

TAPER TURNING AND SCREW-CUTTING

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TAPER TURNING

Introduction

1. It was shown in chapter 2 of this section that if the movement of the lathe tool is parallel to the axis of rotation of the work then a cylindrical surface will be produced. Many parts that are produced by turning on a lathe are required to be conical instead of cylindrical in shape, and the production of such a surface is termed **taper turning**. The methods of taper turning in common use are as follows:—

- Compound slide.
- Tailstock.

- Taper turning attachment.
- Form tool.

Compound Slide

2. As stated previously in chapter 2 the compound slide (Fig. 1) may be swivelled to any required angle; the angle is indicated on the base which is graduated in degrees. Thus, provided that the angle of taper is known, the slide can be set and operated to produce the required taper on the work.

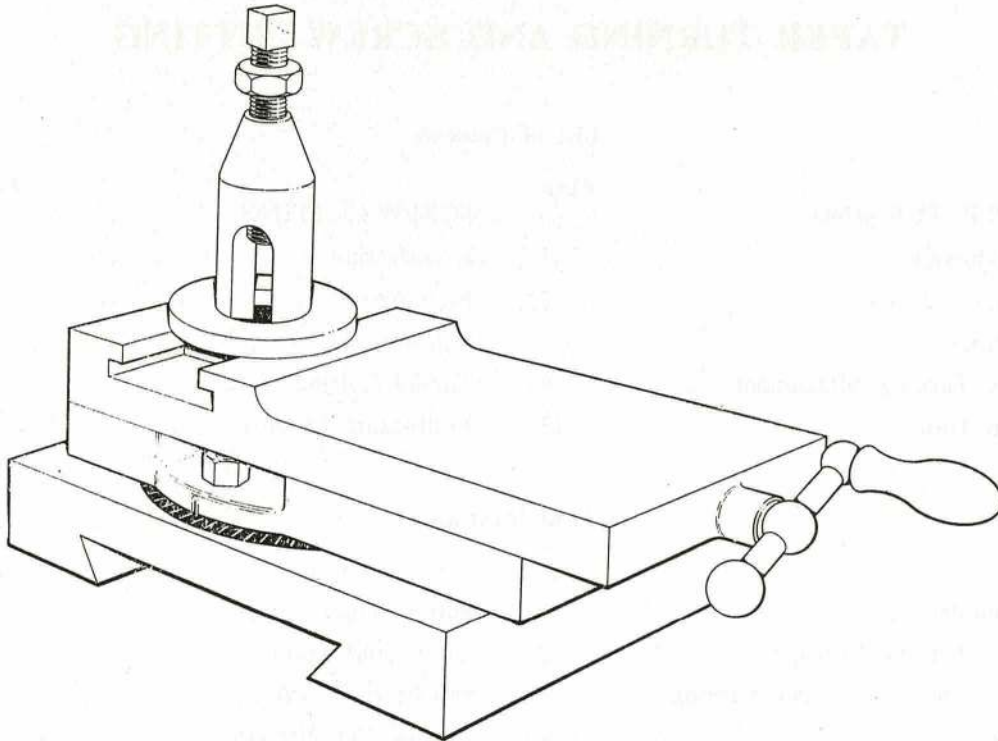


Fig. 1. COMPOUND SLIDE

3. **Principle.** It was seen in chapter 2, paragraph 2, that movement of the tool parallel to the axis of rotation of the work produced a cylindrical form. If the same tool is moved at an angle to the axis of rotation of the work then a tapered surface will be produced (Fig. 2).

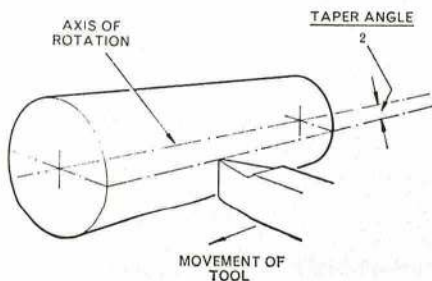


Fig. 2. TAPER TURNING PRINCIPLE

4. **Setting.** The angle at which to set the compound slide is found by use of the following formula:—

$$\tan A = \frac{\text{large dia.} - \text{small dia.}}{\text{length of taper} \times 2}$$

5. **Method.** The method used to produce a taper by means of the compound slide is illustrated at Fig. 3. The compound slide is set at the required angle and the tool is fed along by hand operation of the slide. Although this method is used for taper turning and boring it is suitable only for producing short tapers for two reasons:—

- (a) The length that can be turned is limited to the travel of the compound slide.
- (b) Long tapers would tend to fatigue the operator and thus cause surface irregularities.

