TURNING AND BORING

"There is a difference between 'cut' and 'wear'; tightening a *cut* journal will ruin it; steady, uniform, rotary *wear* upon a journal will outlast the lifetime of almost any machine."

"No man of any pretensions has any right to mix up the terms journal and bearing; a *journal* is that part of a shaft or axle that rests in the bearings; a *bearing* is the part, the contact with which, a journal moves, or the part of any piece where it is supported or the part of another piece where it is supported; a bearing is a guide to steady a shaft or rod and maintain it in position."

SCREW-CUTTING IN THE LATHE.

The operations of turning and boring are performed in the lathe, screw machine, boring mill, etc.; in these the work is usually made to rotate to a cutting tool, which, except for "the feeds," is stationary.

The movement of the work and the cutting of the tools, produce curved or circular, external or internal, and plane surfaces.

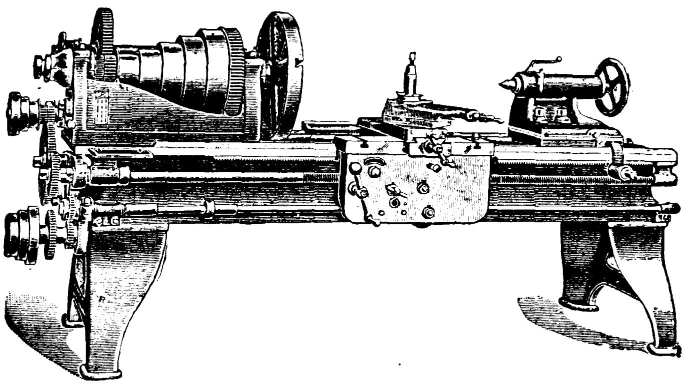

Fig. 62.

The lathe, with its two headstocks, is admirably adapted for all kinds of work supported by the two heads directly, or supplemented by supports or steady rests.

When boring and facing have to be done on the headstock, disadvantages and defects are encountered; the work must of necessity overhang when fixed on the horizontal spindle, causing vibration, etc. Another defect of the horizontal lathe, when used for boring, is the difficulty of setting and securing the overhang work to the face-plate.

The illustration, page 100, is a lathe designed for screw-cutting by the means of the lead-screw shown on the front.

Fig. 62 shows a lathe for turning, boring and screw-cutting; it has self-acting longitudinal and cross feeds, actuated by the spline feed spindle in front, on which is a sliding worm geared into a worm wheel on the carriage; the screw-cutting mechanism is actuated by the long leading screw shown in front, under the rack which is fixed to the shears or slides of the lathe.

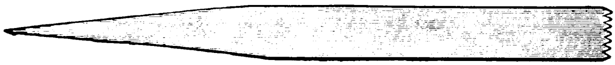

Fig. 63.

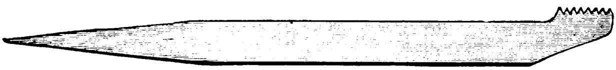

Fig. 64.

There are two ways of cutting a screw-thread in a lathe: 1, *by tools manipulated by the hand, called chasers;* 2, *by cutting tools fixed in the lathe rest, which slides automatically.*

Chasers are of two kinds, the outside and the inside chaser; fig. 63 shows the outside or male chaser; it is the one which cuts the male thread, on a pipe, etc.; fig. 64 shows the inside, or female chaser; this cuts the interior thread on a pipe, etc.

The teeth of chasers are made to correspond to the number of threads per inch which they are intended to cut, and each size chaser can only be used to cut its own number of threads, although the same chaser is equally suitable for different diameters of work; thus, an eight-thread-to-the-inch chaser would cut a thread of this pitch equally as well on a piece of work ¾ inch diameter as on a piece 1 inch diameter.

The mode of applying a chaser to cut an external thread is shown in fig. 65. Here *A* is the work between centers, *B* the tool rest, and *C* the chaser. If the tool rest, *B*, is placed with its upper surface level with the center of the work, then the chaser, *C*, must be tilted slightly, as shown in fig. 65, in order to bring the cutting angles of

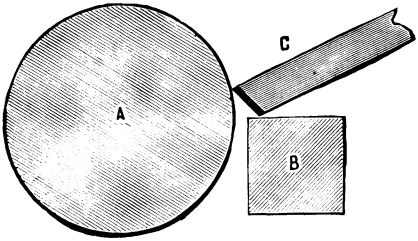

Fig. 65.

