MACHINERY'S REFERENCE SERIES

EACH NUMBER IS ONE UNIT IN A COMPLETE LIBRARY OF MACHINE DESIGN AND SHOP PRACTICE REVISED AND REPUBLISHED FROM MACHINERY

No. 32

SCREW THREAD CUTTING

CONTENTS

49-55 Lafayette Street, New York City.
Worth Street Subway Station.

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INTRODUCTION.*

The terms pitch and lead of screw threads are often confused, and particularly in the case of multiple threaded screws does this confusion cause difficulties. Before we therefore enter upon the subject of figuring change gears for the lathe for cutting screw threads, it may be well to make clear the real meaning of the words "pitch" and "lead" and their relation to the number of threads per inch.

The *pitch* of a screw thread is the distance from the top of one thread to the top of the next, as shown in Fig. 1. No matter whether the screw has single, double, triple, or quadruple thread, the pitch is always the distance from the top of one thread to the top of the next. Often, though improperly, the word "pitch" is used in the shop to denote "number of threads per inch." We hear of screws having 12 pitch thread, 16 pitch thread, etc. This is not correct usage of the word pitch, and only tends to cause unnecessary confusion.

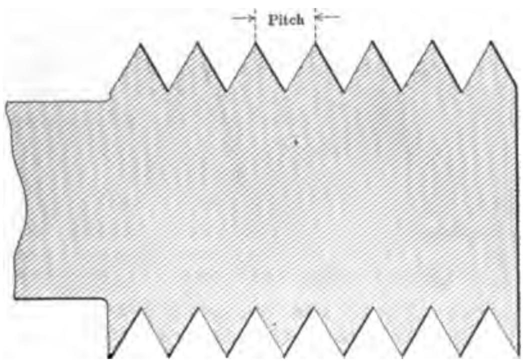

Fig. 1. The Pitch of a Screw Thread.

The *lead* of a screw thread is the distance the screw will move forward in a nut if turned around one full revolution. It is clear that for a single-threaded screw the pitch and the lead are equal, as the screw would then move forward the distance from one thread to the next if turned around once. In a double-threaded screw, however, the screw will move forward two threads, or twice the pitch, so that in a double-threaded screw the lead equals twice the pitch. In a triple-threaded screw the lead equals three times the pitch, and so forth.

The lead may also be expressed as being the distance from center to center of the *same* thread, after this thread has made one turn around the screw. In the single-threaded screw the *same* thread is the next thread to the one first considered. In a double-threaded screw there are two threads running side by side around the screw, so that

* The present introduction, and part of Chaper I, has been reprinted in this book from No. 18 of MACHINERY's Reference Series, entitled "Shop Arithmetic for the Machinist," because it has been considered that any treatise on screw thread cutting would be incomplete without a thorough treatment on the subject of lead, pitch, and change gearing.

the *same* thread here is the second one from the one first considered. In a triple-threaded screw it is the third one, in a quadruple-threaded, the fourth, and so forth. However we consider this, we still see that the lead and pitch are alike for a single-threaded screw, that the lead is twice the pitch for a double-threaded, and three times for a triple-threaded, as already stated. The actual relationship is very plainly shown in Fig. 2, where parts of three screws with Acme threads are shown, the first single-threaded, the second double-threaded, and the last triple-threaded.

The main point to remember, however, is that in *any kind of a screw, the lead is the distance which the screw will move forward in a nut if turned around one revolution.*

In this connection it may be appropriate to give the rules and formulas for the relation between the lead and the number of threads per inch. If there are 8 threads, single, in one inch, the lead is

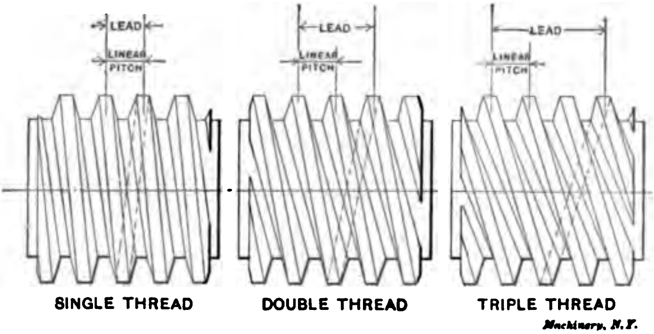

Fig. 2. Comparison between Single, Double and Triple Threads.

evidently ⅛ inch. This we find, mathematically, by dividing *one* by 8, which is the number of threads per inch. The formula, therefore, is

$$\text{lead} = \frac{1}{\text{number of threads per inch}}$$

This formula, expressed in words, says: *The lead of a screw equals one divided by the number of threads per inch.*

Confusion is often caused by indefinite designation of multiple thread screws. The most common way to state the lead and the class of thread is perhaps to say ¼ *inch lead, double,* which means a screw with a double thread, which, when cut, has the lathe geared for four threads per inch, but each thread is cut only to a depth corresponding to eight threads per inch. The same condition is also expressed by: *4 threads per inch, double.* These two ways of expressing the number of multiple threads are both correct, but the expression which ought to be used in order to avoid misunderstanding under any circumstances would be: ¼ *lead,* ⅛ *pitch, double thread.*

CHAPTER I.

CHANGE GEARS FOR THREAD CUTTING.

While the principles and rules governing the calculation of change gears are very simple, they, of course, presuppose some fundamental knowledge of the use of common fractions. If such knowledge is at hand, the subject of figuring change gears, if once thoroughly understood, can hardly ever be forgotten. It should be impressed upon the minds of all who have found difficulties with this subject that the matter is not approached in a logical manner, and is usually grasped by the memory rather than by the intellect. Before attempting to lay down any definite rules for the figuring of change gears, let us therefore analyze the subject. The lead-screw *B* of the lathe (see Fig. 3) must be recognized as our first factor, and the spindle as the second. If the lead-screw has six threads per inch, then, if the lead-screw makes six revolutions, the carriage travels one inch, and the thread-cutting tool travels one inch along the piece to be threaded. If the spindle makes the same number of revolutions in a given time as the lead-screw, it is clear the tool will cut six threads per inch. In such a case the gear *D* on the spindle stud *J*, and gear *E* on the lead-screw, are alike. If the spindle makes twice the number of revolutions of the lead-screw, the spindle revolves twelve times while the tool moves one inch, and consequently twelve threads per inch will be cut. But in order to make the spindle revolve twice as fast as the lead-screw, it is necessary that a gear be put on the spindle stud of only half the number of teeth of the gear on the lead-screw, so that when the lead-screw revolves once the spindle stud gear makes two revolutions.

Simple Gearing.

Suppose we wish to cut nine threads per inch with a lead-screw of six threads per inch, as referred to above. Then the six threads of the lead-screw correspond to nine threads on the piece to be threaded, which is the same as to say that six revolutions of the lead-screw correspond to nine revolutions of the spindle; or in other words, one revolution of the lead-screw corresponds to 1½ of the spindle. From this it is evident that the gear on the lead-screw must make only one revolution while the spindle stud gear makes 1½. Thus, if the lead-screw gear has, for instance, 36 teeth, the gear on the spindle stud should have only 24; the smaller gear, of course, revolving faster than the larger. If we express what has been previously said in a formula we have:

$$\frac{\text{threads per inch of lead-screw}}{\text{threads per inch to be cut}} = \frac{\text{teeth in gear on spindle stud}}{\text{teeth in gear on lead-screw}}$$

Applying this to the case above, we have:

$$\frac{6}{9}=\frac{24}{36}$$

The values 24 and 36 are obtained by multiplying 6 and 9, respectively, by 4. By multiplying both the numerator and the denominator by the same number, we do not change the proportion. As a general rule we may then say that the change gears necessary to cut a certain number of threads per inch are found by placing the number of threads in the lead-screw in the numerator, the number of threads to be cut in the denominator, and then multiply numerator as well as denominator by the *same* number, by trial, until two gears are obtained, the number of teeth of which are both to be found in the set of gears accompanying the lathe. The gear with the number of teeth designated by the new numerator is to be placed on the spindle stud (at *J*, Fig. 3), and

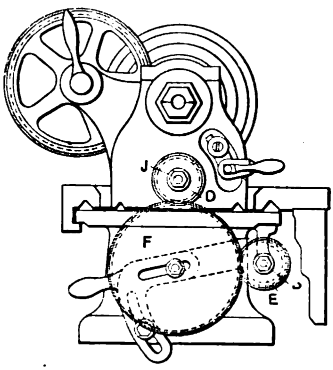

Fig. 3. Simple Gearing.

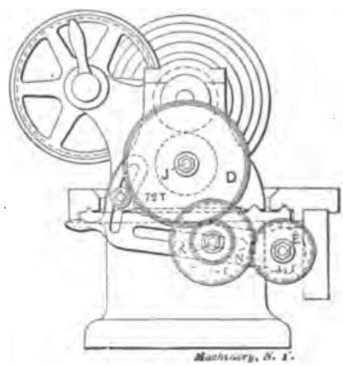

Fig. 4. Compound Gearing.

the gear with the number of teeth corresponding to the denominator on the lead-screw *B*.

A few examples of this will more clearly explain the rule. Suppose the number of teeth of the change gears of a lathe are 24, 28, 32, 36, and so forth, increasing by 4 teeth up to 100. Assume that the lead-screw is provided with 6 threads per inch, and that 10 threads per inch are to be cut. Then,

$$\frac{6}{10}=\frac{6\times 4}{10\times 4}=\frac{24}{40}$$

By multiplying both numerator and denominator by 4, we obtain two available gears with 24 and 40 teeth, respectively. The 24-tooth gear goes on the spindle stud, and the 40-tooth gear on the lead-screw. Assuming the same lathe and gears, let us find the gears for cutting 11½ threads per inch, this being the standard number of threads for certain sizes of pipe thread. Then,

$$\frac{6}{11\frac{1}{2}}=\frac{6\times 8}{11\frac{1}{2}\times 8}=\frac{48}{92}$$

It will be found that multiplying with any other number than eight would, in this case, not have given us gears with such number of teeth as we have in our set with this lathe. Until getting accustomed to figuring of this kind, we can, of course, only by trial find out the correct number by which to multiply numerator and denominator. The number of teeth in the *intermediate* gear *F*, Fig. 3, which meshes with both the spindle stud gear and the lead-screw gear is of no consequence.

Lathes with Reduction Gearing in Head-Stock.

In some lathes, however, there is a reduction gearing in the head-stock of the lathe, so that if equal gears are placed on the lead-screw and the spindle stud, the spindle does not make the same number of revolutions as the lead-screw, but a greater number. Usually in such lathes the ratio of the gearing in the head-stock is 2 to 1, so that with equal gears the spindle makes two revolutions to one of the lead-screw. This is particularly common in lathes intended for cutting fine pitches or, in general, in small lathes. When figuring the gears this must, of course, be taken into consideration. As the spindle makes twice as many revolutions as the lead-screw with equal gears, if the ratio of the gears be 2 to 1, that means that if the head-stock gearing were eliminated, and the lead-screw instead had twice the number of threads per inch as it has, with equal gears the spindle would still revolve the same as before for each inch of travel along the piece to be threaded. In other words, the gearing in the head stock may be *disregarded, if the number of threads of the lead-screw is multiplied by the ratio of this gearing.* Suppose, for instance, that in a lathe the lead-screw has eight threads per inch, that the lathe is geared in the head-stock with a ratio of 2 to 1, and that 20 threads are to be cut. Then

$$\frac{2 \times 8}{20} = \frac{16}{20} = \frac{16 \times 4}{20 \times 4} = \frac{64}{80}$$

which two last values signify the number of teeth in the gears to use.

Sometimes the ratio of the gearing in the head-stock cannot be determined by counting the teeth in the gears, because the gears are so placed that they cannot be plainly seen. In such a case, equal gears are placed on the lead-screw and the spindle stud, and a thread cut on a piece in the lathe. The number of threads per inch of this piece should be used for the numerator in our calculations instead of the actual number of threads of the lead-screw. The ratio of the gearing in the head-stock is equal to the ratio between the number of threads cut on the piece in the lathe and the actual number of threads per inch of the lead-screw.