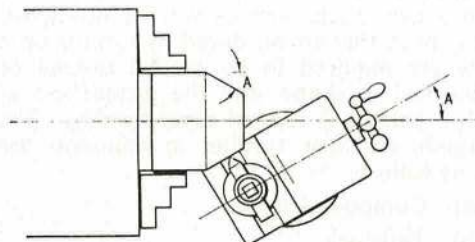


Fig. 3. COMPOUND SLIDE TAPER TURNING

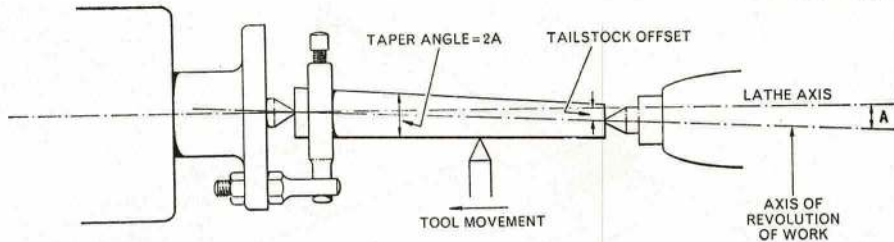


Fig. 4. OFFSETTING.

Tailstock

6. **Principle.** In paragraph 3 it was seen that a tapered surface can be produced by moving the tool at an angle to the axis of rotation of the work. The same effect will be obtained if the tool is moved in the manner that was used for the production of a cylinder, i.e. parallel to the lathe bed, but the axis of rotation of the work is altered so that it is at an angle with the line of movement of the tool (Fig. 4).

7. **Setting.** The alteration of the axis of rotation can be achieved by **offsetting the tailstock**. The amount at which to offset

the tailstock can be found by use of the following formula:—

$$\text{Offset} = \frac{D-d \times l}{T \times 2}$$

Where D = large diameter
 d = small diameter
 l = work length
 T = length of taper

8. **Method.** This method is suitable for producing long tapers only. The adjustment provided for offsetting the tailstock is shown in Fig. 5. To move the tailstock over, one screw is loosened and the other tightened.

