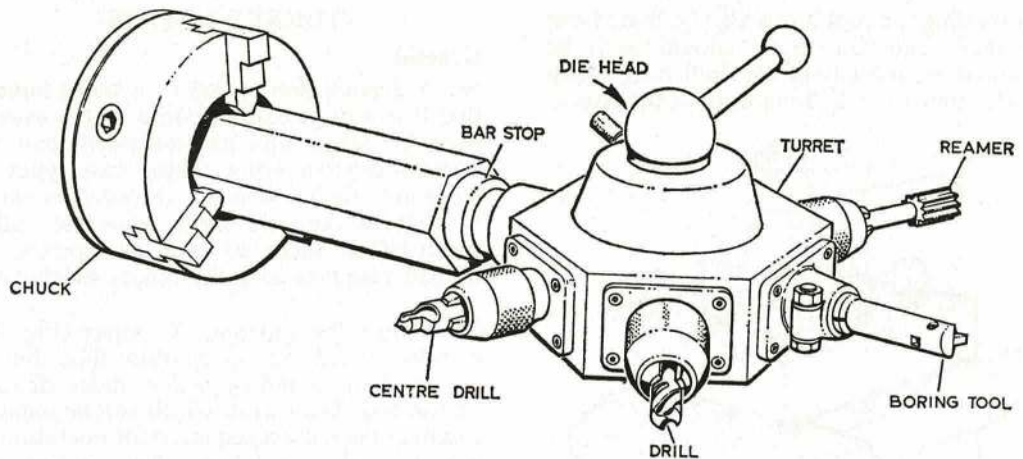


Fig. 15. TOOL LAYOUT

capstan lathe is not usually fitted with a lead screw, and screw cutting is done by **taps** and **die heads**, as applicable, held in the capstan or by use of a **chasing saddle**. The following sequence of operations is given as an example.

Sequence of Operations (Fig. 15)

48. Bar Stop. This is the first tool and it is set so that the correct length of bar stock for the production of each component will be available at the start of each sequence of operations. The tool may be in the form of a simple stop or a combined stop and centre drill.

49. Centring and Facing. To aid accuracy and provide a true start for drilling a **centring tool** may be used. This tool may also have flat cutting faces which "face" the end of the bar whilst centring is being done.

50. Drilling, Boring and Reaming. The next operation would probably be drilling possibly to be followed by reaming, although the most accurate procedure would be to drill, bore and ream whenever practicable. These operations are fairly straightforward, reaming usually being done at a slower speed but at a greater feed than drilling.

51. Tapping. If internal threads are required then a tap is fed forward in the same way as drilling and reaming are done. Provision must be available for extraction of the tap when its function is ended, i.e. when the diameter is large enough collapsible taps can be used; otherwise the spindle rotation must be reversed.

52. External Threads. A die head (Fig. 16) is used to produce external threads. This tool incorporates a self-opening die mechanism so that after its function is completed it can be drawn clear without stopping the machine; also reversing of the spindle is not required.

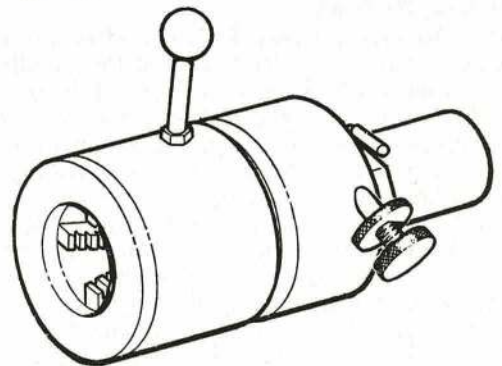


Fig. 16. DIE HEAD

Turning

53. Box turning tools are widely used for turning bar stock. These tools are fitted with a solid vee or rollers which hold and support the work whilst the cutting tool which is also incorporated in the box tool is in operation.

Tool Posts

54. A square tool post (Fig. 17) is carried on the front cross slide and provides a mounting for four more tools. The usual operations done by these tools are facing, turning, chamfering, undercutting and forming. Parting-off may also be done from the front but

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by inverting the tool it can also be done from the rear. The four tools should each be mounted on the left of the tool post which ensures that work is done near to the chuck.