Compound Gearing.

The cases with only two gears in a train referred to are termed simple gearing. Sometimes it is not possible to obtain the correct ratio excepting by introducing two more gears in the train, which, as is well known to mechanics, is termed compound gearing. This class of gearing is shown in Fig. 4. The rules for figuring compound gearing are exactly the same as for simple gearing excepting that we must divide both our numerator and denominator into two factors, each of which are multiplied with the same number in order to obtain the change gears.

Suppose a lathe has a lead-screw with six threads per inch, and that the number of the teeth in the gears available are 30, 35, 40, and so forth, increasing by 5 up to 100. Assume that it is desired to cut 24 threads per inch. We have then,

$$\frac{6}{24} = \text{ratio.}$$

By dividing up the numerator and denominator in factors, and multiplying *each pair of factors by the same number*, we find the gears:

$$\frac{6}{24} = \frac{2 \times 3}{4 \times 6} = \frac{(2 \times 20) \times (3 \times 10)}{(4 \times 20) \times (6 \times 10)} = \frac{40 \times 30}{80 \times 60}$$

The last four numbers indicate the gears which should be used. The upper two, 40 and 30, are driving gears, the lower two, with 80 and 60 teeth, are driven gears. Driving gears are, of course, the gear *D*, Fig. 4, on the spindle stud, and the gear *P* on the intermediate stud *K*, meshing with the lead-screw gear. Driven gears are the lead-screw gear, *E*, and the gear *N* on the intermediate stud meshing with the spindle stud gear. It makes no difference which of the driving gears is placed on the spindle stud, or which of the driven is placed on the lead-screw.

Suppose, for a final example that we wish to cut 1¾ threads per inch on a lathe with a lead-screw having six threads per inch, and that the gears run from 24 and up to 100 teeth, increasing by 4. Proceeding as before, we have

$$\frac{6}{1\frac{3}{4}} = \frac{2 \times 3}{1 \times 1\frac{3}{4}} = \frac{(2 \times 36) \times (3 \times 16)}{(1 \times 36) \times (1\frac{3}{4} \times 16)} = \frac{72 \times 48}{36 \times 28}$$

This is the case directly illustrated in Fig. 4. The gear with 72 teeth is placed on the spindle stud *J*, the one with 48 on the intermediate stud *K*, meshing with the lead-screw gear. These two gears (72- and 48-teeth) are the *driving* gears. The gears with 36 and 28 teeth are placed on the lead-screw, and on the intermediate stud, as shown, and are the *driven* gears.

Fractional Threads.

Sometimes the lead of the thread is expressed by a fraction of an inch instead of stating the number of threads per inch. For instance, a thread may be required to be cut having a ⅝-inch lead. In such a case the expression "⅝-inch lead" should first be transformed to "number of threads per inch," after which we can proceed in the same way as has already been explained. To find how many threads per inch there is when the lead is stated, we simply find how many times the lead is contained in one inch, or, in other words, we divide *one* by the given lead. Thus *one* divided by ⅜ gives us 2 2/3, which is the number of threads per inch of a thread having ⅜-inch lead. To find change gears to cut such a thread we would proceed as follows:

Assume that the lead-screw has 6 threads per inch, and that the change gears run from 24 up to 100 teeth, increasing by 4. Proceeding to find the gears as before, we have:

$$\frac{6}{2\frac{2}{3}} = \frac{2 \times 3}{1 \times 2\frac{2}{3}} = \frac{(2 \times 36) \times (3 \times 24)}{(1 \times 36) \times (2\frac{2}{3} \times 24)} = \frac{72 \times 72}{36 \times 64}.$$

The rule for finding the number of threads per inch, when the lead is given, may be expressed by the formula:

$$\text{number of threads per inch} = \frac{1}{\text{lead of thread}}$$

which is simply a reversal of the formula given on page 4.

Rules for Selecting Change Gears.

What has been said in the foregoing in regard to the figuring of change gears for the lathe may be summed up in the following rules:

1. To find the number of threads per inch, if the lead of a thread is given, *divide one by the lead.*

2. To find the change gears used in simple gearing, when the number of threads per inch on the lead-screw, and the number of threads per inch to be cut are given, *place the number of threads on the lead-screw as numerator and the number of threads to be cut as denominator in a fraction, and multiply numerator and denominator with the same number until a new fraction results representing suitable number of teeth for the change gears.* In the new fraction, the numerator represents the number of teeth in the gear on the spindle stud, and the denominator, the number of teeth in the gear on the lead-screw.

3. To find the change gears used in compound gearing, *place the number of threads per inch on the lead-screw as numerator, and the number of threads per inch to be cut as denominator in a fraction, divide up both numerator and denominator in two factors each, and multiply each pair of factors* (one factor in the numerator and one in the denominator making "a pair") *by the same number, until new fractions result representing suitable number of teeth for the change gears.* The gears represented by the numbers in the new numerators are driving gears, and those in the denominators are driven gears.

Cutting Metric Threads with an English Lead-Screw.

It very often happens that screws or taps having threads cut according to the metric system are required. The lead of these screws is expressed in millimeters. Thus, instead of saying that a screw has so many threads per inch, it is said that the screw has so many millimeters lead. Suppose, for example, that we have a lathe having a lead-screw with 6 threads per inch, and that a screw with 3 millimeters lead is required to be cut. We can find the change gears to be used in the same manner as has been previously explained for screws cut according to the English system, if we only first find out *how many threads per inch we will have if we cut a screw with a certain lead given in millimeters.* Thus, in this case, we must find out how many threads there will be in one inch, if we cut a screw with a 3 millimeters lead. There are 25.4 millimeters to one inch, so that, if we find out how many times 3 is contained in 25.4, we evidently get the number of threads in one inch. To find out how many times 3 is contained in 25.4, we divide 25.4 by 3. Then we get as a result the number of threads per inch. It is not necessary to carry out the division; simply write it as a fraction in the form $\frac{25.4}{3}$, which implies that 25.4 is to be divided by 3. This fraction is the number of threads per inch to be cut. We now proceed exactly as if we had to do only with English threads. We place the number of the threads on the lead-screw in the lathe as the numerator in a fraction, and the number of threads to be cut, which number is expressed by the fraction $\frac{25.4}{3}$, as the denominator. Then we have

$$\frac{6}{\frac{25.4}{3}}$$

This seems very complicated, but as we remember that the line between the numerator and denominator in a fraction really means that we are to divide the numerator by the denominator, then if we carry out this division we get

$$6 \div \frac{25.4}{3} = \frac{6 \times 3}{25.4} = \frac{18}{25.4}$$

If we now proceed as in the case of figuring change gears for any number of threads per inch we multiply numerator and denominator by the *same* number, until we find suitable numbers of teeth for our gears. In the case above we can find by trial that the first number by which we can multiply 25.4 so that we get a whole number as the result is 5. Multiplying 25.4 by 5 gives us 127. This means that we must have one gear with 127 teeth, whenever we cut metric threads by means of an English lead-screw. The gear to mesh with the 127 teeth gear in this case has 90 teeth, because 5 times 18 equals 90.

If we summarize what we have just said in rules, we would express them as follows:

1. To find the number of threads per inch, when the lead is given in millimeters, *divide 25.4 by the number of millimeters in the given lead.*

2. To find the change gears for cutting metric threads with an English lead-screw, *place the number of threads per inch in the lead-screw multiplied by the number of millimeters in the lead of the thread to*

be cut as the numerator of a fraction, and 25.4 as the denominator, and multiply numerator and denominator with 5. The numerator and denominator of the new fraction are the gears to be used. These same rules expressed in formulas would be

$$\text{number of threads per inch} = \frac{25.4}{\text{lead in millimeters}}$$

and

$$\frac{\text{number of threads per inch in lead-screw} \times \text{lead in millimeters of screw to be cut} \times 5}{25.4 \times 5} = \frac{\text{gear on spindle stud}}{\text{gear on lead-screw}}$$

Of course, it is sometimes necessary to compound the gears, because the gear on the spindle stud would otherwise get too many teeth, that is, it would be too large. Suppose, for an example, that we wish to cut a screw having 6 millimeters lead on a lathe having a lead-screw with 8 threads per inch. According to our rule and formula the gear

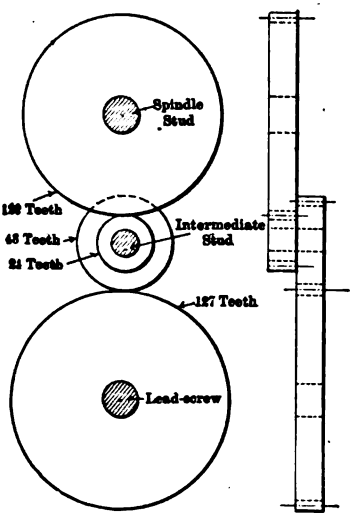

Fig. 5. Example of Gearing for Cutting Metric Thread with English Lead-Screw.

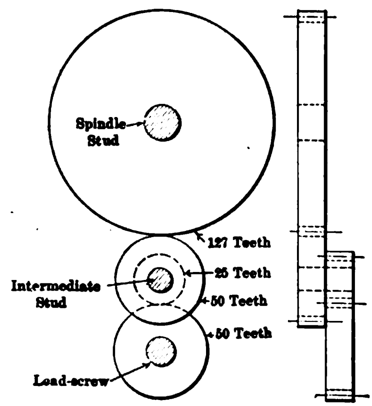

Fig. 6. Example of Gearing for Cutting English Thread with Metric Lead-Screw.

on the spindle stud would then have 8 × 6 × 5, or 240 teeth. As no lathe is provided with a change gear with so many teeth, we must use compound gearing. In this case we would proceed as follows:

$$\frac{8 \times 6 \times 5}{25.4 \times 5} = \frac{48 \times 5}{127 \times 1} = \frac{48 \times 120}{127 \times 24},$$

which is exactly the same method as has already been explained under the head of compound gearing in connection with the figuring of change gears for English screws. The method of mounting these gears is shown in the diagram, Fig. 5.

What should in particular be impressed upon the minds of the reader is that there is *no difference in method* of figuring the gears whether the thread to be cut is given in the English or in the metric system. If given in the latter system, simply transform the "lead in millimeters" to "number of threads per inch" and proceed in exactly the same way as if the thread had been given according to the English system.

The 127-teeth gear is always placed on the lead-screw when cutting metric threads with an English lead-screw.

Cutting an English Thread with a Metric Lead-Screw.

The method of figuring the change gears when an English screw is to be cut with a metric lead-screw is simply the reverse of the one already explained. We simply transform the millimeter lead of the metric lead-screw into "number of threads per inch." This we do in the same way as explained before, we divide 25.4 (which is the number of millimeters in one inch) by the number of millimeters in the lead of the metric lead-screw. After having obtained this number of threads per inch, we proceed as usual, putting the number of threads per inch of the lead-screw in the numerator, and the number of threads per inch to be cut in the denominator of a fraction, simplifying the fraction, and multiplying both numerator and denominator by 5 to get the number of teeth in the change gears.

Suppose, for example, that we wish to cut 5 threads per inch with a lead-screw having 4 millimeters lead. The number of threads per inch of the lead-screw is, then, $\frac{25.4}{4}$, and we find our gears by writing our fraction,

$$\frac{\frac{25.4}{4}}{5}$$

This fraction can be simplified by actually dividing $\frac{25.4}{4}$ by 5, in which case we get

$$\frac{25.4}{5 \times 4} \text{ as a result.}$$

Multiplying both numerator and denominator by 5 gives us then,

$$\frac{25.4 \times 5}{5 \times 4 \times 5} = \frac{127}{100}$$

which gives us the number of teeth in our change gears.