NOTE.—These hand tools or chasers would appear, at first acquaintance to many, to be old-fashioned, and not up-to-date devices for performing the very beautiful process of producing a perfectly uniform thread; nevertheless, chasers cannot be entirely superseded, even by the very perfect modern lathe, as a good workman can produce, with their aid and with ease and certainty, screws of the greatest cleanness and delicacy—the pressure required being very slight—threads can be cut by this method on the thinnest and the most fragile materials, which would be quite unable to resist the more violent treatment to which they would be subjected by any other process of screw-cutting; this system is used by manufacturers of brass fittings for telescopes and exceedingly light work, the thickness of the tube employed frequently exceeding only to a very small extent the depth of the screw thread which is cut upon them; it is not unusual to give the finishing touch to the threads of machine and engine work with the hand chaser when accurate and perfect threads are required.

the tool into the right position. To start a thread, the end of the work should first be beveled off, as shown in fig. 66, and the points of the chaser teeth applied lightly to the work: if the chaser is held still in the one place, it is evident the teeth will simply cut a series of rings or circles on the surface of the work instead of a spiral thread; at the same time, therefore, as the teeth are applied to the work, a sliding motion towards the left hand must be given to the chaser; the exact rate at which the

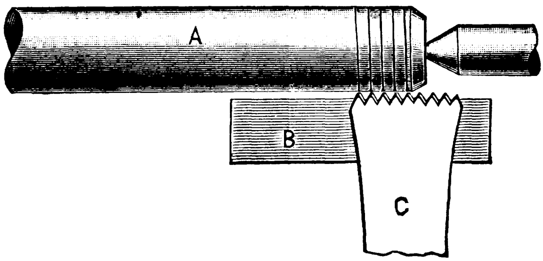

Fig 66.

chaser is moved depends on the pitch of the screw to be cut, and also the speed at which the work is revolved in the lathe.

To cut a true thread, the chaser should move through a distance of one tooth for each revolution of the work, and this motion should be perfectly uniform; the speed of the lathe also should be constant and regular; if this operation be correctly performed the teeth of the chaser will produce one continuous spiral line, which should run quite true as the work revolves; the chaser is then brought back to the right-hand end of the work, and another cut taken, so as to deepen the line already made.

SCREW CUTTING IN THE LATHE.

Great care is necessary for the first few cuts, to insure that the chaser-teeth engage in the same cuts each time, and that they do not start fresh threads; the line or groove is thus cut deeper and deeper, until it becomes a V-shaped groove, with, of course, the V-shaped ridge, or thread, between.

Fig. 67 shows a hand-chaser being used for cutting an internal thread. In this case the tool-rest, *B*, is placed across the mouth of the hole, and the chaser is inserted and gradually advanced, with its teeth against the interior surface, as shown.

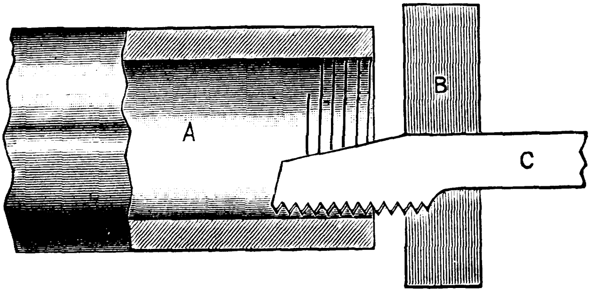

Fig. 67.

In chasing wrought iron or steel, plenty of soap and water or oil, preferably the former, should be used as a lubricant. If the chaser be moved along unevenly, or if the speed of the lathe fluctuate, an irregular thread will be produced, and this will be readily recognized by the "wobbling" appearance it has when running. A thread of this description is caused by incorrect speed of travel.

If the chaser-teeth be inserted in a true thread, without any cutting taking place, the screw will carry the chaser along at the proper speed. By trying this plan with the lathe running at various speeds, the reader will readily see how the speed at which the work revolves necessitates a faster or slower sliding motion of the chaser accordingly to produce a screw of the desired pitch.

