MODEL ENGINEERS' WORKSHOP

Screwcutting In the Lathe

Martin Cleeve

This article was previously published in Model Engineer No. 3557, March 1977, and was drawn to our attention by the letter below submitted to MEW by Alastair Sinclair. Given the high levels of interest in screwcutting clutches for modern lathes based on the Hardinge design in recent years, we felt that this article would be particularly useful for readers.

Dear Sirs,

I am pleased that you have decided to make the readership aware of the very excellent Metal Master Machine Tool in the February issue. I remember reading about this in the article by David Urwick in ME No 3480 January 1974 (a copy of which I still have) and thinking that there could not be a more versatile machine available for the model engineer. I was particularly impressed with the screwcutting system employed which featured the single tooth dog clutch on the headstock mandrel to ensure perfect pick up of the thread being cut every time even at high speed and without stopping the machine, except when checking progress. David mentioned in his article that this system was based on that of the EXE lathe which originated the method and which first became available during the 1920's.

Now by far the most detailed and informative article describing the working principle of this system is given in ME No 3557 March 1977 by Martin Cleeves entitled 'Screwcutting in the Lathe' which goes on to extoll its particular advantages and to describe how he modified his ML7 to use this system by the introduction of a clutch on an extended output spigot of the tumbler reverse. He also gives advice on the cutting of metric threads using this and of multiple start threads which it seems it can do with considerable ease. There are no construction details of his clutch mechanism given but the photographs are good and no doubt there are Myford owners out there who would be keen to try this excellent method and design their own clutch details to suit.

I have to say that given the superiority of the EXE system which provides totally foolproof thread cutting, it is difficult to see why this was not adopted as the standard method of design for all screwcutting lathes thereafter.

Alastair Sinclair,
January 2015

SCREWCUTTING IN THE LATHE

Martin Cleeve revives an old, but efficient method

WHEN LATHE SCREWCUTTING I often wonder how many readers own and use a lathe called "The Super Exe" designed many years ago with a special feature to make screwcutting easy; it being impossible to cut a "crossed thread" thereon. Not that I own an Exe, but in an old 1940 Tyzack Catalogue there is an advertisement for the Exe which reads:

"Screwcutting.—The special screwcutting clutch on mandrel enables all threads (including uneven numbers or fractional threads) to be picked up correctly in pitch, with absolute certainty every time. This feature is absolutely unique among small lathes and makes screwcutting so easy that even those without previous experience can cut any thread easily and quickly."

Strangely, it was not until I had made an exhaustive study of lathe screwcutting that I understood the importance of what the Exe makers were saying.

Subconsciously perhaps I thought I knew the answers anyway. After all, any screwcutting lathe will "pick up correctly in pitch with absolute certainty every time" provided you follow the correct procedures, so I was unable to see anything in the advertisement worth special attention. Had the Exe people said that screwcutting passes could be initiated at any convenient instant by the flick of a lever, that it was never necessary to reverse the lathe spindle to reposition a threading tool for each fresh cutting pass, that a leadscrew indicator was not required, and that it was impossible to overrun into a shoulder, I might have taken more notice—or I might have thought it was a mere advertisement puff: who can tell?

There was the point, too, that if the Exe threading system was so efficient, why was it not (and why is it not) standardised for industrial lathes where users have the right to expect that they are not being fobbed off with second best? And to meet the more demanding screwcutting requirements of the pending full metrication, why are some lathes being fitted with very expensive *geared* leadscrew indicators: indicators which nevertheless are still suitable for only a handful of pitches compared with the literally *infinite* pitch range covered by the Exe method?