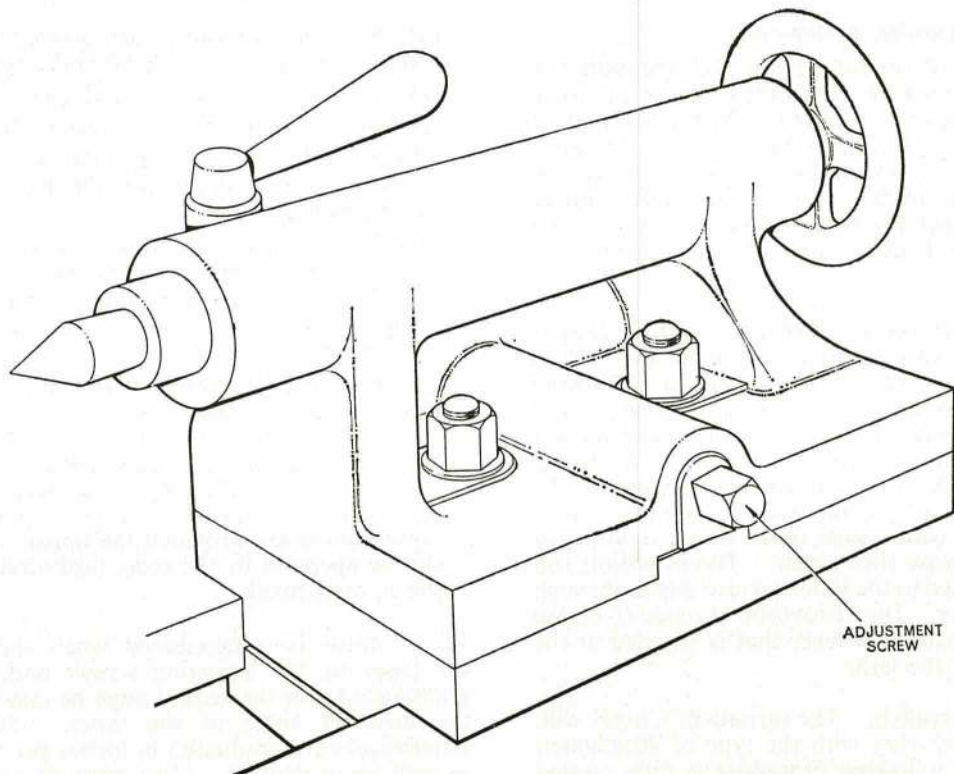


Fig. 5. TAILSTOCK ADJUSTMENT

(A.L. 22, Nov. 65)

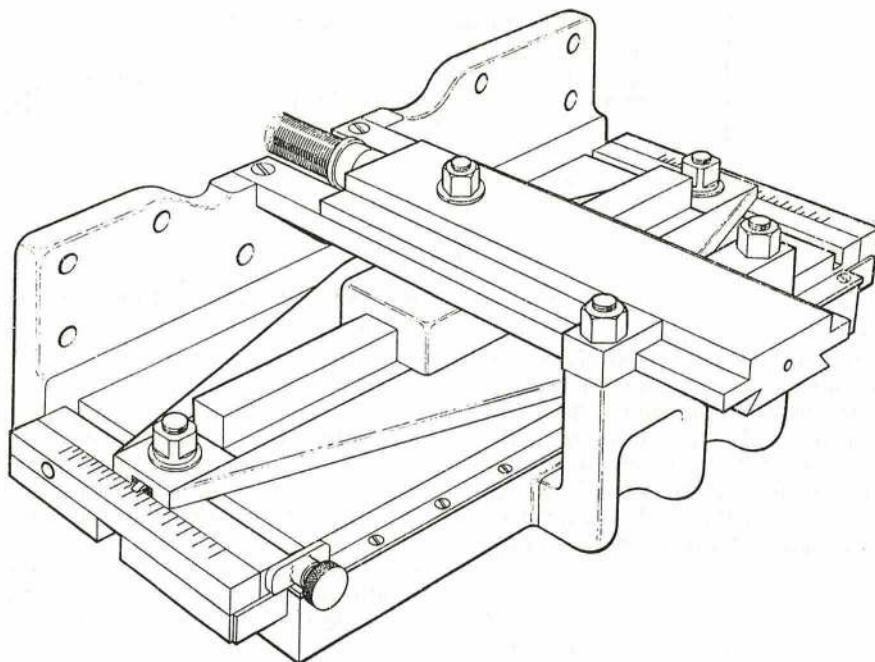


Fig. 6. TAPER TURNING ATTACHMENT

Taper Turning Attachment

9. The compound slide and the tailstock methods are limited in the scope of the work which can be produced. The former method is suitable for short tapers only; the latter method is unsuitable for short tapers or accurate work. Thus, the **taper turning attachment** (Fig. 6) was designed for producing a comprehensive range of taper turning and boring.

10. **Construction.** There are various designs of taper turning attachments but they are in the main all similar, thus the following information is of a general nature. The attachment is bolted by means of the bracket to the back of the cross slide. The bracket carries the slide on which is mounted the pivoted taper guide plate, and this in turn engages with a slide block which is attached to the cross slide screw. The extension rod is attached to the slide and also passes through a bracket. Here provision is made to clamp it by means of a lever that is situated at the front of the lathe.

11. **Operation.** The turning of a taper will, of course, vary with the type of attachment and the following procedure is only quoted as an example:—

- (a) Slacken the two taper guide plate screws and the adjustment locking screw.
- (b) Use the fine adjustment screws to set the taper guide plate to the required taper.
- (c) Tighten the adjustment locking screw, check the setting, and tighten the two taper guide plate screws.
- (d) To obtain a suitable setting for the desired length of taper, clamp the extension rod and then set the cross slide so that the securing bracket is suitably positioned on the slide.
- (e) Unclamp the extension rod; the taper can now be machined.