When it is desired to cut a screw of, say, two or three inches, with a hand-chaser, the first inch or so should be well started before following up to the remaining portion of the screw; this, if correctly done, will then form a guide to lead the chaser up to the part as yet uncut.

The second method of screw-cutting in the lathe is performed by cutting-tools fixed in the lathe rest.

For cutting screws of any pitch by a tool fixed in the lathe rest, the lathe requires to be specially fitted with, 1, a leading or guide screw; 2, a quadrant fitted with one or more studs for carrying the change wheels; 3, a saddle or carriage upon which is fixed the slide rest carrying the cutting tools; 4, a nut attached so that it can be readily put into or out of gear with the leading screw.

The following illustration, fig. 68, shows the general arrangement of lathe for cutting a screw. *A* is the leading screw; the round metal bar, *B*, on which the screw is to be cut, is placed between the steel centers of the fast and movable headstocks of the lathe; a "carrier," or dog, *C*, is secured to the bar at the end next to the fast headstock, which engage with a driving stud, *D*, attached to the face-plate.

The cutting of a screw in a lathe, whether V-shape or a square thread, is an operation, the most important part of which is the selection of the proper change wheels. Every turn or revolution of the leading screw moves the carriage and cutting tool through a distance equal to the pitch of the leading screw. If the iron bar, *B*, fig. 68, revolves at the same rate as the leading screw, *A*, the pitch of the screw cut upon the bar will be

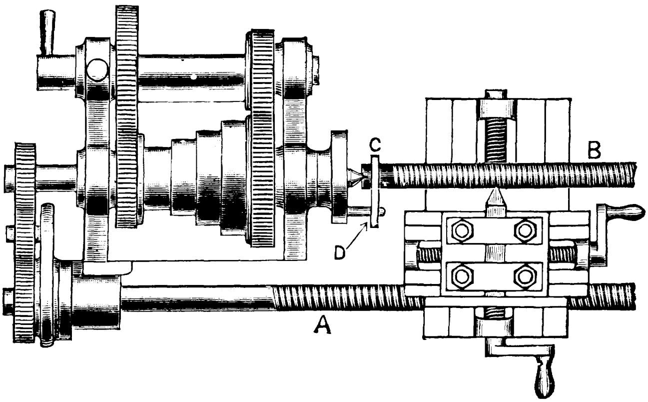

Fig. 68.

the same pitch as that of the leading screw; to cut the same thread as the leading screw, therefore, the driving wheel on the lathe mandrel must be the same size as the follower or driven wheel on the leading screw.

If the bar revolve faster than the leading screw, then the pitch of thread cut on the bar will be less than that on the leading screw; if the bar revolve slower than the leading screw, the thread cut upon the bar will be of greater pitch than that of the leading screw.

Fig. 68 shows the general arrangement *looking down on the work of a lathe* arranged for cutting screw threads, with a cutting tool fixed in the tool-holder, which slides or travels automatically.

When V-threads are cut in a screw-cutting lathe by tools sliding automatically, a single-pointed tool is generally used.

Fig. 69 shows the front tool for cutting the male or outside thread; fig. 70 shows the inside tool for cutting the interior thread.

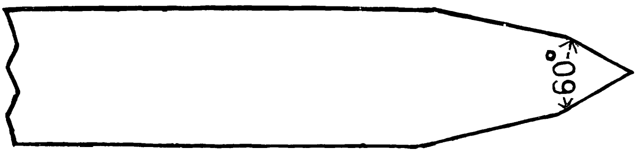

Fig. 69.

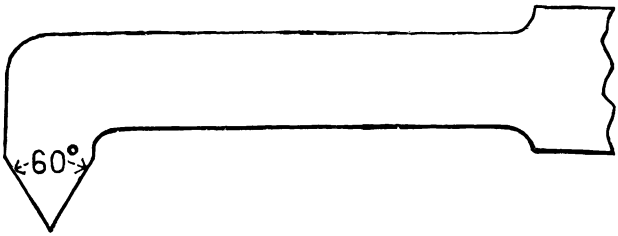

Fig. 70.

It will be noticed that the tools are very similar to the ordinary turning and boring tools, but with the points ground to a V-shape, the angle of the V corresponding exactly with the correct angle for the screw to be cut.