After a perusal of these notes the reader will be able to answer the last few questions for himself. However, my studies of lathe screwcutting were initially made so as to be able to deal as efficiently as possible with metric threads, and my inquiries were considerably aided by an introduction to the Hardinge HLV-H high precision lathe which I found will not only screwcut perfectly at high speeds, but does so without risk of overrunning or

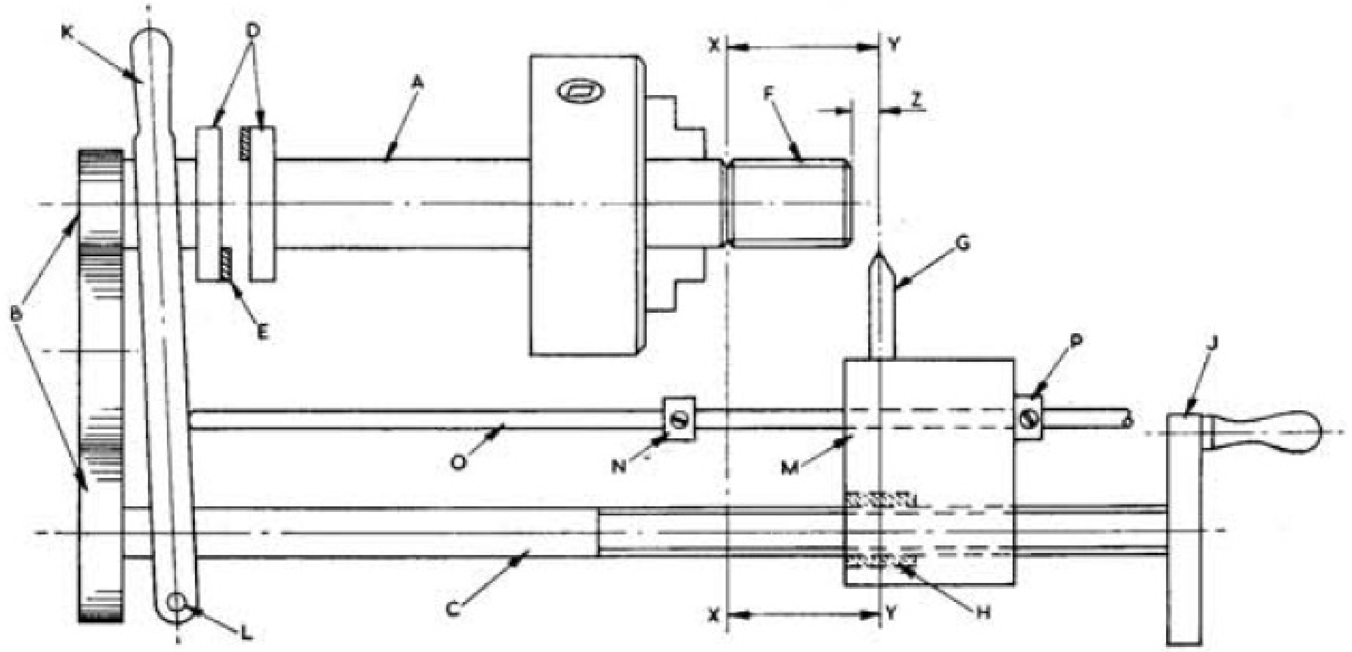


Diagram illustrating how a lathe can be designed (or modified) to give instant repeat pick-up for all thread pitches

Fig. I

cross-threading, no matter what type of thread is being cut, and regardless of whether the leadscrew is to metric or Imperial standards.

In these notes, the expression "pick-up" or "repeat pick-up" means that a threading tool is repeatedly following the first thread helix to be cut during a lathe screwcutting operation. "Instant repeat pick-up" means that as soon as a threading tool has been repositioned for a fresh cutting pass, that cutting pass can always be taken immediately, there being no waiting for circumstances to assume favourable conditions.

The necessary mechanism for achieving instant repeat pick-up for all threads is illustrated in the diagram, Fig. 1, where the drive from the lathe spindle A through gearing B to the leadscrew C is taken through clutch D, which is of the "single tooth" type, i.e. it has only one driving and one driven dog tooth E. Letter F represents the work-piece to be threaded, G the threading tool, and H the nut engaging with the leadscrew.

When the clutch D is disengaged, the leadscrew C can be rotated by means of handwheel J. The dog-clutch is operated by lever K, pivoted at L.