Note.—Where the lathe saddle has only one slide, the cross feed screw must be slackened to enable the taper to be turned. Where double slides are provided the upper slide can be operated by the cross feed screw in the normal manner.

12. It must be remembered when setting the taper by the adjusting screws and the graduations that the setting must be one-half the included angle of the taper. Some attachments are graduated in inches per foot as well as in degrees. Care must be taken to ascertain whether the graduations refer to

the attachment setting or to the taper produced on the work, the latter being twice the attachment setting.

Form Tool

13. The use of a form tool to produce a tapered surface on the work is illustrated in Fig. 7. The form tool is ground to the angle required and set up in the tool post of the lathe. Care must be taken to ensure that the edge of the tool is exactly straight or else the work will not be accurate. This method is suitable for short tapers only, because the machining in this way of long tapers tends to cause the work to chatter and vibrate which results in a rough finish.

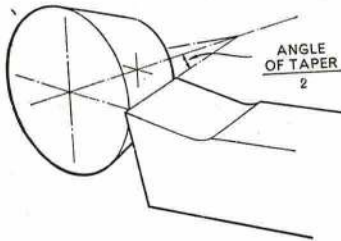


Fig. 7. FORM TOOL TAPER TURNING

SCREW-CUTTING

Introduction

14. When threads are required to be cut by the use of a lathe this is normally the last operation on an otherwise completed piece of work. Thus it is obvious that accuracy is all important, and it is equally obvious that the threaded portion must be turned down to the top size or major diameter of the thread at some time previous to the commencement of the screw-cutting operations.

15. It was stated previously (chap. 2) that production of threads of the correct pitch requires accurate mechanical feed of the tool. The tool is ground accurately to the shape of the thread required, i.e. it is a form tool, the accuracy of the angle of which can be checked by use of a centre gauge (Fig. 8).

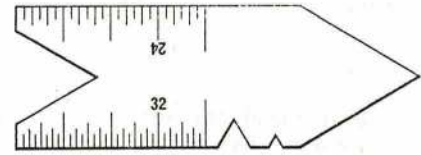


Fig. 8. CENTRE GAUGE

Principle

16. Screw-cutting in a lathe is basically a process of reproduction, the original which is being copied being the lead screw. The drive to the tool is transmitted via the lead screw, so that for every revolution of the lead screw the saddle carrying the tool will, when engaged, move a distance equal to the pitch of the lead screw. Thus, if the work revolves at the same speed as the lead screw, the tool will cut a thread of the same pitch as the lead screw.

17. This does not mean that a lathe can produce threads of only one pitch. Provision is made to revolve the work faster than the lead screw when a smaller pitch is required and vice-versa. Therefore, the pitch of the screw to be cut and that of the lead screw may be expressed as a ratio, and this ratio must be maintained when selecting the change gears.

Gearing

18. The provision made for obtaining the required ratio between the spindle and the lead screw is a set of change gears which can be interposed, as required, between the two drives, i.e. the spindle and the lead screw. A typical set of gears that may be provided for use with a lathe ranges from 20-teeth, increasing by multiples of 5 to 120-teeth. There is also one duplicate of one of these gears (usually the 20-toothed or 40-toothed one) to provide a straight drive to enable threads of the same pitch as the lead screw to be cut, and one gear having 127-teeth for metric threads.

19. The formula used to find which of the gears are needed for the cutting of any given thread is as follows:—

$$\frac{\text{T.P.I. of lead screw}}{\text{T.P.I. to be cut}} = \frac{\text{No. of teeth on driver}}{\text{No. of teeth on driven}}$$

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Thus to cut, for example, a thread of 7 T.P.I. using a lead screw of 4 T.P.I.:—

$$\frac{4}{7} = \frac{\text{driver}}{\text{driven}}$$

Select a gear wheel, the number of teeth of which should be divisible by 7 exactly, e.g. 35 teeth. To maintain the ratio of $\frac{4}{7}$ the driver must have 20 teeth.