The formula expressing this calculation would take this form:

$$\frac{25.4 \times 5}{\begin{array}{c}\text{number of threads}\\ \text{per inch to be cut}\end{array} \times \begin{array}{c}\text{lead in millimeters}\\ \text{of lead-screw}\end{array} \times 5} = \frac{\text{gear on spindle stud}}{\text{gear on lead-screw}}$$

Expressed as a rule this formula would read:

To find the change gears for cutting English threads with a metric lead-screw, *place* 25.4 *as the numerator, and the threads per inch to be cut multiplied by the number of millimeters in the thread of the lead-screw in the denominator of a fraction, and multiply numerator and denominator by* 5. *The numerator and denominator of the new fraction are the change gears to be used.*

In this case too, of course, it sometimes becomes necessary to compound the gears, in order to get gears which are to be found in the set of gears provided with the lathe. Sometimes, the gears may be available, but they are so large that the capacity of the lathe does not permit them to be placed in a direct train; then, also, it becomes necessary to compound the gears. Take the case which we have already referred to, where we were to cut a screw with 5 threads per inch, using a lead-screw having 4 millimeters lead. We then obtained the gears with 127 and 100 teeth respectively. Now suppose that the lathe does not have a change gear with 100 teeth to be placed in a direct train. The gears to be used in a compound train would then have to be found as has already been described, and, as shown in the following calculation:

$$\frac{25.4 \times 5}{5 \times 4 \times 5} = \frac{127}{100} = \frac{127 \times 1}{50 \times 2} = \frac{127 \times 25}{50 \times 50}$$

The 127-teeth gear is always put on the spindle stud when cutting English screws with a metric lead-screw. A diagram of the arrangement of the gears in the last example is shown in Fig. 6.

If there is any special reduction gearing in the head of the lathe, this must of course be taken in consideration, in a manner as has already been described under the heading "Lathes with Reduction Gearing in Head-stock," on page 7.

CHAPTER II.

KINKS AND SUGGESTIONS IN THREAD CUTTING.

In the following, a number of kinks and suggestions in thread cutting have been collected and presented. These suggestions have been made from time to time by the readers of MACHINERY, and the methods outlined are in use every day in some shop or other in the country. The names of the persons who originally contributed the descriptions of the suggestions given or the devices shown, to the columns of MACHINERY, have been given in notes at the foot of the pages, together with the month and year when the article appeared.

Indicator for Thread Cutting.

When cutting a thread in a lathe, if the number of threads to the inch being cut is a multiple of the number of threads to the inch on the lead-screw, the split nut may be thrown into mesh with the lead-screw at any time, and the tool will follow the first cut. This is not the case, however, when the number of threads to the inch being cut is not a multiple of the number of threads to the inch on the lead-screw. Because of this, lathes are generally equipped with a backing belt, which is thrown in when the tool has made the desired cut, and the carriage is brought back to the starting point without having been disengaged from the lead-screw, which of course, necessarily brings the tool into the right relation with the work. This is a good arrangement for short threads, say two or three inches in length, but when they are longer, and especially when they are large in diameter (which means slower speed) the backing belt is not a very economical contrivance, because considerable time is wasted while the carriage is being moved by the lead-screw from the end of the cut back to the starting point.

Fig. 7 shows a simple device which may be attached to any lathe, and used to good advantage when cutting threads. It can be fastened to the carriage as shown in the cut, and preferably on the side next to the tail-stock, as very often there is not enough thread on the lead-screw to permit putting it on the opposite side. This indicator is used in the following manner: Start the lathe, and when one of the three points marked *A* of the triangular pointer (see plan view), is opposite the zero mark, throw the split nut into mesh with the lead-screw. After the tool has reached the end of its cut, bring the carriage back by hand to the starting point. Wait until either of the points marked *A* is again opposite the zero mark, then throw the split nut into mesh with the lead-screw as before. If this is done with each successive cut, the tool will always come right with the thread. When the pointer is a triangle as shown, the worm-wheel, which is in mesh with the lead-screw, should be so proportioned that its number of teeth is three times the threads per inch of the lead-screw. If, for example, the lead-screw has eight threads per inch, then the worm-wheel should have twenty-four teeth. Then, when either of the points marked *A* is opposite the zero mark, the lead-screw and the lathe spindle would occupy the same relative positions. The device does not work for fractional threads.* This device, it is claimed, was originated in this country thirty or thirty-five years ago by William Gleason, of

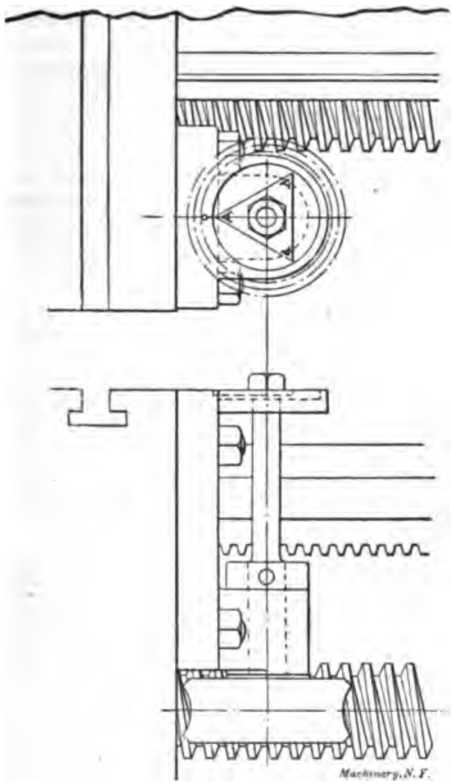

Fig. 7. Device Permitting Opening up the Lead-nut and Running Carriage back by Hand.

Rochester, N. Y. In fact, however, it is much older than that, having originally been invented in England.

Another Thread Catching Device for the Lathe.

The device shown in Fig. 8, which permits the lead-nut to be opened, and the carriage run back when cutting threads, still insuring "catching the thread," was applied to several lathes in the Worcester Polytechnic Institute some years ago by Mr. O. S. Walker of the same city. Mr. Walker states that he first saw it in the shops of the E. W. Bliss Co., Brooklyn, N. Y., nearly twenty-seven years ago.

* Franklin D. Jones, Brooklyn, N. Y., October, 1907.

The lathes to which this device was applied had the lead-screw at the back, which explains the peculiar engraving. *A* is a casting bolted to the back of the carriage and supporting the split nut indicated by the dotted lines at *C C*. At the left of and supported by *A* is a vertical spindle carrying on its upper end the worm-wheel *E*, engaged with the lead-screw, and at the lower end the disk *D*. The worm-wheel should either have as many teeth as there are threads per inch in the lead-screw *S*, or a number of teeth which is some multiple of the number of threads per inch.

The disk *D* has equidistant slots milled across its periphery, the number of slots being as many as the number of teeth in the worm-wheel is times the number of threads per inch of the lead-screw. In this instance, the lead-screw has six threads per inch, the worm-wheel has thirty-six teeth, and there are six slots milled in the periphery of *D*. Fastened to the lower side of the lower half-nut is the latch *F*, which engages with one of the slots or notches in *D* when the split

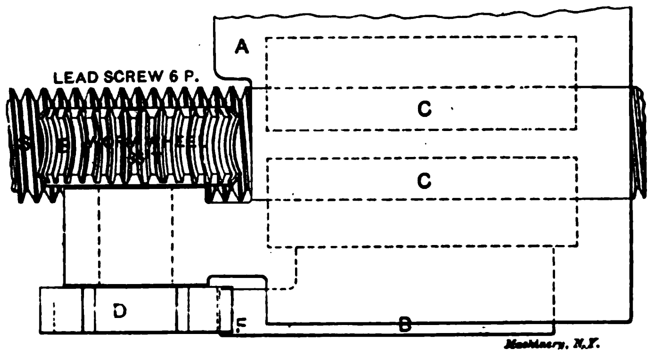

Fig. 8. Another Device of the Same Principle as that in Fig. 7.

nut is closed. It is thus evident that when the split nut has been disengaged from the lead-screw and the carriage run back for a fresh cut, the lead-screw cannot again be engaged until the worm-wheel turns into position for one of the slots to correspond with the latch *F*. The latch being engaged, the worm-wheel ceases to turn, acting then as a sort of half nut on the screw. Therefore the lead-screw can only be engaged at even inches of its length and necessarily the thread-cutting tool must engage with the thread already started when this has a whole number of threads per inch; but on fractional threads, the device fails as constructed. However, by having three slots in the disk *D*, instead of six, fractional threads having one-half for the fraction could be caught and with only one slot in the disk, fractional threads including one-half, one-third, one-sixth, two-thirds and five-sixths could be caught, but under these conditions the time required to bring the notch around so that the latch *F* could be engaged would usually be nearly equal to that required to reverse and run the carriage back, especially on short work.*

* H. P. Fairfield, Worcester, Mass., February, 1901.

Combination Threading Tool.

Thread-tool holders have always been of considerable interest to toolmakers and others required to produce accurate threads. This interest is largely due to the difficulty of producing a thread-tool holder which fills all the requirements placed on such a tool.

Fig. 9 shows a combination spring and solid threading tool especially useful for working on tool steel. It is made high enough so as to rest on the carriage instead of on the rocker of the tool-post; therefore the tool is always parallel. The cutters are easily and quickly made and may be quickly changed in the holder. They may be easily set, by

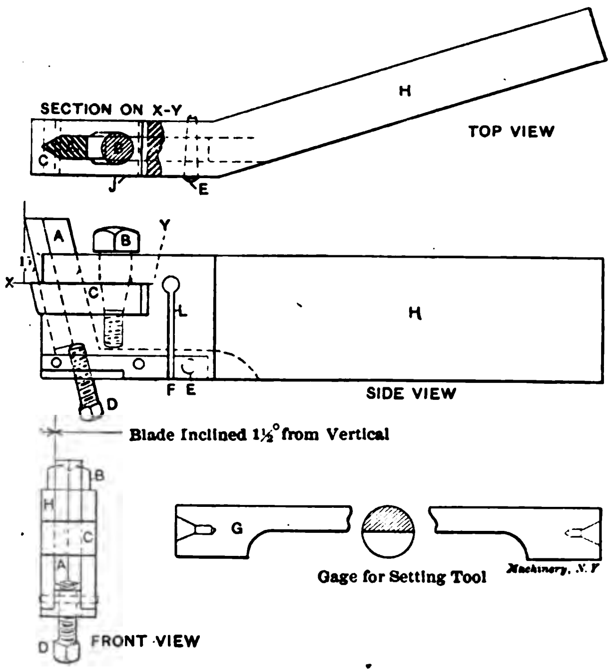

Fig. 9. Special Spring Threading Tool Holder.

bringing the face of the holder at *J* parallel to the face-plate and raising the cutter to the center line with the set-screw *D*. The gage shown at *G*, which consists of a smooth piece of round stock centered at the ends and milled out to the center line for a short distance, furnishes a convenient means for locating the top of the cutter at the proper height.