The basic method for using this arrangement for screwcutting is to leave the half-nuts H engaged with the leadscrew. To initiate a screwcutting pass from the position shown in Fig. 1, assuming tool depthing has been attended to, the lathe is started, and the dog-clutch engaged by moving lever K to the right, which of course sets the leadscrew rotating and traverses the tool from right to left. On near completion of the cutting pass, the carriage M contacts collar N, previously suitably positioned on rod O, and pushes rod O to the left where it contacts lever K, thus automatically disengaging the dog-clutch.

With disengagement of the clutch, the leadscrew ceases to rotate, so traverse is automatically arrested, although the component will continue to rotate, and may in fact remain in motion. The carriage and tool are now repositioned for the next cutting pass by withdrawing the tool from the thread groove and hand turning the leadscrew by means of wheel J until the tool is clear of the workpiece, and after attending to depthing, the next cutting pass is taken by re-engaging the dog-clutch.

Pick-up is assured because between cutting passes the only point of disconnection to the leadscrew drive is at the clutch, and as this has only one driving and one driven dog, the relationship between the thread being cut and the position of the threading tool can never be more nor less than 360 deg., or one component thread turn, out of phase, and one component turn must exactly equal one thread pitch of the screw being cut, whatever that pitch may be.

When repositioning the carriage ready for a fresh cutting pass by hand turning the leadscrew with the half-nuts engaged, the starting clearance Z can be held to any convenient minimum. The total distance X – Y will depend entirely upon the length of the thread to be cut.

Industrial lathes that screwcut on this principle do not, however, employ a leadscrew handwheel for carriage and tool repositioning, but have a secondary dog-clutch plate rotating in a direction opposite to that of the lathe spindle so that on completion of each cutting pass the leadscrew can be reversed by power from the headstock. When necessary, too, this reverse drive is used for cutting left-hand threads, with cutting passes being made from left to right.

It should be noted, however, that for tool repositioning purposes when screwcutting, reversal of the leadscrew by means of power from a tumbler reverse cluster will not hold pick-up. In fact on the Myford ML7 for example where the tumbler reverse driving gear has 25 teeth, the chances of holding pick-up would be one in twenty-five, apart from other considerations, if the tumbler reverse is operated after screwcutting has commenced.

Faster Tool Repositioning

Evidently, on a small lathe, repositioning the carriage by rotating the leadscrew is slower than repositioning by rack and pinion traverse. However, it so happens that when a thread being cut is in the same language as that of the leadscrew (English with English, or metric with metric) it is often convenient and quicker to reposition the tool after each cutting pass by opening the half-nuts and hand traversing the carriage to the right by rack and pinion. But to do this the distance X – Y (Fig. 1) must embrace a whole number of thread turns on the component being threaded, and a whole, or integral number of leadscrew threads or turns.

For example, if with a leadscrew of 8 t.p.i., a thread of 9 t.p.i. is being cut on a workpiece, and X – Y is one inch (note this includes the starting clearance Z), then on completion of each cutting pass the half-nuts may be disengaged and the carriage rack and pinion traversed to the right through a distance X – Y of one inch (8 leadscrew threads) and the half-nuts re-engaged. A right-hand stop collar P may be set to avoid call for repeated measurements. If 26 t.p.i. is being cut with a leadscrew of 8 t.p.i., distance X – Y would have to be in units with a minimum value of ½ in. (4 leadscrew threads) because 4 leadscrew threads span a minimum of 13 thread turns on the component.

Another way of looking at this is as follows. Suppose 11 t.p.i. is being cut with a leadscrew of 8 t.p.i., and distance X – Y holds 22 thread turns on the component-plus-starting-clearance. Evidently if on completion of the cutting pass the leadscrew is hand turned back to reposition the tool at Y, the leadscrew will have to be turned through 16 revolutions. But 16 revolutions of the leadscrew equals 16 leadscrew threads which equals 2 in., so the tool may be repositioned far more quickly by disengaging the half-nuts on completion of the cutting pass and rack and pinion traversing 2 in. to the right, then re-engaging the nuts. The result is the same whichever way you do the repositioning.