Similarly if a driven gear wheel having 105 teeth was chosen then the driver must have 60 teeth:—

$$\frac{60}{105} = \frac{4}{7}$$

20. Simple Train. These gear wheels, together with any convenient size of intermediate or idler gear, could be set up as a simple train (Fig. 9). The idler gear serving the dual purpose of both driven and driver does not influence the speed ratio.

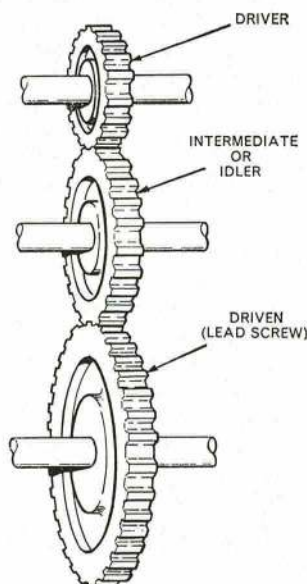


Fig. 9. SIMPLE TRAIN

21. Compound Train. It may be found that it is not possible to cut a certain number of threads per inch using a simple train of gears, e.g. very small or fractional threads, owing to the fact that gears with the correct number of teeth required are not available in the set supplied. At such times a compound train of gears (Fig. 10) must be used. Thus, for example, to find the change wheels required to cut a thread of 30 T.P.I. using a lead

screw of 4 T.P.I.:—

$$\frac{\text{T.P.I. of lead screw}}{\text{T.P.I. to be cut}} = \frac{4}{30} = \frac{\text{driver}}{\text{driven}}$$

Now the smallest gear supplied has 20 teeth and the largest 120 teeth. To maintain the ratio using the largest gear as the driven would need a driver having 16 teeth:—

$$\frac{4}{30} = \frac{16}{120} \text{ which is not included in the set.}$$

It is therefore necessary to split this ratio into two ratios so that two sets of gears can be employed thus:—

$$\frac{4}{30} = \frac{2}{3} \times \frac{1}{5}$$

Taking the last ratio:—

$$\frac{1}{5} = \frac{20}{100}$$

Hence the first driver will have 20 teeth and the first driven will have 100 teeth. Similarly the other ratio $\frac{2}{3}$ can be expressed as $\frac{50}{75}$ or $\frac{40}{60}$ so the second driver can have 50 teeth (or 40) and the second driven 75 teeth (or 60) as applicable. Such a compound train of gears will give the original ratio of $\frac{4}{30}$.

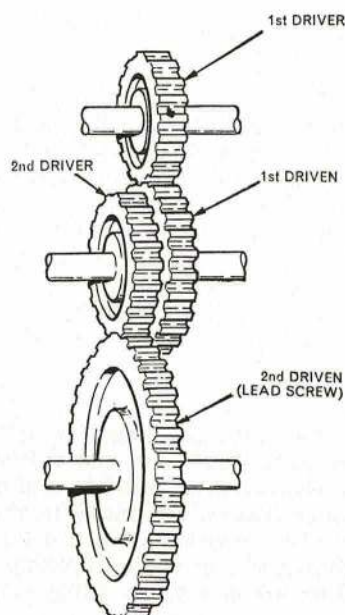


Fig. 10. COMPOUND TRAIN

22. Metric Threads. It has been stated previously that one gear having 127 teeth is provided in the set of change gears for use when cutting metric threads. This gear was derived as follows. There are approximately 25.4 m.m. in 1 inch and therefore there are 254 m.m. in 10 inches. Therefore, if gears $\frac{10}{254} = \frac{\text{driver}}{\text{driven}}$ are used on a lathe having 1 T.P.I. a thread of 1 m.m. pitch will result. A gear having 254 teeth would be too large for practical use so the ratio is divided by 2 and so becomes $\frac{5}{127}$; this is the constant used for finding the change gears required when cutting screws of metric pitch with the aid of the 127-gear and 1 T.P.I. lead screw.