NOTE.—When cutting internal screw-threads it is important to remember that the diameter of the hole should be equal to the diameter at the *bottom* of the male screw-thread, which is to fit into it; thus the hole intended for an inch bolt, having eight threads per inch on it, would be bored out to just under seven-eighths inch diameter.

SCREW-CUTTING IN THE LATHE.

There is one important difference, however, between the shape of a turning tool and a screw-cutting tool; *i. e.*, that the tool point is canted or sloped over at an angle; this is necessary in the screw-cutting tool to prevent it rubbing against the sides of the thread, owing to the slope or "rake" of the latter; the rake of a thread depends on the pitch of the screw and the diameter of the work on which it is cut; thus, a screw of one-eighth pitch cut on a bolt of one-inch diameter, will have greater rake or slope than that of a thread of same pitch cut on a bolt of two inches diameter.

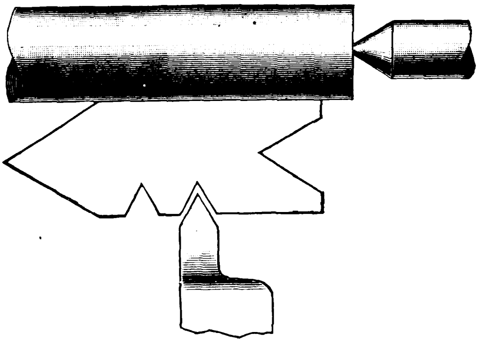

Fig 71.

It may be said, however, that in actual practice it is not necessary to make a separate tool for each pitch of thread when cutting V-threads of reasonably small pitch and diameter, the clearance angle given to the cutting edges of the tool usually being sufficient to allow for slight variations in the rake of the thread.

It is necessary to have some gauge to which the tool can be ground to the correct shape; one way is to grind it to fit between the threads of an ordinary plug-tap, but a special screw-cutting gauge is more satisfactory; the one shown in fig. 71 is a useful form; the V-openings are cut out to the standard angle, 60°, and as it is made of light sheet steel, it can be readily applied to the tool when grinding, to test it.

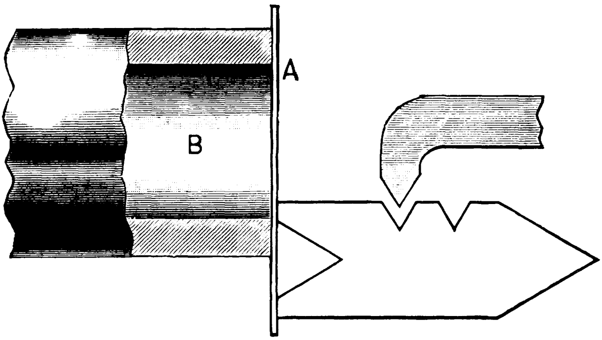

Fig. 72.

The method of setting an outside screw-cutting tool in correct position with regard to the work is shown in fig. 71, and fig. 72 shows how the gauge may be used for setting an inside screw-cutting tool. It will be noticed that a steel rule or other flat strip of metal, *A*, is laid across the end of the work, *B*, to form a surface for the end of the gauge to rest against.

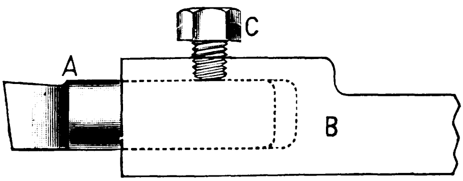

Fig. 73.

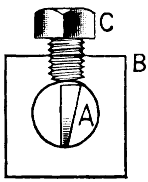

Fig. 74.

The form of tool used for cutting square threads is very similar to a parting tool, only that canting, or rake,

SCREW-CUTTING IN THE LATHE.

must be provided for in the portion that enters the work, to prevent side rubbing.

A tool holder of the kind shown in fig. 73 simplifies the making of square-thread tools very much. The tool itself is filed up out of a small round piece of tool-steel, *A*, which is then fixed in the holder, *B*, by means of the set-screw, *C*. The tool-steel being circular in section, can be turned round in the holder before the set-screw is tightened, so as to give any desired degree of rake.

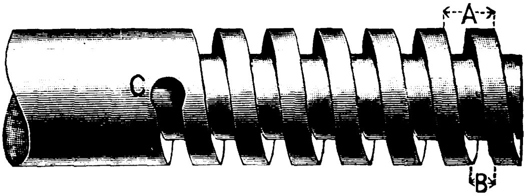

Fig. 75.