However, in setting the right stop P, the total distance X – Y must be used as the thread turns reference. For example minimum pick-up for 26 t.p.i. is 13 thread turns in half an inch (4, 8 t.p.i. leadscrew threads) so even if you are cutting only a ½ in. length of 26 t.p.i., if you want to reposition by rack and pinion you have to set 4 leadscrew threads to the right. If you are cutting exactly one-half inch length of 26 t.p.i. you would have to rack and pinion traverse through 8 leadscrew threads, otherwise you would have no starting clearance. For a 2 in. length of 19 t.p.i. you would have to traverse to the right through 24 leadscrew threads, 3 in., giving you a 1 in. starting clearance. Under these conditions, if tailstock support is required and the piece to be threaded is smaller in diameter than the tailstock barrel, the extra starting clearance can be provided for by using a half-centre.

Advantages of Dog-clutch Control

However, apart from whether or not the carriage is repositioned by rack and pinion, the advantages of the dog-clutch control for screwcutting are overwhelming. Pick-up is ready immediately after repositioning the tool for each fresh cutting pass, quite regardless of how awkward the pitch relationship between the leadscrew and the thread being cut, and there is no waiting for a leadscrew indicator to register favourable positions.

Moreover, threads for which a leadscrew indicator is of no use, such as metric, British Association, worms and fractional pitches all pick-up equally well. It is never necessary to reverse the lathe spindle to reposition the carriage, neither is it ever necessary to stop the lathe spindle until completion of a thread, except to check sizing. In those instances where it is possible to return the carriage for each fresh cutting pass by rack and pinion traverse, the half-nuts are disengaged and re-engaged on a "dead" leadscrew, hence there is no "snatch" and false starts are virtually impossible.

Blind bore threading ceases to be a hazardous operation, and generally higher threading speeds are possible. Brass can often be threaded at 500 r.p.m. for example, and the Hardinge HLV-H high precision lathe will thread at speeds of up to 1000 r.p.m., this being the maximum recommended.

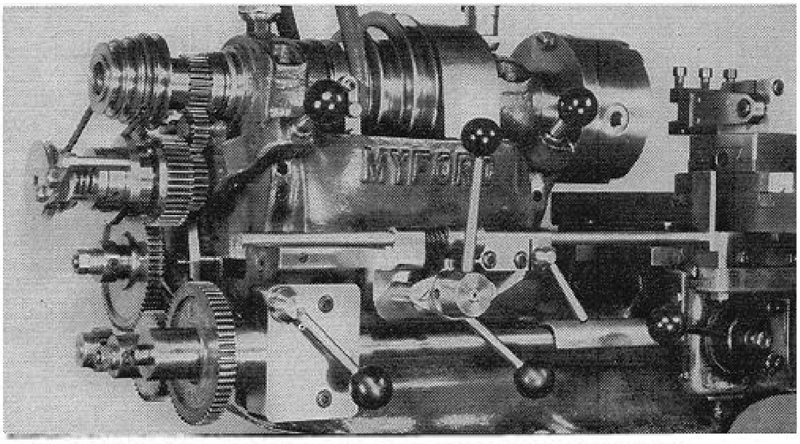
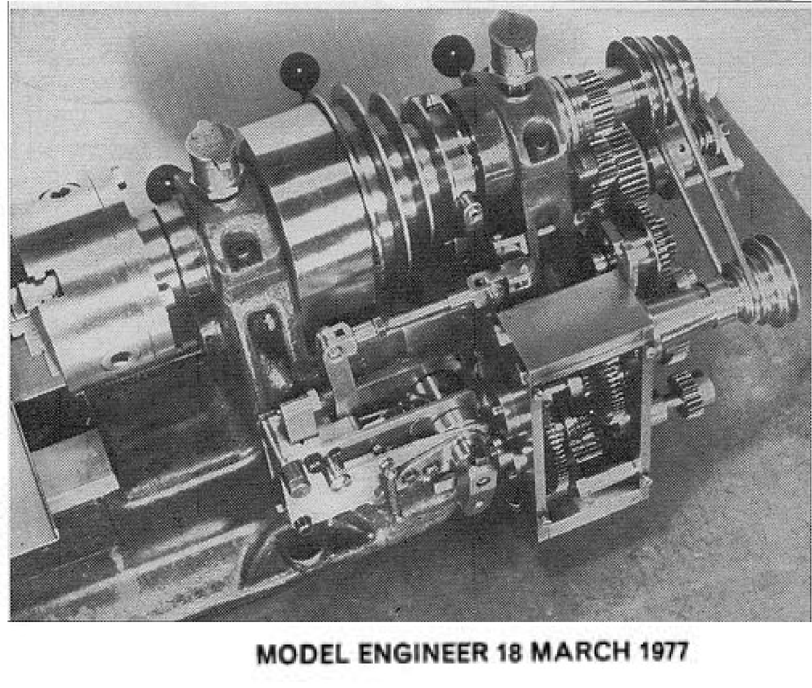