The construction of the tool will be readily understood. A slot is milled out on the front end of holder *H* at an angle of 15 degrees, to receive the blade *A*. This slot, as shown in the front view, also has an inclination of 1½ degree from the vertical to make the cutter agree with the average inclination of the thread in a U. S. standard screw. In a horizontal slot in the end of the holder is fitted the clamping yoke *C*. This has an opening in it through which the blade *A* passes, and is provided with a tapering seat for the tightening screw *B*. As this is screwed down, yoke *C* is drawn in, and the blade *A* is held firmly back against its seat. A saw cut at *F* extends nearly through the holder, thus leaving the upper end flexible to give it the effect of the well-known goose-neck tool. Through a slot in the bottom is passed a tie piece which is pinned fast to the outer division of the holder and may be, if so desired, connected with the shank by the taper pin *E*. This allows the tool to be used either as a solid or as a spring tool-holder.*

Another thread-tool holder is shown in Fig. 10. This was especially designed for the economical use of high-speed steel in thread cutting. One advantage of the holder is that cutters can be broken off from

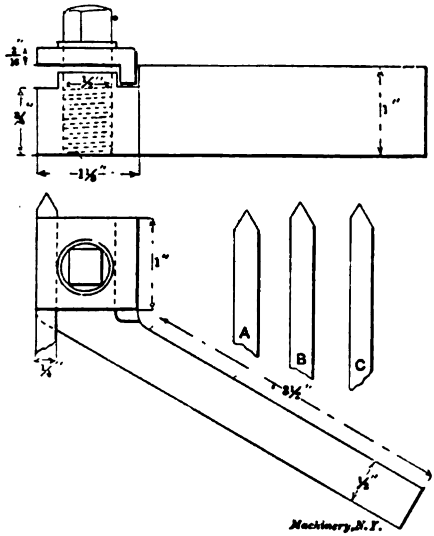

Fig. 10. Thread Tool Holder for High Speed Steel Tools.

the bar and used without further working. By grinding the cutters as indicated at *A*, *B*, and *C*, a variety of pitches can be cut close up to a shoulder.* *

Spring Holder for Threading Tools.

The thread-tool holder shown in Fig. 11 is intended for the blades or single-point cutters made by the Pratt & Whitney Co. The improvement in the design over common holders consists in the provision for permitting the tool to spring away from the work if too heavy a cut is taken. In other respects the principle of the holder is the same as that of the one manufactured by the Pratt & Whitney Co., itself, for these tools. Referring to the engraving, *A* is the body, which is slotted at *B*, proper resistance being given the tool by the set-screw *C* which has a spring at the lower end, acting upon the front part of the holder.

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* Everett Kneen, Kearny, N. J., August, 1906.

* * Stephen Courter, Paterson, N. J., August. 1908.

At *D* may be inserted a blade or key, which will keep the front part of the holder from bending to one side while cutting.

A great many designs of spring tool-holders have been tried, the one shown in Fig. 11 being comparatively common. The difficulty with holders of this kind is that it is almost impossible to adjust the screw for each particular pitch to be threaded so that the spring has the proper tension. It is evident that in cutting a coarse thread there is no need of the tool being as sensitive as when cutting a very fine thread, but there is no means for judging when in each particular case the proper springing action has been attained. Another objection to the design shown below is that it prevents a full and clear view of the thread being cut, the projecting part extending partly above the work. Of all spring thread-tool holders hitherto designed, however, this one is about as good as any. A spring tool-holder for threading

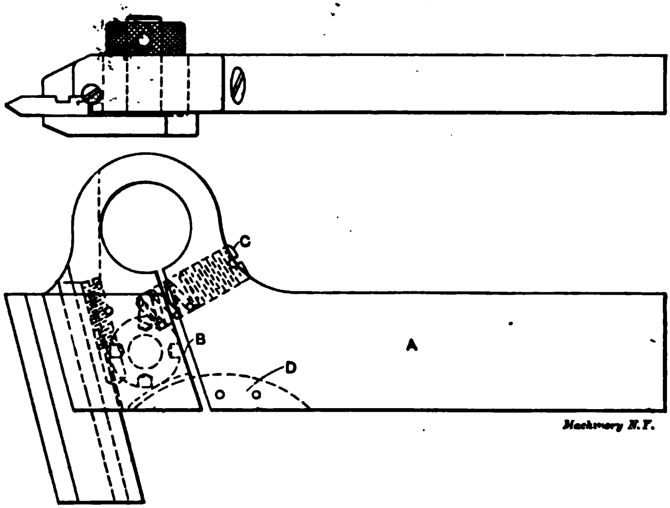


Fig. 11. Spring Holder for Threading Tools.

tools which will overcome the objections mentioned is greatly in demand, and many attempts have been made to solve the problem, but as yet none has been entirely successful.

Tool for Cutting Square Screw Threads.

In Fig. 12 is shown a tool of the chaser type for cutting square screw threads. This tool has been recently patented by Messrs. C. & G. B. Taylor, Bartholomew St., Birmingham, England. Ordinarily, square screw-thread tools, even when they have been used very little, are found to have worn to such an extent that the resulting groove is not as wide as required. It is obvious that it is impossible to regrind these tools after the sides of the cutting teeth have worn down below the required width. With the hope of overcoming this defect, the tool shown in the cut has been designed. As seen, the tool consists of two halves, *A* and *B*, each being provided with teeth which gradually cut the groove to the required depth. The required width is obtained by adjusting the relative position of th two tools *A* and *B*, so that the tool *B* widens the grooves already cut by *A*. These two tools or chasers are held in a tool-holder *E*, and the adjustment is

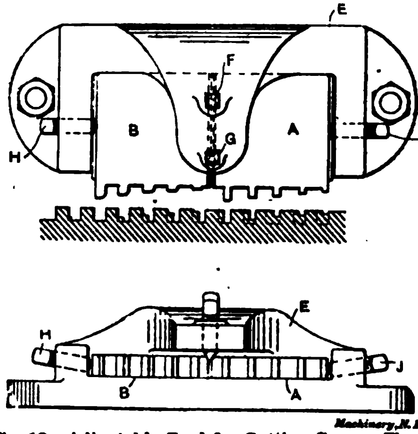


Fig. 12. Adjustable Tool for Cutting Square Threads.

effected by means of two screws *F* and *G* having conical ends, which are forced in between the tools *A* and *B*, these in turn being clamped by the screws *H* and *J*. Whether the tool will prove to possess such practical qualities as will insure for it any extensive application is

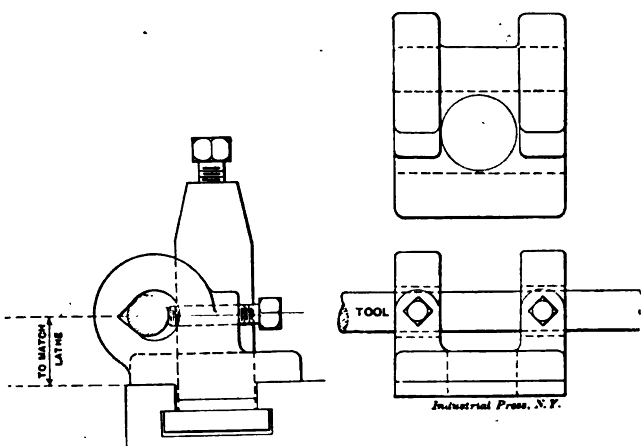


Fig 13. Internal Thread-Tool Holder.

difficult to say, but the idea is ingenious, and may be applied in other cases than that of cutting square screw threads.

Internal Threading Tool Holder.

The lathe boring and threading tool holder shown in Fig. 13 has been in use in a well-known Ohio shop, and has given very good satisfaction. It is a plain iron casting, tongued and fitted to the tool-post slide of the lathe in which it is intended to be used, and is clamped in position by inserting a piece of steel in the tool-post and secured as an ordinary tool would be clamped. The threading tool is clamped by two set-screws, and the heart-shaped holes for the tool not only accommodate different sizes of tools, but insure rigidity.

Cutting Triple Threads.

Fig. 14 illustrates an economical device for cutting triple threads. The frame *A* is bolted to the lathe carriage, and it is of such height that the center *B* is in line with the lathe centers. The cutters *C* are held in slides *D*, which slide in grooves planed in the circular part of the frame *A*. These slides are held in place by a circular plate *E*, which also serves to move the slides in and out, through the medium of the cam slots *F* acting on pins in the slides. Plate *E* is held in

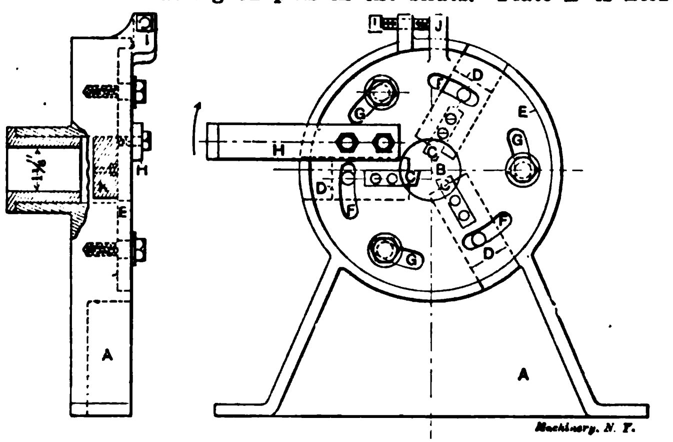


Fig. 14. Device for Cutting Triple Threads.

place by bolts in the slots *G*. A handle *H* serves to rotate plate *E*. A set-screw *I* in a lug cast on frame *A* bears against a lug *J* on plate *E* and acts as a gage to vary the depth of cut.

The tools or cutters *C* are set in the slides *D* so that the top surface is in line with the center *B*. They are fastened to the slides by screws as shown in section at *K*, and they are all set in the same plane so that each one cuts a different thread. At the head-stock end of the lathe a slide is bolted, which engages with arm *H* and throws it up in the direction of the arrow thus drawing the cutters back at the end of the cut. A removable bushing provides adjustment for cutting threads on rods of various sizes. With this device four feet of triple square thread 1⅛ inch diameter and ¾ inch lead can be cut in twenty minutes.*

Face-Plates for Cutting Multiple Threads.

The following method of cutting multiple-threaded screws of two, three, four, five, etc., threads is very simple and mechanically perfect.

* Fred Seaburg, Chicago, Ill., December, 1907.

A plain circular plate, Fig. 15, to bolt on the face-plate of the lathe, is made, and located and held in exact position with two small dowel-pins, *AA*. Then a number of circles are scored in this plate. The circle nearest the center is divided into three parts, the next one into four parts, which answers for two divisions as well, the next one into five parts, etc. Holes are drilled in the circles large enough in diameter to hold pins for driving the carrier. To use the plate for cutting

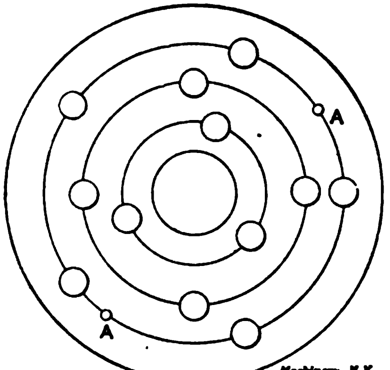


Fig. 15. Device for Facilitating the Cutting of Multiple Threads.

multiple threads, the carrier is moved from one pin to another until each thread is cut. The plate mentioned is kept specially for multiple thread cutting, and can be bolted on by bolts through the back of the face-plate.*

Fig. 16 shows another interesting development of face-plate arrangement for threading lathes, brought out by the firm of Ferdinand Pless, Fechenheim, a. M., Germany, and intended for facilitating the cutting

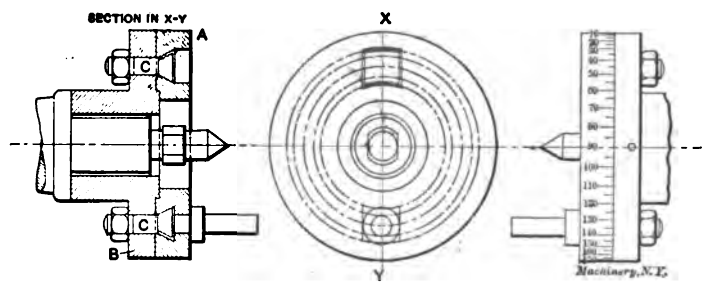


Fig. 16. Another Device for Cutting Multiple Threads

of multiple threads in the lathe. As seen from the illustration, it consists of two parts, *A* and *B*, the part *A* being free to be rotated in relation to the part *B* when the bolts *C* are loosened. The driving pin for the lathe dog is attached to the plate *A*, and in cutting multiple threads, when one thread is finished, the bolts *C* are simply loosened, and the plate *A* turned around in relation to the spindle of the machine an amount corresponding to the type of thread being cut; thus, for