For a lathe having a 2 T.P.I. lead screw the constant would be $\frac{2 \times 5}{127} = \frac{10}{127}$

For a lathe having a 4 T.P.I. lead screw the constant would be $\frac{4 \times 5}{127} = \frac{20}{127}$

The general formula for use when metric threads have to be produced on an English lathe is:—

$$\frac{\text{driver}}{\text{driven}} = \frac{5}{127} \times \frac{\text{T.P.I. of lead screw}}{\text{pitch of work in m.m.}}$$

Example. Find the gears required to cut a 6-millimetre pitch thread on a lathe with a lead screw having 4 threads per inch.

$$\begin{aligned} \frac{\text{driver}}{\text{driven}} &= \frac{5}{127} \times 4 \times 6 \\ &= \frac{120}{127} \end{aligned}$$

Note.—The 127-gear is always a driven gear and should be fitted on the lead screw.

Thread Cutting

23. As stated previously, the portion of the work to be threaded will have been turned down or bored to the correct diameter, this being equal to the major diameter of the external thread and the minor diameter of the internal thread. It is also assumed that any calculations and setting-up of the gear train will have been completed, leaving the actual machining to be carried out.

24. Vee Threads. The tool to be used is ground to the required profile; the angle can be checked with the aid of a **screw-cutting** or **centre gauge** and the radius at the end by means of a **screw pitch gauge**. The screw-cutting gauge is then used to ensure that the tool is set with its axis at right angles to the axis of the work (Fig. 11) and, of course, on centre.

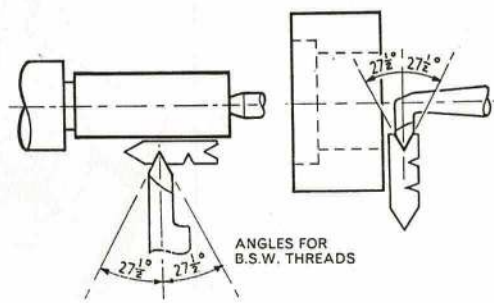


Fig. 11. SETTING THE TOOL

25. To cut the threads the tool must be traversed a number of times by means of the lead screw, the feed being increased a little deeper each time until the correct depth is achieved; the following method is recommended;

(a) Set the compound slide to half the required thread angle, e.g. $27\frac{1}{2}^\circ$ for B.S.W. and 30° for metric (Fig. 12).

(b) Set the cross-slide with the tool just touching the work, and set the stop. If a stop is not fitted, mark the graduated sleeve.

(c) Engage the nut and, at the end of the first traverse, operate the cross-slide quickly to move the tool clear of the threads (backwards or forwards depending upon whether external or internal threads are being cut) and at the same time disengage the nut.

(d) Return the carriage to the starting position, set the cross-slide to the stop or marked position and apply the required feed by means of the compound slide handle.

(e) Engage the nut and repeat operations (c) and (d) until the thread is almost complete. The final finishing to size is usually done by means of a **chaser**.