Fig. 2. The dog-clutch can be seen fitted to an extended tumbler-reverse output spigot, operated by rod passing through centre of spigot and coupled by levers to a snap release mechanism at rear.

For my own conversion to single-tooth dog-clutch control for screwcutting, limitations of space made it necessary to fit the dog-clutch to an extended tumbler-reverse output spigot, as you can see in Fig. 2. The clutch is engaged by means of a pull rod running through the centre of the spigot, and is locked in the engaged position by means of an over-centre-lever mechanism at the rear of the headstock. When this mechanism (Fig. 3) is released, either by carriage traverse or by operating the hand control lever, a powerful spring disengages the dogs: this ensures that threading passes are arrested repeatedly within 0.001 in. (0.025 mm.), consequently it is not necessary to pre-machine a run-out recess, this is progressively shaped by the threading tool and takes the form of

Fig. 3. Below: Rear of headstock of ML7 lathe. Mechanism at left is associated with instant runout stop when screwcutting. The gearbox contains a 1:10 reduction for slow feeds.



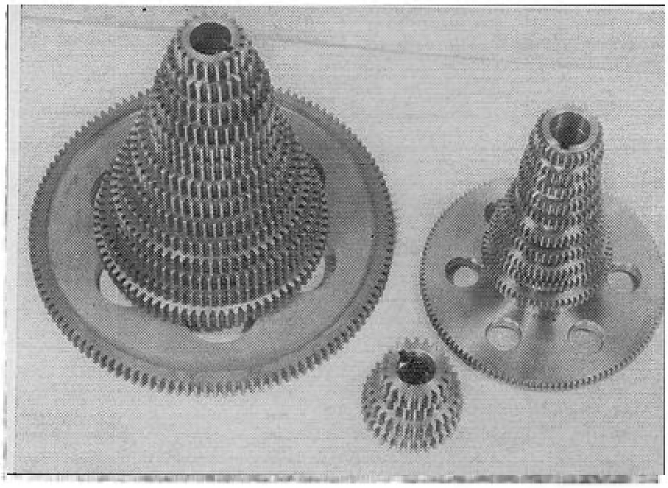


Fig. 4. Set of Myford gears on left, set of gears of reduced d.p. on right. 127 wheels at base of each.

an annular groove with a section corresponding to that of the thread being cut.

Having the dog-clutch on the tumbler-reverse spigot necessitated using a permanent 40 t. first gear driver (an additional 40/20 cluster gives a 20 first driver when needed), but this is no disadvantage because it is used only for screwcutting gear trains, slow self-act feeds being taken from an independent reduction gearbox, Fig. 3, lower right, the gearbox being driven by a light spring belt with four speed changes.