* James H. Gomersall, Germantown, Pa., March, 1900.

instance, if a double thread is cut, the plate *A* is turned around one-half revolution, or 180 degrees; for triple thread, 120 degrees; for a quadruple thread, 90 degrees, etc. The periphery of plate *A* is graduated in degrees, and a zero line provided on plate *B*, so that the required setting is very easily obtained. On lathes which are con-

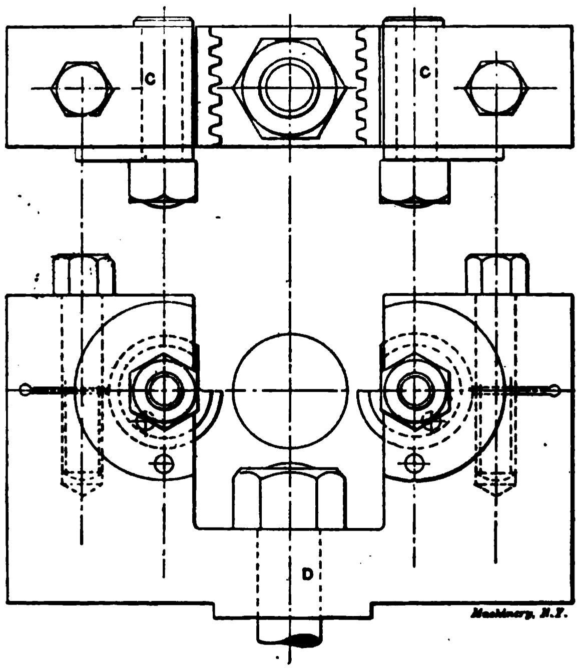


Fig. 17. Double Tool-Post with Circular Formed Thread-Tool.

stantly used for thread cutting the advantage of an arrangement of this type is very evident, as it saves employing any of the more or

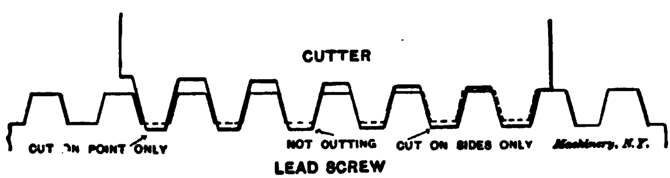


Fig. 18. Cutting Action of the Tools.

less cumbersome methods in vogue for moving the work in relation to the tool when cutting multiple threads.

Method for Cutting Lathe Lead-Screws.

The method shown in Fig. 17 may be used for cutting lathe lead screws. Two cutting tools are used, one in front, right side up, and the other at the back, also right side up, to cut on the reverse trip. The cutting tools are round, like short sections of the screw to be cut, but left-hand to cut a right-hand screw. They are cut with the thread on a taper and the outside turned straight so that the leading cutter tooth will cut to the full depth fed at each traverse, and the succeeding teeth widen the cut, only the last two usually cutting on the full side of the thread, as shown in Fig. 18. The limiting element in using this device is the torsional strength of the screw being cut. The bolts *CC* and their washers and nuts help to hold the cutters in place. Bolt *D* holds the device to the top of the cross-slide, in place of the tool-post.*

Accurate Threading of Taps and Die Hobs.

Experience in tap and die making has taught that it is one thing to make a perfect screw and quite another to make a tap which will perfectly correspond with it. It is well known that a tap shortens in hardening, this shrinkage varying somewhat with different grades of steel, so that a tap and a screw made with the same lead-screw will

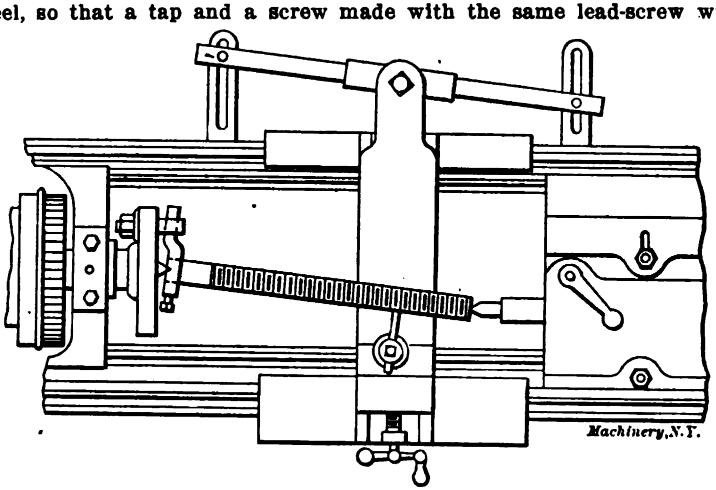


Fig 19. Arranging Lathe for Cutting Taps Long in the Lead.

not correspond in pitch. Therefore, to be accurate, allowance must be made in chasing the thread on the tap for the shrinkage that will take place in the hardening.

To carry out this idea a little further: A hob and a tap may thus be made to correspond, but after a die is hobbed and hardened it will not exactly match the hob or the tap which it is intended to suit. So we see that the hob should be made with an allowance of two shrinkages to counteract the shortening that takes place when it (the hob) is hardened and again when the die is hardened. While it is not the best policy to make taps and dies in the tool-room, it often becomes necessary to do so for sizes varying from the standard, and the problem then presents itself to cut them so as to make the proper allowance for shrinkage. The following method shows how this is accomplished in a very satisfactory manner:

The change gears of the lathe are first arranged as usual for cutting

* E. H. Fish, Worcester, Mass., October. 1906.

the required number of threads per inch. The tail-stock is then set over either way for a short distance and the taper attachment is set to correspond with the set-over of the tap. The thread is then cut as usual, the tool being set by the face of the tap. The thread cut in this way will be slightly coarser than would have been the case if the centers were in line with the axis of the lathe. The reason for this will be obvious from the cut, Fig. 19, and a little practice will enable the machinist to judge just how much the tailstock should be set over to obtain the required result. For example: If the tap is 10

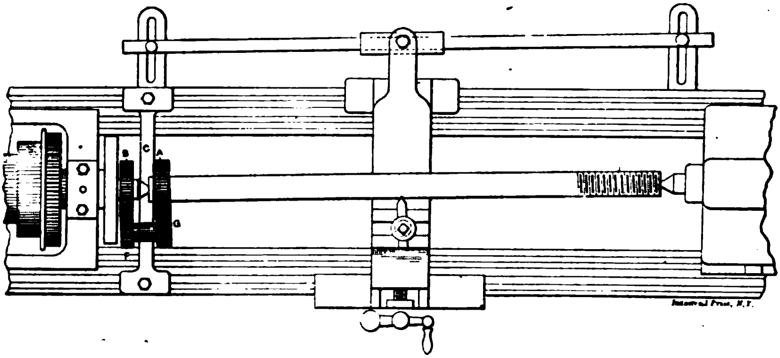


Fig. 20. Another Arrangement for Cutting Taps Long in the Lead.

inches long and is set over ½ inch, while the tool is moving the whole length of the tap, the movement of the carriage parallel to the axis of the lathe would be through a distance of but 9.987 inches, so that the thread is lengthened 0.013 inch; in other words, there are as many threads in 10 inches on the tap as would have been cut in 9.987 inches had the centers been in line with the shears.

If now in cutting this tap we were to use an ordinary dog, driven from the faceplate, it will be apparent that the result would be a

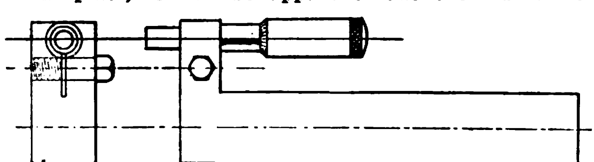


Fig. 21. Micrometer for Testing the Lead of Lead-Screws.

drunken thread, since the velocity of revolution of the tap would not be constant throughout its revolution, but would be variable; therefore a dog as shown in Fig. 19 is required to transmit a uniform motion from the spindle to the tap. One could also employ a small gear *A*, Fig. 20, mounted upon the end of the tap, and a similar gear *B* attached to the live center or to the face-plate. A fixture *C* is used for supporting a short shaft on each end of which is placed a pinion, as shown at *F* and *G*. These pinions are of the same size and engage with the gears *A* and *B*. When they are properly adjusted so as to run freely with these gears, they impart a perfectly uniform movement to the tap being chased.

Testing a Lead-Screw.

A method of testing the pitch of a lead-screw, at any position of its length, consists in procuring a micrometer screw and barrel complete, such as can be purchased from any of the manufacturers of accurate measuring instruments, and bore out a holder so that the axis of the micrometer screw will be parallel to its body when the screw is in place, as shown in Fig. 21. With the lathe geared for any selected pitch, the nut engaged with the lead-screw, and all backlash of screw, gears, etc., properly taken up, clamp the micrometer holder to the lathe bed, as shown in Fig. 22, so that the body of the holder is parallel to the carriage. Adjust the micrometer to one inch when the point of the screw bears against the carriage and with a surface gage scribe a line on the outer edge of the face-plate. Now rotate the lathe spindle any number of full revolutions that are required to cause the carriage

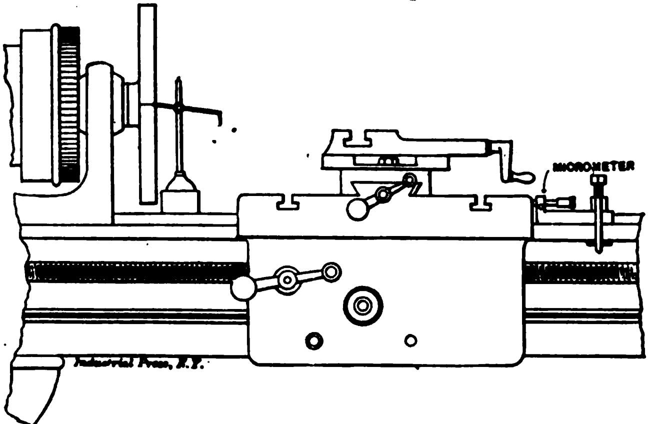


Fig. 22. Testing the Lead-Screw.

to travel over the portion of the lead-screw that is being tested, bringing the line on the face-plate to the surface gage point. If the distance traveled by the carriage is not greater than one inch, the micrometer will indicate the error directly. For lengths of carriage travel greater than one inch an end measuring rod, set to the number of even inches required, can be used between the micrometer point and the lathe carriage. The error in the lead-screw is then easily determined by the adjustment that may be required to make a contact for the measuring points between the carriage and the micrometer screw. The pitch can be tested at as many points as are considered necessary by using end measuring rods, of lengths selected, set to good vernier calipers. The style of holder shown can, with the micrometer screw, be used for numerous other shop tests and as the screw is only held by friction caused by the clamping screw, it can easily be removed and placed in any form of holder that is found necessary.*

* Walter Cantelo, Bridgeport, Conn., July, 1903.

Cutting a Smooth Thread.

When cutting threads, one often meets with difficulty in obtaining a smooth thread, such as is required for screw gages and taps. One good way to obtain a smooth thread is to turn the tap nearly to size and harden it; then draw the temper to a "light blue." When turning to size, if the tool does not stand up well, draw still lower, the object being to leave just enough temper in the tap to make the steel firm. By taking light chips with a hard thread tool, a glossy, smooth thread will result. Another advantage gained by hardening the tap before finishing is that it will greatly eliminate the chances of the lead changing after the final hardening. A thin lubricant of lard oil and turpentine is an excellent one for thread cutting. When cutting two or more taps it is customary in some shops to rough out both or all the taps, leaving the dogs on them, and for the sizing or finishing cut the taps are chased without moving the thread tool. But if the thread tool dulls a trifle when making the finishing cut on the first tap, the succeeding taps will not be exactly the same size.*

Removing Broken Taps.