Fig. 74 shows the end view of the tool and its holder.

The width of a tool for cutting a single square thread must be equal to half the pitch of the thread. This will be seen from fig. 75, where *A* shows the pitch of the thread, which is equal to the thickness of a thread and a space. *B* shows the width the cutting tool should be, *i. e.*, exactly half of *A*. In cutting a double or triple thread the case is different, as will be seen from fig. 76, which represents a double thread. Here the pitch, *A*, is equal to

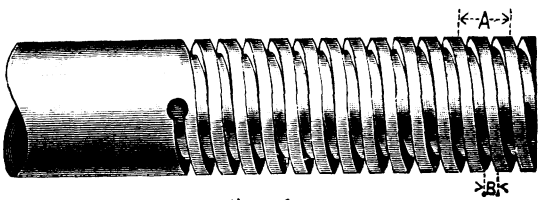

Fig. 76

the thickness of two threads and two spaces, so that the width of the cutting tool, *B*, must be exactly one-quarter of the pitch, *A*.

Fig. 77 shows a double-threaded screw with only the first groove cut. When the second groove is cut in the center of the intervening portions of the work, it leaves the double thread.

A neat way of finishing off a square thread is to drill a small hole into the work at the end of the thread for the tool to run into, as shown at *C*, in fig. 75. The diameter of the hole should be slightly larger than the thickness of the tool, and the depth a little greater than the depth of the thread. The lathe must be stopped just before the

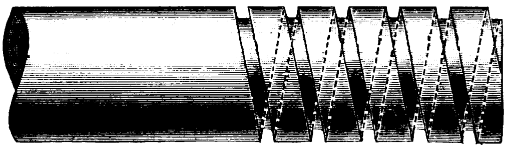

Fig. 77.

tool reaches the hole, and pulled round by hand for the last half turn or so. As soon as the tool finishes its cut, it is withdrawn and run back again in readiness for taking a fresh cut.

The process of cutting a screw in the lathe is comparatively simple. The work being mounted between centers, the tool fastened in the slide-rest, and the proper screw-cutting change wheels placed in gear, the lathe is started and a preliminary cut taken along the work; the tool is then withdrawn, the clasp-nut disengaged from the leading screw, the carriage is run back to the starting point, and the tool is set in a little deeper than before; the clasp being dropped into gear with the leading screw again, a second cut is taken along.

This series of operations is repeated until the screw is cut to a sufficient depth. There are, however, one or two precautions which must be observed; in the first place, a screw-cutting tool, by reason of its shape, is weak at the point, and is therefore easily broken; consequently, the depth of cut taken should not be greater than the tool can easily stand, and this should be regulated in a systematic manner. A simple plan is to mark, with a piece of chalk, the position of the cross-slide handle with which the tool is fed to the work, when the tool is withdrawn after a cut has been taken; it is wound in again before taking the next cut, so that the chalk mark is in exactly the same position as before; this shows the position of the tool during the previous cut, so that the operator can now readily judge how much further to turn the handle round to advance the tool sufficiently for the next cut.

This done, the old chalk mark is wiped out, and a fresh one substituted, the marking being repeated as each successive cut is taken.

The same guidance can be obtained in a neater way by placing a brass ring or clip over the handle of the slide rest, with a line marked across it, as shown in fig. 78; the ring is slipped back after each cut has been set in, so as to bring its mark again opposite to the arrow mark on the boss on the slide-rest, in readiness for the adjustment of the following cut.

Some lathes are provided with a small graduated disk on the handle which winds the tool in, a fixed pointer being attached to the lathe saddle; in this case, of course, the simpler expedients already described are not required.