Left-hand threads are cut by starting at the chuck end and hand disengaging the dog-clutch when the tool has run clear of the component. The tool is then reset for the next cutting pass by hand turning the leadscrew until the carriage is repositioned against a left-hand dead stop. Repositioning the carriage by rack and pinion is not possible for left-hand threads unless the lathe is run backwards and the thread is cut by traversing from right to left.

Multiple-start Threads

It is interesting to note that if when repositioning the carriage by rack and pinion traverse, a "wrong" position is chosen for re-engaging the half-nuts, multiple start threads can be cut, the starts being automatically indexed.

Suppose for example the lathe is set to cut a lead of 4 t.p.i. with a leadscrew of 8 t.p.i., i.e. 4 work thread turns (w.t.) to 8 leadscrew threads (l.s.t.). Ordinarily, to cut a lead of 4 t.p.i., and to reposition the carriage by rack and pinion, the requirement would be to traverse to the right

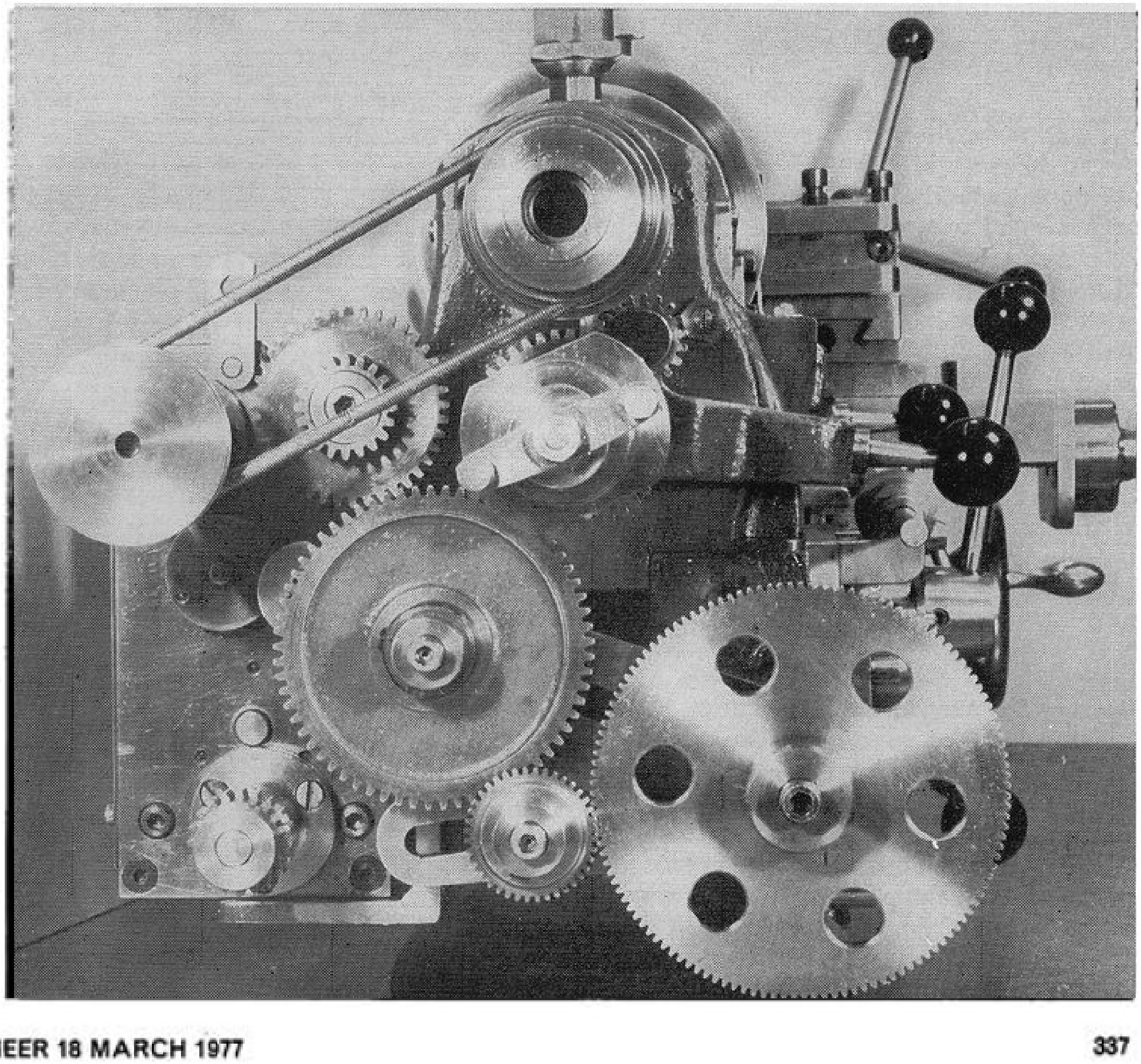


Fig. 5. This view shows a 127T "translation" gear of reduced pitch. Here the quadrant is set to cut a 2 mm. pitch with gearing 40–65–20 40–127. The 40–127 wheels are 30 d.p.

through 2, 4, 6, 8 etc. leadscrew threads according to the length of the component to be threaded, the minimum relationship between the component threads and leadscrew being 2 l.s.t. to 1 w.t. So, if for example for a single lead 4 t.p.i. the component length plus starting clearance could be covered by a right traverse of 1 in. (8 l.s.t.) but the carriage is nevertheless set at 9 leadscrew threads distance from the run-out groove, these 9 leadscrew threads would be equal to 4½ lead turns on the component, but as the single tooth dog-clutch cannot recognise, or pick up half a lead turn on a component, what happens is this: the first cutting pass cuts a 4 t.p.i. lead, but after rack and pinion traversing to the right through 9 leadscrew threads (1⅛ in.) and re-engaging the