To remove a broken tap from cast iron, the hole should first be thoroughly cleaned out by means of a small squirt gun filled with

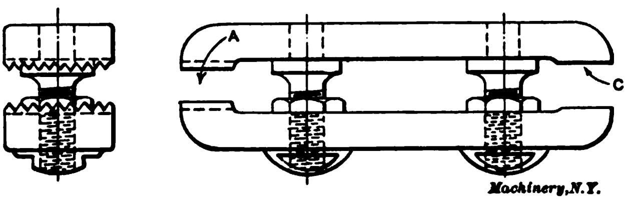


Fig. 23. A Limit Screw Thread Gage

kerosene. All small broken pieces of the tap can be removed with a pair of tweezers. Then the tweezers, which should be as large as possible, should be inserted between the hole and the flutes of the tap and by slowly working back and forth and occasionally blowing out with kerosene, the broken piece is easily released. A through hole, of course, simplifies matters somewhat.**

A Handy Screw Thread Gage.

When cutting threads on screws and bolts, whether by threading dies or in a lathe, much time is wasted by gaging the threads with either a nut or a ring thread gage of the ordinary type. In the case of a piece held between lathe centers, in order to gage the thread with the ring gage, it is necessary to remove the piece from between the centers. The Dresdner Bohrmaschinenfabrik A.-G., Dresden, Germany, is making a gage for measuring the threads of screws, which serves the same purpose as a ring gage, but saves the user considerable time. This gage is shown in Fig. 23. The end marked *A* fits over the threads, and the end marked *C* is supposed not to pass over the threaded screw, when

* F. E. Shailor, Great Barrington, Mass., March, 1907.
** H. J. Bachmann, New York City, January, 1906.

threaded to the right size. Thus, not only can the size of the threads be tried, but at the same time the gage acts as a limit gage.

Method of Driving Lathe When Cutting Screws of Steep Pitch.

When cutting screws of very quick pitch, or cutting the teeth of spiral gears in a lathe, place a pulley on the lead-screw and lengthen the cone belt so as to drive the lead-screw directly from the countershaft, and drive the spindle back through the change gears. By doing this, the carriage may be driven back and forth much quicker and with less strain on the lathe. When cutting a quick pitch, more power is generally required to operate the carriage than to drive the spindle.*

Case Hardening Ring Thread Gages.

To harden ring thread gages without distortion, anneal the gage after roughing out, and when finished cutting the thread, fill it with powdered cyanide and then heat it in a gas furnace, being very careful to exclude cold drafts as much as possible. When the heat has reached the right temperature, turn the gas almost off, and let the piece remain

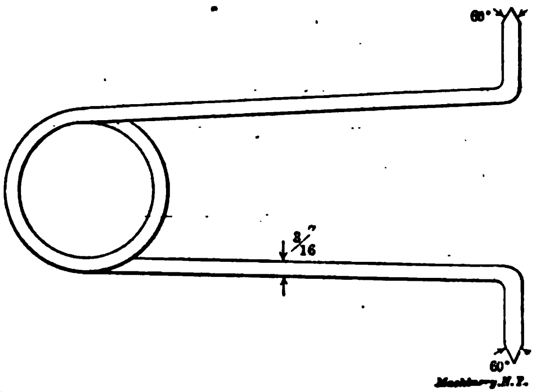


Fig. 24. Tool for Cleaning Threads in Chucks and Face-plates

in the furnace for about ten minutes. Then dip it in oil and keep it moving around in a path shaped like the figure 8. When cool enough, remove it and clean it with kerosene oil.* *

Thread Cleaner for Chucks and Face-plates.

The practice of cleaning out the threads on chuck and other face-plates every time they are screwed on the spindle is very necessary to maintain the accuracy of the chuck and should therefore not be neglected, especially by apprentices. The only instrument necessary is a piece of 3/16-inch drill rod bent into the shape of a safety pin and having its two ends bent outward with the points filed to 60 degrees, as shown in Fig. 24. Inserting this little tool between the threads and moving it around by hand insures the removal of all dirt and chips that have accumulated in the threads. In this connection it is also well to remember that after removing a chuck or face-plate from the spindle, it should be laid away face down or with the chuck jaws rest-

* Eugene Wopaletzky, Trenton, N. J., November, 1904.
* * Everett Kneen, Kearny, N. J., July, 1906.

ing on the bench or floor, thus keeping the chips away from the thread as much as possible.*

A Compound Gearing Arrangement.

A certain lathe, which was single geared, was required to have its thread-cutting capacity increased. Compound gearing was therefore arranged for as shown in Fig. 25.

To the left is shown the original gearing on the lathe, with which from 3 to 48 threads per inch can be cut. The key from the end of the lead-screw was removed, and in place of the gear *D*, the extension *A* was screwed on. A keyway was cut in this extension, so that the long key *B* extended from the end of the shoulder at *C* through *A* and into the keyway in the end of the lead-screw. It thus locked the extension onto the lead-screw and also provided a key for the gear *D*. The notch in the key is to facilitate its removal.

In the place of the original intermediate stud, the stud in the center of the engraving was substituted. On this stud the gears were sep-

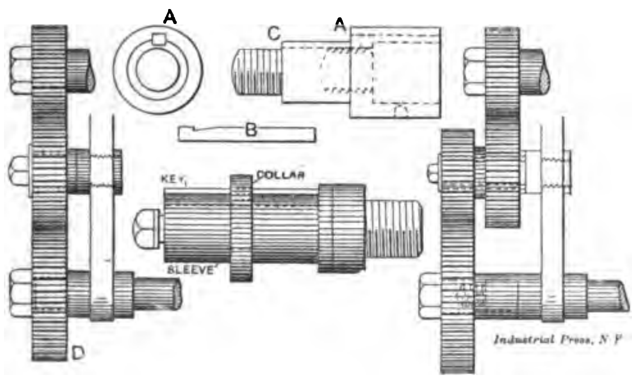


Fig. 25. A Compound Gearing Arrangement.

arated by the collar, while a key, running the entire length of the sleeve, made the gears run together. The complete arrangement is shown to the right in the illustration. By making this alteration it is possible with the same lathe to cut from 1 to 144 threads per inch.**

Thread-Rolling Dies for Small Interchangeable Screws.

Fig. 26 shows a thread-rolling device as applied to a punch press. *A* is a punch holder to fit the punch press. *B* is the bolster, or a piece of cast iron about 1 inch thick, upon which are located two cast iron blocks, one made stationary and the other adjustable by slotting *B*, so that the block can be forced ahead by the set-screw *C*. There is a groove in the stationary block and a tongue in the punch holder *A* to prevent the dies from getting out of line. The screw *D* is for holding a thin piece of steel as a stop so that the thread can be cut to the desired length. The screw *E* holds a wire supporting the piece to be

* H. J. Bachmann, New York City, January, 1906.
** James P. Hayes, Meriden, Conn., September, 1902.

threaded until the upper die, *F*, comes down and carries it past the lower die *G*. In cutting the die, it may be made in one piece, *H* being the circumference of the thread to be rolled and G_1 the desired length for the lower die. F_1 is the desired length for the upper die, which must be longer than the lower die so that it will roll the wire past the die *G* and permit it to drop out of the way. The part *K* must be cut out when cutting in two parts. The proper angle to which to cut the die depends on the pitch of the thread. The pitch divided by the circumference of the screw to be rolled will give the tangent of the angle. In cutting the die, which must be of good tool steel and hardened after making, the shaper is used. The cut is taken with a tool that can be taken off and put back again without changing its location, such a tool, for instance, as a circular threading tool. In case the point should

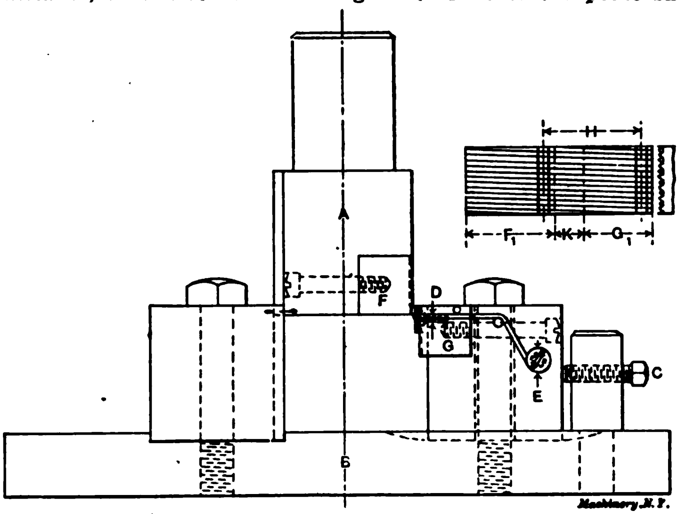


Fig. 26. Thread Rolling Device.

happen to get dull, the tool can then be removed for grinding. If the feed screw has not got the desired graduations on it, a brass index plate can be made very quickly, and used on the machine. The brass plate should be of a good size and cut accurately in a milling machine, and a pointer clamped on the shaper.*

Producing Threads by a Rapidly Revolving Steel Disk.

Fig. 27 illustrates a method used for threading studs, pins, etc., of manganese steel, this material being so hard that it cannot be cut by any kind of tool steel. A plain, hardened tool steel disk, having the edge made according to the angle of thread, is employed. This disk is revolved at a high speed, and at the same time forced into the work, which is revolved slowly. Due to the friction between the edge of the disk and the work, and the softening of the material, owing to the heat generated by the friction, the disk wears away the stock, and, by means

* Stacy Oliver, Great Barrington, Mass., July, 1907.

of this, creates the thread. The stock is coming off in very small, thin scales like chips, which to some extent remind one of the scales of a fish. An ordinary lathe may be rigged up for the purpose, by removing the tool-post and top-rest, and substituting for them the fixture shown in the cut. The disk must be driven independently by an overhead drum, or some similar arrangement.

The peripheral speed of the disk is usually between 3,000 and 4,000 feet per minute. The operation is unavoidably slow and expensive, and the method is used only when no other way is possible. It is very likely, however, that the efficiency can be increased to some extent by increasing the peripheral speed of the disk, perhaps as high as 24,000 feet per minute, same as used on friction saws.

It is likely that high-speed steel would be preferable to ordinary tool steel as material for the disks, but, as the process described is necessarily slow, and is used only when no other way of threading is possible, it has not as yet been developed to the limit of its capacity. There is a certain point in the gradual development of the method above which it becomes economically preferable to employ high-speed steel for the disk, but below this point of development, although high-speed steel may be the best, the ordinary tool steel disk, owing to its smaller first cost, is economically the one to be preferred. A preference for the one or the other kind of steel is influenced by a number of factors, *viz.*, the number of pieces to be threaded per unit of time; the peripheral speed of the disk; the pressure between disk and work; and the efficiency of the system of cooling.

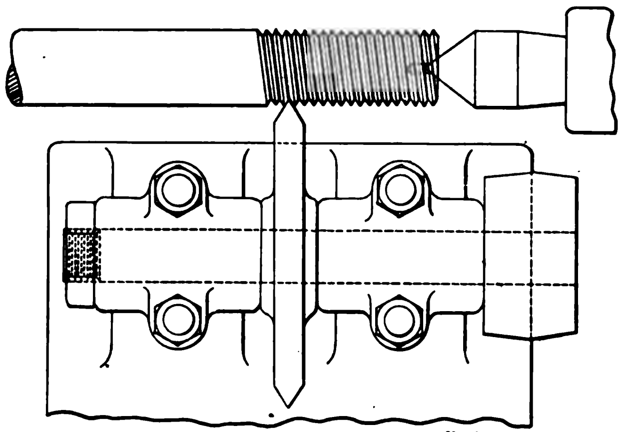


Fig. 27. Cutting Thread by a Rapidly Revolving Hardened Steel Disk.