There is another important precaution to be taken, viz., that the tool shall follow in the same path at each successive cut. There will be no trouble on this point when cutting any thread which is an exact multiple of the thread on the leading screw, or guide screw, of the lathe. If, for example, the guide screw has four threads per inch,

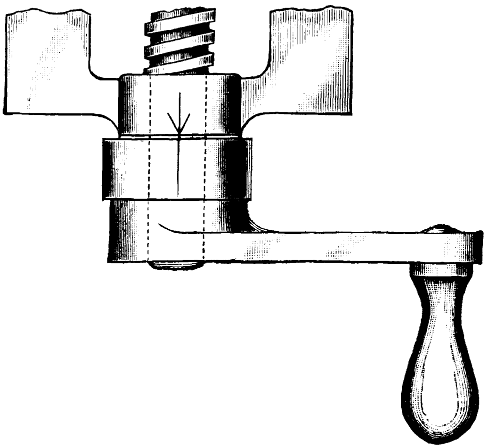

Fig. 78.

and the screw to be cut has twelve threads per inch, the work will always be in the right position for the tool to follow in the thread when the clasp-nut engages with the leading screw.

The same will be true if the screw to be cut has eight, sixteen, twenty or any number of threads per inch which is divisible by four.

The reason for this is that the change-wheel on the spindle and the change-wheel on the leading screw are in exactly the same proportion to each other as the threads on the leading screw and the screw being cut; and, since the number of teeth in one wheel is an exact multiple of the teeth in the other wheel, the smaller wheel of the two will always make an exact number of complete revolutions for each revolution of the larger.

To cut twelve threads per inch, as in the case mentioned above, a wheel with forty teeth would be placed on the spindle, and a wheel with 120 teeth on the leading screw; the spindle would therefore make three complete revolutions for each revolution of the leading screw, and the commencement of the screw-thread on the work would accordingly be brought to exactly the same position in relation to the tool each time the clasp-nut became engaged with the leading screw.

If, instead of twelve threads to the inch, a screw of ten threads to the inch is to be cut, the wheels required would be forty on the spindle and 100 on the leading screw; it will be apparent that for each turn of the leading screw the spindle will now make only 2½ revolutions, and the work will therefore be half a revolution behind its proper position, thus causing the point of the tool to come on top of the thread instead of in the groove between the threads, if the clasp-nut be engaged with the leading screw.

If the leading screw be allowed to make another complete revolution before engaging with the clasp-nut, the work will make another two and a half revolutions, which will bring it into the right position again for starting the tool in the proper groove. The work is therefore only in the correct position for starting a cut once during every two revolutions of the leading screw. Similarly, with other threads which are not exact multiples of the thread of the leading screw, it will be found that to bring the tool to the right position the clasp-nut must only be dropped in at certain intermediate positions of the change-wheels.

To prevent any mistake arising, the usual plan is to stop the lathe before the tool commences its first cut along the work, and chalk a tooth on the spindle wheel and a tooth on the leading screw wheel, placing another chalk mark on the headstock opposite the former and a chalk mark on the lathe bed opposite the latter, the clasp-nut being then engaged with the leading screw.

The saddle is run back to the starting point after each cut, and as soon as both chalk marks on the wheels come opposite to the stationary marks again at the same instant, the clasp-nut may be engaged with the leading screw, and another cut taken.

When cutting a double thread, a wheel with an even number of teeth should be selected for the spindle, and a chalk mark should be made on each of two exactly opposite teeth. The space into which one of these teeth falls in the wheel with which it gears should also be marked; when the first thread has been cut, the mandrel wheel should be disengaged and turned through half a revolution, so that the other marked tooth comes opposite the marked space; the wheels are then geared together again, and the second thread can be cut.

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For a triple thread the spindle wheel should be divided into three, and for a quadruple thread into four, and so on.

For cutting a right-hand thread, the tool traverses from right to left, and for a left-hand thread it traverses from left to right.

In the latter case the necessary reversal in the direction of rotation of the leading screw is obtained by inserting an extra wheel in the train of gear wheels between the spindle and the leading screw; this extra wheel does not in any way affect the *speed* of rotation of the leading screw: it simply alters the *direction* in which it revolves.

A square thread must be finished to exact size with the tool. A V-thread can be finished off with a hand chaser.

All that is necessary to cut any pitch desired is to arrange gearing to revolve the screw as many times as it has threads to the inch, while the feed stud, or spindle, is making as many revolutions as the desired pitch.