half-nuts, on taking the second cutting pass, a second 4 t.p.i. lead will be cut 180 deg. out of phase with the first lead, i.e. the threads are formed exactly mid-way between those first cut. At the third cutting pass the first helix is deepened, and at the fourth cutting pass the second helix is deepened and so on until both starts are fully formed. Cutting passes can be initiated at any convenient instant and it makes no difference how many revolutions the component may make between cutting passes, the starts are always cut in strict order. If four starts are being cut the starts are cut 1-2-3-4, 1-2-3-4 until completion and without any further special intervention by the operator.

This approach to the machining of multi-start threads shows a pronounced difference to the more orthodox method of fully forming one of the starts before indexing and commencing on the next start —or series of starts if there are more than two. Moreover, the automatic indexing just described greatly facilitates the threading of multiple start nuts, because although it is easy enough to check an external thread for finish size, there is no ready means for checking an internal thread until all starts have been completed (or are thought to have been completed) and if then a screw gauge will not enter, which of the starts is too tight? There is no way of telling, and each start would have to be carefully re-indexed and shaved until a fit is obtained—and in re-shaving all starts, a start that may not have needed enlarging may be cut oversize.

Gearing for Metric Threads

The subject of gearing an English leadscrew to cut metric threads was touched upon briefly in a previous article. Inasmuch as there are 2.54 cm. to 1 in., the threads per inch that a lathe is geared to cut can be converted into "threads per centimetre" by the introduction of additional gearing in the ratio 1:2.54, i.e. 100:254 with the elimination of the decimal point, or 50:127 when reduced to lowest terms, 127 being a prime number. The