The question of cooling is in itself an interesting one. The reason why the heat does not draw the temper of the tool steel in the disk while the heat is so great that it softens the metal of the work, is that the disk is revolving at a high speed and the work only revolving very slowly, so that a unit of length of the periphery of the disk is in contact with the work but a very short time, while every point on the work, at the place where it is cut, is in contact with the disk a comparatively long time. Owing to this the disk has ample time to cool off, while the work accumulates the generated heat. The high speed of the disk also throws the film of air nearest to the disk outward, owing to the centrifugal force, and new cool air comes constantly in at the center, a current of air thus at all times tending to cool the disk.

The cooling thus obtained is found to be satisfactory at the present speed at which the disk is run, but at a higher speed a system of cooling by an air jet, or still better, perhaps, by water, could be employed

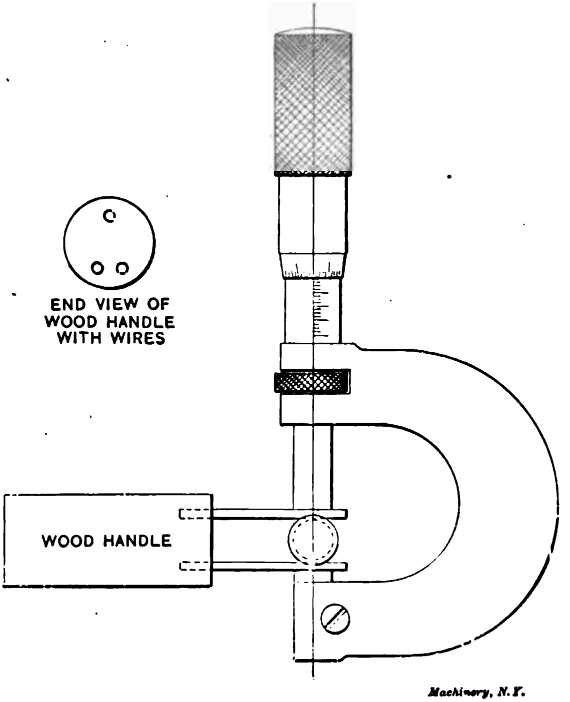


Fig. 28. Holder for Wires when Measuring Taps by the Three-wire System.

to advantage. This would also increase the limits within which an ordinary tool steel disk could be used to advantage. For increasing the peripheral speed of the disk as previously mentioned, undoubtedly the best way would be to increase the diameter of the disk, permitting the number of revolutions to remain the same as before; but at the present stage of the development of this device there are some limitations to the size of the disk, inasmuch as it is used in an ordinary lathe, and the space possible to utilize for the disk is not very great. Another difficulty in increasing the diameter, rather than the number of revolutions, is that for a large diameter disk it is necessary to arrange the disk on an inclined angle in relation to the work in order to get a perfect thread, and this necessarily means a more expensive rigging.

The principle involved in this method of cutting threads is the same as that involved in the friction saw. But the principle of the latter machine cannot be carried out to its full extent in the present case, because the steel to be threaded must not be heated more than to a certain degree. Above this limit, increased heating would mean injury to the quality of the steel. The heat also must not be so high that it burns the thread.

If the call for threaded parts of this kind of steel would be great enough so that a special machine would be warranted to be built, then the efficiency of the method could be increased by a careful taking care of all the points previously referred to, but, at the present time, the demand is not large enough to warrant the expenditure of building such a machine.*

To Measure a Thread with Micrometer and Three Wires.

A United States standard or Sellers thread may be accurately measured with a micrometer by the aid of three wires, preferably Stubbs steel. Select a diameter of wire that will lie in the thread nicely and project above the tops of the thread. Use two wires on one side in adjacent V's and one wire on the opposite side, so as to be in the middle plane between them. For convenience these wires may be sharpened and stuck into a block of soft wood, two on one side of the screw and one on the other, as shown in Fig. 28. Then, having gotten the diameter as measured over the top of the wires, the thread diameter may be obtained by the following rule: From the diameter as measured over the wires, subtract three times the diameter of the wires. To the remainder add the quotient obtained by dividing 1.5155 by the number of threads per inch. Suppose that a screw with 14 threads per inch is measured in this manner, using 0.053 inch diameter wire, and the diameter over wires is 0.5507 inch. Subtracting 3 × 0.053, or 0.159 from 0.5507, leaves 0.3917. To the remainder add $\frac{1.5155}{14} = 0.1082$, giving the diameter as 0.4999, or ½ inch.**

* Oskar Kylin, High Bridge, N. J., January, 1908.
** Ernest Kroff, Cincinnati, Ohio, January, 1906.

CHAPTER III.

TABLES AND FORMULAS FOR MAKING THREAD TOOLS.

The present chapter contains some information regarding the making of special threading tools, square threading tools, and several tables which will prove useful when making thread tools. It is not a complete treatise on the making of thread tools, but contains such general information as the tool-maker is most likely to require.

Formula for Planing Thread Tools.

Fig. 29 shows a diagram of, and below will be found formulas for, thread tools, with special reference to those used in a Pratt & Whitney thread tool holder, which holder is the one considered the best and mostly used by leading firms. As the planing of thread tools used in this holder is rather particular, and quite confusing to those not familiar with the process, formulas are given by means of which the angles to which the planer or shaper-head should be set, can easily be figured. The formulas will be readily understood from the diagram, but a word may be needed in explanation of "the leading" and "the following" side of the thread tool, the former being that side of the tool first entering the work when a thread is cut.

1. Tool with Side Clearance.

a = depth of thread.
b = width of flat on offset tool.
c = actual width of flat.
d = outside diameter of screw.
v = clearance angle.
w = ½ angle of thread.
y = angle of helix.
x = normal angle (to which to set planer head, when planing tool on side).

$$\tan y = \frac{\text{Lead}}{(d - a)\ 3.1416}.$$

$$\tan x = \frac{\cos y \pm (\cot w \times \sin v \times \sin y)}{\cot w \times \cos v}.$$

Use + for leading side and — for following side.

For Acme (29 deg.) thread and 15-degree clearance angle, the formula can, for all practical purposes, be written:

$$\tan x = \frac{\cos y \pm \sin y}{3.735}$$

The width of flat on the offset tool is figured from the formula: $b = c \times \cos y$.

2. Tool without Side Clearance.

If the tool has no side clearance, the angle of helix can be considered $= 0$ deg., and above formula reduces itself to: $\tan x = \frac{\tan w}{\cos v}$; for 60 deg. screw thread, United States standard, the formula has this appearance: $\tan x = \frac{\tan 30°}{\cos 15°} = 0.5977$; $x = 30$ deg. 52 min.

In this latter case the width of flat of tool (c) remains unchanged.

It will be noticed that formulas are given first for "tools with side clearance" and second for "tools without side clearance"; of course any thread tool ought to be given a side clearance, the amount of which depends on the angle of helix of thread to be cut, but on account

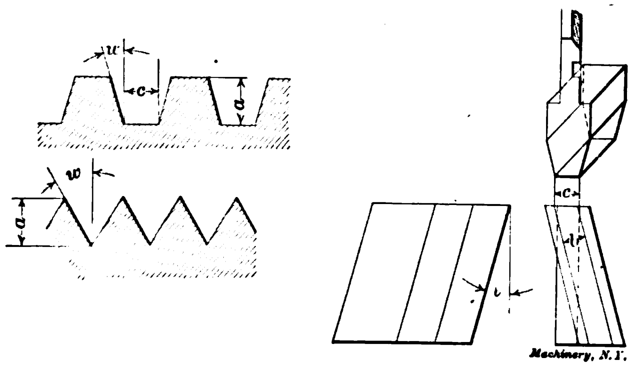


Fig. 29. Diagram Illustrating the Planing of Thread Tools.

of the small angle of helix on fine pitch threads, the necessity of using a tool with side clearance in such cases is reduced to a minimum, and can for practical reasons be dispensed with.

Widths of Tools for Cutting Square Threads.

When cutting square threads it is customary to make the screws exactly according to the theoretical standard of the square thread. The width of the point of the tool for cutting *screws* with square threads is therefore exactly one-half of the pitch, but the width of the point of the tool for cutting taps, which afterwards are used for tapping nuts, is slightly less than one-half the pitch, so that the groove in the tap becomes narrower, and the land or cutting point wider than the theoretical square thread, thereby cutting a groove in the nut which will be slightly wider than the thread in the screw, so as to provide for clearance. An inside threading tool for threading nuts evidently must be of the same width as the land on the tap would be, or in other words, slightly wider than one-half the pitch. This provides, then, the required clearance. The accompanying table gives the width of the point of the tool for all ordinary pitches from one to twenty-four threads per inch. The second column gives the width of the point for cutting taps to be used for producing square thread nuts. The third column gives the width of the point of the tool for cutting screws which, as we have said, equals one-half the pitch, and the fourth column gives the width of the point for inside threading tools for nuts. While the table has been carried to as fine pitches as those having twenty-four threads per inch, square threaded screws having so fine a pitch are very seldom used. Some manufacturers of square threading tools, however, make square threading tools for pitches as fine as these, and for this reason they have been included.

Clearance Angles of Square Thread Tools.

In the Chart Fig. 30, reproduced from MACHINERY'S Data Sheet No. 97, directions are given for the use of the diagram presented, by

TOOLS FOR SQUARE THREAD.

No. of Threads per Inch	Width of Point of Tool			No. of Threads per Inch	Width of Point of Tool		
	For Taps	For Screws	For Inside Thread Tools for Nuts		For Taps	For Screws	For Inside Thread Tools for Nuts
1	0.4965	0.5000	0.5035	8	0.0615	0.0625	0.0635
1⅓	0.3715	0.3750	0.3785	9	0.0545	0.0555	0.0565
1½	0.3333	0.3333	0.3363	10	0.0490	0.0500	0.0510
1¾	0.2827	0.2857	0.2887	11	0.0444	0.0454	0.0464
2	0.2475	0.2500	0.2525	12	0.0407	0.0417	0.0427
2½	0.1975	0.2000	0.2025	13	0.0375	0.0385	0.0395
3	0.1641	0.1636	0.1691	14	0.0352	0.0357	0.0362
3½	0.1408	0.1428	0.1448	15	0.0328	0.0333	0.0338
4	0.1235	0.1250	0.1265	16	0.0307	0.0312	0.0317
4½	0.1096	0.1111	0.1126	18	0.0272	0.0277	0.0282
5	0.0985	0.1000	0.1015	20	0.0245	0.0250	0.0255
5½	0.0894	0.0909	0.0924	22	0.0222	0.0227	0.0232
6	0.0818	0.0833	0.0848	24	0.0203	0.0208	0.0213
7	0.0699	0.0714	0.0729				

means of which the clearance angles on the sides of square threading tools may be determined at a glance. The example given in the chart will fully explain its use.

Tables Giving Angles of Threading Tools.

The tables on pages 38 and 39 will be of interest and use to tool-makers. The first table in question deals with the circular threading tool. This kind of tool most generally has its cutting face below its center line, which, of course, changes the angles; it not only changes the angles, but as we lower the cutting edge, the same becomes a convex line. On large diameters this second error is not noticeable to any extent, although it exists from the very moment we lower the cutting face of such a tool. This one item makes it very difficult to accurately give the angle to make such a tool, which should cut an accurate 60-degree thread, when the tool is cut a certain amount under its center line.