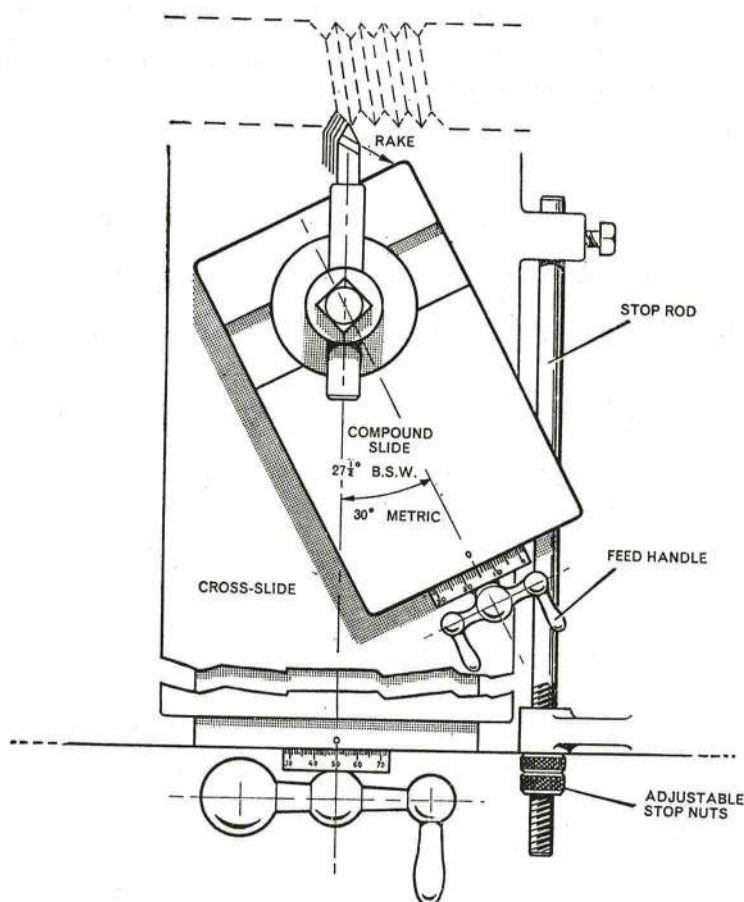


Fig. 12. CUTTING VEE THREADS

26. **Thread Chasing.** To finish the thread to size, a chaser of the correct type and profile is used and either hand or machine chasers may be employed. A hand chaser is shown in use (Fig. 13); the chaser rest is clamped in the tool post in such a manner that when the chaser is placed upon it the top of the chaser teeth will be on centre. The chaser is traversed along the thread until a ring gauge will screw onto the thread with a good fit.

27. **Square Threads.** A single tool ground to the correct profile and fed in much the same way as a parting tool (Fig. 14A) can be used to cut small square threads. Large square threads can be cut by using a parting tool to the full depth, followed by a thin knife tool which is fed parallel to the axis of the work (Fig. 14B). The compound slide can be used for putting on the feed, withdrawal and re-setting of the tool being done by means of the cross-feed.

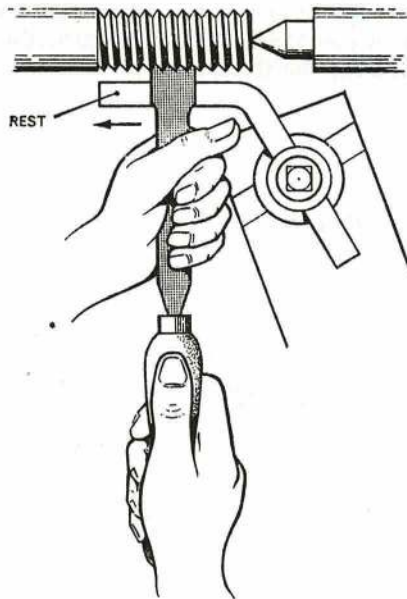


Fig. 13. USING A CHASER

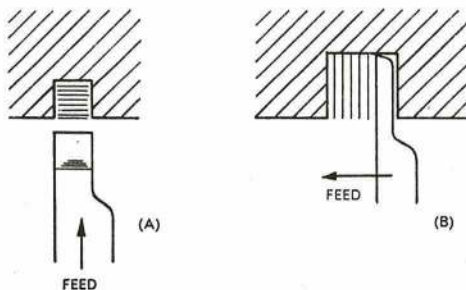


Fig. 14. CUTTING SQUARE THREADS

28. **Thread Finishing.** There are various ways of finishing off a thread when it does not run off clear at each end. Sometimes a recess can be cut for the tool to run into (Fig. 15A and B), or it may be possible to finish off the thread gradually (Fig. 15C) by carefully backing out the tool for approximately the last half-turn.

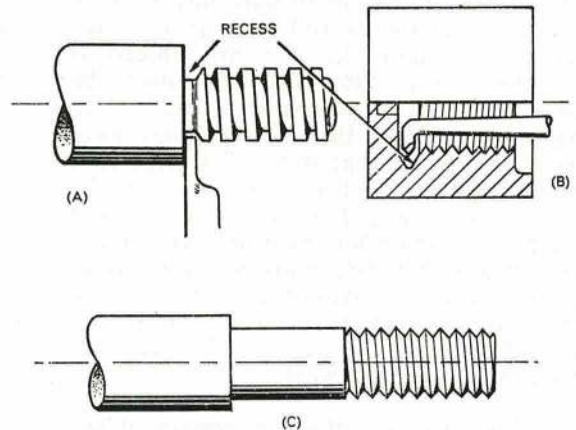


Fig. 15. THREAD FINISHING

29. **Left-hand Threads.** When left-handed threads are required the rotation of the lead screw must be reversed. This effect can be obtained by inserting another gear in the gear train and thus the tool will be moved from left to right. The number of teeth on the reversing gear will not affect calculations because it serves both as a driver and a driven gear. It may be necessary to turn a groove in the work in order to provide space for starting the tool. Some lathes are provided with a reversing tumbler mechanism.