No.	BASIC TRANSLATION RATIO	EXAMPLES OF BASIC USABLE FORM	TRANSLATION ERROR ASSUMING A PERFECT LEADSCREW	ERROR PLUS OR MINUS
1	50:127	——	NIL	——
2	63:160	$\frac{3\times21}{4\times40}$ or $\frac{7\times9}{8\times20}$	1 in 8000	+
3	215:546	$\frac{5\times43}{13\times42}$ or $\frac{5\times43}{14\times39}$	1 in 5460	+
4	37:94	$\frac{1\times37}{2\times47}$	1 in 4700	−
5	13:33	$\frac{1\times13}{3\times11}$ or $\frac{1\times65}{3\times55}$	1 in 1650	+
6	24:61	$\frac{3\times40}{5\times61}$	1 in 1525	−
7	59:150	$\frac{1\times59}{3\times50}$	1 in 1071	−
8	80:203	$\frac{8\times10}{7\times29}$	1 in 1016	+
9	28:71	$\frac{4\times35}{5\times71}$	1 in 590	+
10	11:28	$\frac{1\times55}{4\times35}$	1 in 466	−
11	15:38	$\frac{1\times30}{2\times38}$	1 in 380	+

FIG. 6 EXAMPLES OF TRANSLATION GEARING FOR CUTTING METRIC THREADS WITH AN ENGLISH LEADSCREW (& VICE VERSA)
WHEN INVERTED FOR GEARING A METRIC LEADSCREW TO CUT ENGLISH THREADS THE ERRORS ARE REVERSED I.E. + TO − & − TO +
SEE ALSO TEXT

ratio 50:127 is sometimes referred to as "translation gearing" because it translates from English to metric standards (and sometimes vice-versa when inverted). That the 50 of the 50:127 gearing does not always appear in gear trains is explained by the fact that the 50 wheel often cancels with other wheels in the gearing when this is being arranged in its most convenient form for setting on a quadrant.

Although Myford can supply a 127 wheel, it has a pitch diameter of 6.35 in. which makes it inconveniently large for incorporation in most gear trains, so with this point in mind, and in view of the theoretical 100% accuracy of translation obtainable from a 127 wheel, I made one in No. 30 DP which with teeth ⅔ the size of the Myford standard has a pitch diameter of only 4.23 in., and this (Fig. 4) together with a set of similar driving gears of corresponding pitch can be "mixed" with standard change gears to give all necessary gear trains for metric pitches. An example of this gearing in use may be seen in Fig. 5 where it was convenient to use wheels:

$$\begin{array}{l}40-65-20\\ \qquad\quad 40-127\end{array}$$

for cutting a thread of 2.0 mm. pitch, the last

40 – 127 wheels being of reduced DP. The 65 between the first 40 and 20 is an idle gear that happened to comfortably bridge the gap. "Idle" gears (sometimes shown as "A" for "Any") play no part in the ratio.

Although the 127 wheel will offer extremely accurate translation ratios, the ultimate pitch obtained cannot be more accurate than the lead of the leadscrew on any particular lathe, so more convenient though slightly less accurate translation gearing is often used. Some of these ratios were given in a previous article. The Table Fig. 6 includes some more, shown in descending order of accuracy. Ratio No. 5 is used with Myford quick-change gearboxes when metric pitches are required.

Although No. 3 translation ratio appears to be too complicated to be of practical use, I do in fact use it when gearing a leadscrew of 3.5 mm. pitch for cutting t.p.i. because the whole formula cancels to

$$\frac{\text{Driving gears}}{\text{Driven gears}} = \frac{8}{\text{t.p.i.}} \times \frac{39}{43}$$

Thus for instance, to cut 16 t.p.i. the gearing becomes

20 – A – 43
39 – 40 (leadscrew gear)

and quite a range of t.p.i. can be geared by merely changing the leadscrew gear, using a wheel with the same number of teeth as would be used if the leadscrew was of 8 t.p.i. With the inverted No. 3 translation ratio the error becomes *minus* 1 thou. in. in about 5 7/16 in.—or 1.0 mm. in 5460 mm., whichever way you like to look at it, assuming a perfect leadscrew, which is doubtful.

However, nowadays I only use translation gearing when I want to cut one or two screws of opposite language to that of the leadscrew that happens to be in place at the time.

If a number of screws have to be made I change the leadscrew to the appropriate language so that I can always reset the carriage by rack and pinion. Indeed I sometimes attach a cord and counterweight to the carriage so that this resets itself as soon as the half-nuts are disengaged. It all saves time!