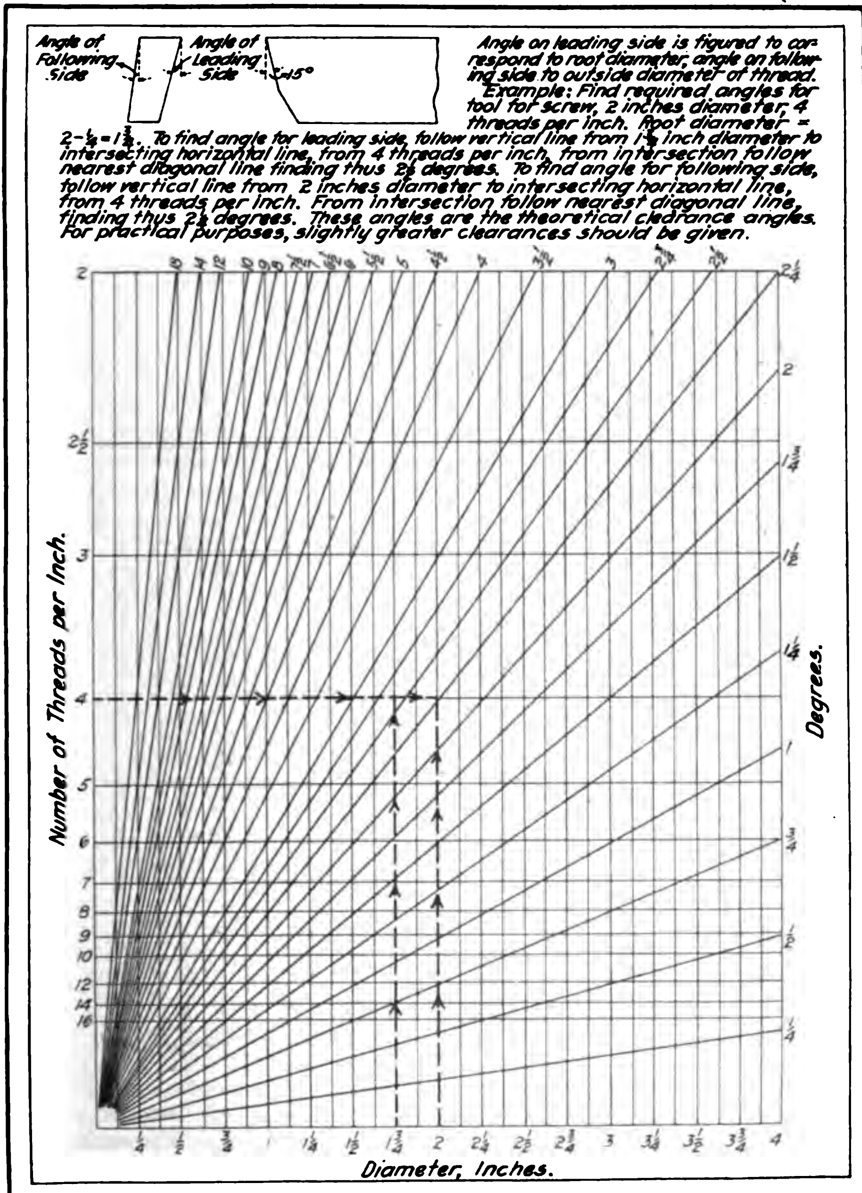
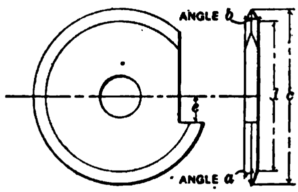


Fig 30. Diagram giving Clearance Angles of Square Thread-Tools

The angles in the table below were computed by taking diameter *d* to be ⅛ inch smaller than *c*; this difference was used throughout the tables. The first column gives the largest diameter of tool, while the second gives the diameter from which the following angles were obtained. The eight columns following give the angle of one side of

CIRCULAR THREADING TOOLS.



a — ANGLE WITH SIDE OF TOOL
b — INCLUDED ANGLE OR 2 × ANGLE a
c — LARGEST DIAM. OF TOOL
$d = c - .125$ (THESE TABLES WERE COMPUTED FROM THIS RATIO)
e — DISTANCE FROM CENTRE LINE TO CUTTING FACE

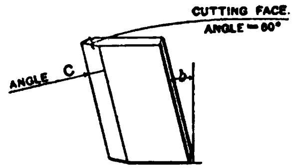
LARGEST DIAM. OF TOOL — c	DIAM. d = c — .125	ANGLES ON CENTRE LINE WHEN e = .125		ANGLES ON CENTRE LINE WHEN e = .1875		ANGLES ON CENTRE LINE WHEN e = .250		ANGLES ON CENTRE LINE WHEN e = .3125	
		ANGLE a	ANGLE b	ANGLE a	ANGLE b	ANGLE a	ANGLE b	ANGLE a	ANGLE b
¾	⅝	31° 41′	63° 22′	34° 34′	69° 08′	40° 10′	80° 20′		
⅞	¾	31 15	62 30	33 05	66 10	36 18	72 36	42° 25′	84° 50′
1	⅞	30 56	61 52	32 13	64 26	34 20	68 40	37 50	75 40
1⅛	1	30 43	61 26	31 41	63 22	33 13	66 26	35 34	71 08
1¼	1⅛	30 34	61 08	31 19	62 38	32 29	64 58	34 12	68 24
1⅜	1¼	30 28	60 56	31 04	62 08	31 59	63 58	33 18	66 36
1½	1⅜	30 23	60 46	30 53	61 46	31 37	63 14	32 40	65 20
1⅝	1½	30 19	60 38	30 45	61 30	31 22	62 44	32 13	64 26
1¾	1⅝	30 17	60 34	30 38	61 16	31 09	62 18	31 52	63 44
1⅞	1¾	30 14	60 28	30 32	61 04	31 00	62 00	31 36	63 12
2	1⅞	30 13	60 26	30 29	60 58	30 52	61 44	31 23	62 46
2⅛	2	30 11	60 22	30 25	60 50	30 45	61 30	31 13	62 26
2¼	2⅛	30 10	60 20	30 22	60 44	30 40	61 20	31 04	62 08
2⅜	2¼	30 09	60 18	30 20	60 40	30 35	61 10	30 57	61 54
2½	2⅜	30 08	60 16	30 18	60 36	30 32	61 04	30 51	61 42
2⅝	2½	30 07	60 14	30 16	60 32	30 29	60 58	30 46	61 32
2¾	2⅝	30 06	60 12	30 14	60 28	30 26	60 52	30 42	61 24
2⅞	2¾	30 06	60 12	30 13	60 26	30 24	60 48	30 38	61 16
3	2⅞	30 05	60 10	30 12	60 24	30 22	60 44	30 34	61 08
3⅛	3	30 05	60 10	30 11	60 22	30 20	60 40	30 32	61 04
3¼	3⅛	30 04	60 08	30 10	60 20	30 18	60 36	30 29	60 58
3⅜	3¼	30 04	60 08	30 09	60 18	30 17	60 34	30 27	60 54
3½	3⅜	30 04	60 08	30 09	60 18	30 16	60 32	30 25	60 50
3⅝	3½	30 03	60 06	30 08	60 16	30 15	60 30	30 23	60 46
3¾	3⅝	30 03	60 06	30 08	60 16	30 14	60 28	30 22	60 44
3⅞	3¾	30 03	60 06	30 07	60 14	30 13	60 26	30 20	60 40
4	3⅞	30 03	60 06	30 07	60 14	30 12	60 24	30 19	60 38

Machinery, N.Y.

tool and also the included angle for such tools which have their cutting face 1/8, 3/16, 1/4 and 5/16 inch below the center line. Should one desire to construct such a tool for very coarse threads, say, for instance, for 2 or 3 pitch, it can readily be done with very accurate results by simply manipulating the figures in the table.

Example: A circular tool is to be made, of which the extreme diameter is to be 2 inches and which is to be used for cutting 2-pitch threads; its cutting face is to be 5/16 inch below the center line, and it must cut to the depth of 0.433 inch when the top width of cut equals 0.500 inch. Now the table gives us for a 2-inch diameter 60-degree tool cut 5/16 inch below center, the half angle 31 deg. 23 min., or 62 deg. 46 min. included angle. These angles would be accurate for making a tool that was to be used on threads that have an approximate depth of about 1/16 inch, but for the tool in question we would come nearer right if we reckoned our two diameters, namely, 2 inches for the one and 1⅛ inch for second diameter, since 2 × 0.433 = 0.866, which is nearly ⅞ inch, and 2 inches — ⅞ inch would equal 1⅛ inch for the second diameter. Now if we consider the intermediate diameter 1 9/16 inch—which is found as follows: 2 — 1⅛ = ⅞ inch; ⅞ ÷

STRAIGHT THREADING TOOLS.



ANGLE *b* = CLEARANCE ANGLE OF TOOL	ANGLE C = ANGLE MEASURED ON FORWARD SIDE OF TOOL. C = ANGLE WITH CENTRE LINE		C = INCLUDED ANGLE	
8	30°	15′	60°	30′
9	30	18	60	36
10	30	23	60	46
11	30	28	60	56
12	30	33	61	06
13	30	39	61	18
14	30	45	61	30
15	30	52	61	44
16	30	59	61	58
17	21	07	62	14
18	31	16	62	32
19	31	25	62	50
20	31	34	63	08

2 = 7/16 inch; 7/16 + 1⅛ = 1 9/16 inch—we find upon referring to the tables that a 1 9/16-inch diameter is not given, so we divide the difference between a 1½-inch and 1⅝-inch diameter; this difference is 27 minutes, half of which would be about 14 minutes. This added to the angle given in the 1⅝-inch line would equal 32 deg. 27 min., which would be the proper angle to make the tool.

We will now turn to the straight threading tool, which is a more accurate tool than the circular, because we have not the convex side to contend with. The cutting edge of a straight tool is always a straight line (provided it is made accurately) regardless of what the clearance angle is, although we have the same problem to contend with in this style of tool as in the circular, namely: when the cutting angle equals 60 degrees, for example, what is the angle on forward side of tool?

The table above gives this angle. As will be seen in this table, the first column gives the clearance angles which range from 8 to 20 degrees, inclusive. In the second and third columns are the respective single and included angles, which when measured on the forward side of the tool will coincide with a perfect 60-degree angle on the cutting face.

There is still another item which is of no less importance than any previously mentioned, and which concerns both the straight and circular threading tools, and that is the setting of such tools in the machine so that they may stand in alignment with the angle of the thread that is being cut. Many threads are cut which are smooth on one side and rough on the other; the cause is not having an equal amount of clearance on each side of the threading tool. The old style of lathe tool which was used for threading purposes had a little advantage over the circular and straight tools in this respect, because it had clearance both ways, but with such tools that can be ground without changing their form, we must obtain front clearance only. This makes it more essential to have these tools stand as near in line with the angle of the thread as possible; but when we speak of setting such tools perfectly in alignment with the angle of a thread, we have an impossibility to contend with, because the root of a thread is always smaller in diameter than the apex, and as the lead on both root and apex remains the same, the angle must of course change, when going from one diameter to another. In other words, the angle of the spiral at the root diameter is always greater than at the apex of thread. The most correct diameter to select would be about midway between the root and apex of thread, but as the changes of angles are very slight, and really too slight for practical importance, they are generally computed from the diameter over the apex of the thread.

No. 10. Examples of Machine Shop Practice.—Cutting Bevel Gears with Rotary Cutters; Making a Worm-Gear; Spindle Construction.

No. 11. Bearings.—Design of Bearings; Causes of Hot Bearings; Alloys for Bearings; Ball Bearings; Friction of Roller Bearings.

No. 12. Mathematics of Machine Design.—Compiled with special reference to shafting and efficiency of hoisting machinery.

No. 13. Blanking Dies.—Making Blanking Dies; Blanking and Piercing Dies; Construction of Split Dies; Novel Ideas in Die Making.

No. 14. Details of Machine Tool Design.—Cone Pulleys and Belts; Strength of Countershafts; Tumbler Gear Design; Faults of Iron Castings.

No. 15. Spur Gearing.—First Principles of Gearing; Formulas for Spur Gearing; Design and Calculation of Gear Wheels; Strength of Gear Teeth.

No. 16. Machine Tool Drives.—Speeds and Feeds of Machine Tools; Geared or Single Pulley Drives; Drives for High Speed Cutting Tools.

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The Industrial Press, Publishers of Machinery,

49-55 Lafayette Street Worth Street Subway Station **New York City, U.S.A.**