Multi-Start Threads

30. When calculating the gears to be used for cutting particular threads the factor to be used should be the **lead**. This factor did not affect previous calculations because the foregoing information has been confined to single threads where, of course, the pitch is equal to the lead. For multi-start threads, if there are "X" starts then **lead** = **X** × **pitch**. The lead screw is always single-start.

Example—Find the gears required to cut a 3/8 in. pitch 3-start thread on a lathe with a lead screw having 4 threads per inch. 3/8 in. pitch 3-start has a lead of $3 \times 3/8 = 9/8$ in.

$$\begin{aligned} \frac{\text{Driver}}{\text{Driven}} &= \frac{\text{lead of thread to be cut}}{\text{lead of lead screw}} \\ &= \frac{9/8}{1/4} = \frac{36}{8} = \frac{9}{2} \end{aligned}$$

i.e. a simple gear train having a 90-toothed driving gear and a 20-toothed driven gear.

31. When cutting multi-start threads with a single tool the procedure is to cut each thread separately, i.e. the first thread is completed and then the tool must be positioned to cut the second thread and so on. It is assumed that suitable gears have been fitted in the gear train. If a three-start thread of $\frac{1}{4}$ in. pitch is required, when the first thread having $\frac{3}{4}$ in. lead has been cut there is still space for the other two threads in between, but care must be taken when producing these remaining threads otherwise the work can easily be scrapped. There are several methods which can be used to produce satisfactory work.

32. One method utilizes movement of the tool by an amount equal to the pitch, to the left if the thread is right-handed and vice-versa. When using this method the operator must ensure that all backlash is taken up on the compound slide before the first thread is cut.

33. When a gear train is being employed, a method that is often used is to divide the number of teeth of the driving gear into the same number of divisions as the number of starts of the threads required (Fig. 16); the number of teeth giving equal divisibility can be arranged when deciding the change gears to be used. If a 3-start thread is required and the driver has 45 teeth then the gear will be marked at each 15th tooth as follows. The lathe is set ready for the first thread and the first tooth on the driving gear and the meshing teeth on the idler gear should be marked; the second and third position teeth on the driver should also be marked. When the first thread has been completed, the idler gear should be moved carefully out of mesh with the driving gear and then the driver moved forward by hand until the second

marked tooth will mesh with the marked teeth on the idler. After the second thread has been completed the setting procedure is repeated for the third thread.

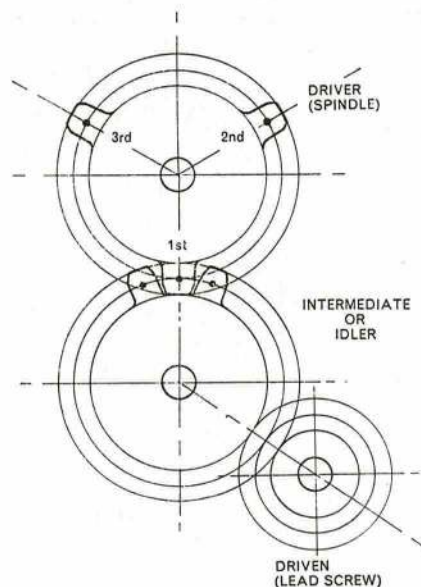


Fig. 16. MARKED GEAR WHEELS

34. Alternative methods of indexing the work are:—

- (a) The use of a driving plate having a number of equally spaced indexing slots into any of which the driving pin can be clamped.
- (b) Indexing catch plates that may be graduated or have accurately drilled circles of holes. A twelve-hole circle enables 2, 3, 4 or 6 start threads to be produced and a ten-hole circle 2 or 5 start threads.

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