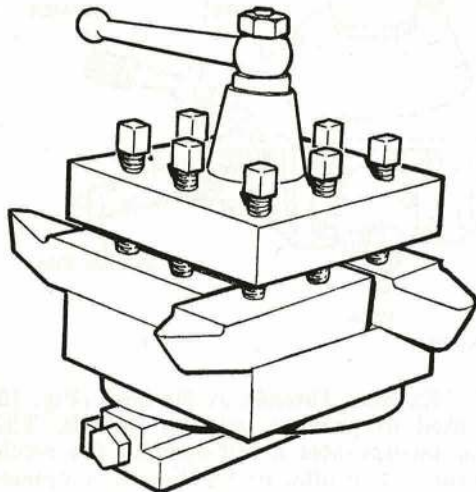


Fig. 17. SQUARE TOOL POST

Holding the Work

55. Because a tailstock is not fitted on a capstan lathe the work is held at the spindle by either a chuck or some sort of fixture. Self centring types of chucks are widely used because of their ease and speed of operation, and many chucks are operated pneumatically. In addition, a set of **soft jaws** are often provided. Mild steel left in its normalized state is used to make these jaws, thus allowing them to be machined to suit each job. This ensures that a higher degree of accuracy can be maintained than with the standard hard jaws and the soft steel also avoids damage when holding previously machined surfaces.

56. **Collet Chuck.** This type of chuck is used when the parts required are made from a bar that is fed through the hollow spindle. The chucks are supplied with **sets of collets** to cover a range of bar diameters, and some are made to operate automatically.

57. **Fixtures.** On both capstan and turret lathes the work may be irregular in shape and at such times it will have to be held either by use of fixtures or by using a standard chuck fitted with special jaws. The type of fixture to be used will of course vary with the shape of the work and will often have to be made up locally.

TURRET LATHES

General

58. A general description of a **turret lathe** is that it is a large capstan lathe that is usually used for larger and heavier work than the normal capstan lathe. These two types of lathe are similar in many respects, so much so that in America both types are called turret lathes: those we know as capstans are termed **ram-type** and the others **saddle-type**.

59. Unlike the capstan, the **turret** (Fig. 18) is not carried on a separate slide but is mounted on a saddle which slides directly on the bed. The turret, which can be indexed round in the correct sequence for operation of the particular tool, and the carriage are generally power operated.

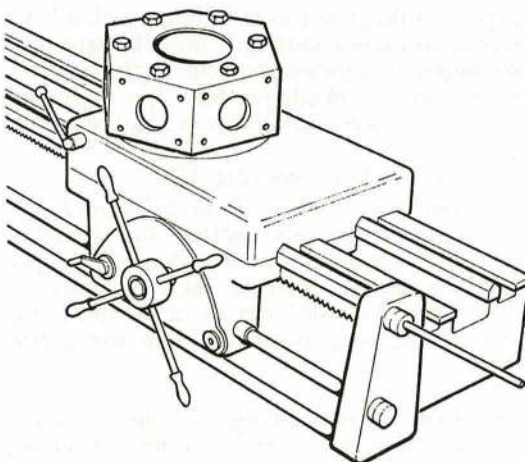


Fig. 18. TURRET

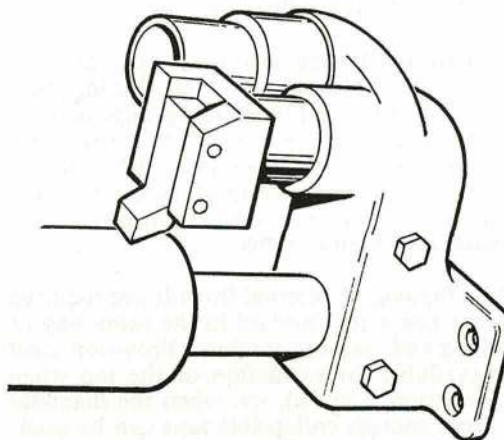


Fig. 19. KNEE TOOL HOLDER

60. Because the two types of lathe are so very much alike, most of the information given for the capstan lathe is applicable to the turret lathe. The tools used with a turret are generally heavier than those used with a capstan and the turret is usually fitted with **knee tool holders** (Fig. 19) which can be fitted with several tools, thus increasing the number of operations which can be carried out.

AUTOMATIC LATHES

General

61. As stated previously the capstan lathe and, of course, the turret lathe were developments of the centre lathe with the main object of producing parts by repetition, the various operations in the production sequence being done manually under the control of the operator. The next development was to produce a machine which carried out all the operations automatically, thus there are now such machines as **single-spindle autos**, **multi-spindle autos**, **chucking autos** and so on, which come under the general heading of **automatics**.

62. Although the machines themselves have become more complicated because of the introduction of suitably designed cams, cam drums, clutches and turret indexing mechanism, once the machine has been correctly tooled and set-up by a skilled setter it can be worked with the minimum of attention, thus saving manpower as well as speeding up production.

63. It may be said that a skilled capstan operator can use the automatic feed for a turret operation and at the same time himself operate cross-slide tools to do another operation, but this overlapping of operations can also be allowed for when designing the set-up for an automatic.

64. The production of cams, cam drums and so on for setting up an automatic is a long and costly operation and will only be justified when very large numbers of an item are required. Such disadvantages have to a large extent been overcome with the advent of **camless multi-spindle automatics** which can be quite suitable for small quantity production.

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