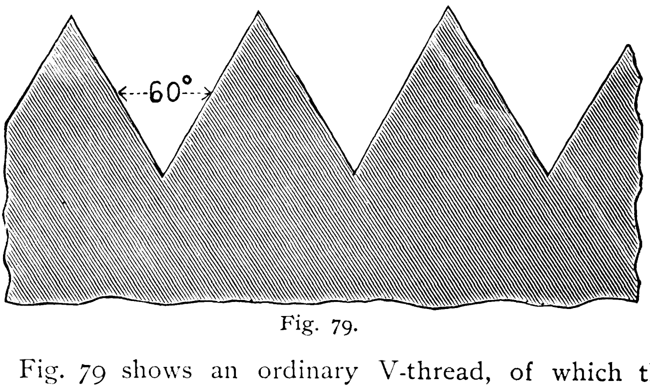

Fig. 79.

Fig. 79 shows an ordinary V-thread, of which the angle is 60°.

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Fig. 80 shows the American Standard thread; it is the V-thread, with one-eighth of its depth cut off the top and bottom, the angle being 60°.

Fig. 81 shows the Whitworth, or English Standard thread; it is a V-thread, with one-sixth of its depth rounded off the top and bottom the angle being 55°.

The following quotation from Low and Bevis' "Manual of Machine Drawing and Design" presents the relative merits of screw-threads shaped according to the Whit-

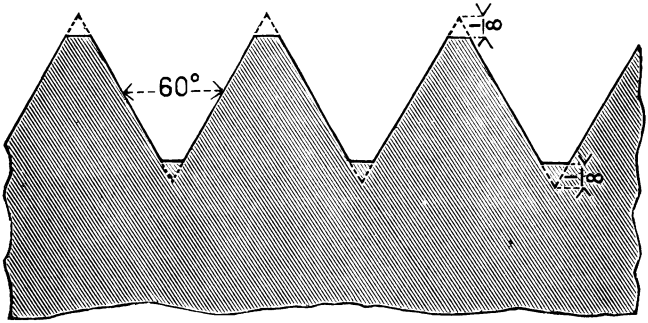

Fig. 80.

worth and Sellers system respectively, as seen through English eyes. The comparison, however, seems to be fair. Without underrating the good points of the Sellers thread, we believe that the Whitworth thread has its good points also, and that they are not as fully appreciated in this country as they might be:

"Comparing the 'Whitworth' and 'Sellers' screw-threads, the former is stronger than the latter because of the rounding at the root. The point of the Whitworth thread is also less liable to injury than the Sellers. The

SCREW-CUTTING IN THE LATHE.

form of the Sellers thread is, however, one which is more easily produced with accuracy, in the first place, because it is easier to get with certainty an angle of 60 degrees than an angle of 55 degrees, and, in the second place, because it is easier to make the point and root perfectly parallel to the axis than to ensure a truly circular point and root. The Sellers thread has also a slight advantage in that the normal pressure, and therefore the friction, at every point of the acting surface is the same; while in the Whitworth thread the normal pressure, and therefore the friction, is greater at the rounded parts. The surface of the Sellers thread will, therefore, wear more uniformly than the surface of the Whitworth thread. The total friction, and also the

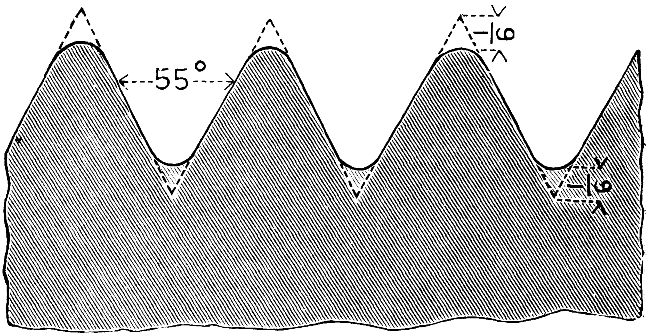

Fig. 81.

bursting action on the nut, are slightly greater in the Sellers thread than in the Whitworth, because of the greater angle of the V, it will be seen that for a given diameter of screw the diameter at the bottom of the thread is greater in the case of the Whitworth than in the Sellers. A bolt with a Sellers thread is, therefore, weaker than the same size of bolt with a Whitworth thread. The strength of the Sellers screw is still further reduced on account of the sudden change of the cross-section of the bolt at the bottom of the thread."

CHANGE-WHEELS.

Cutting a screw in the lathe is a mechanical operation, of which the most important part is the selection of the proper change-wheels. Change-wheels, or change-gears, are the gear-wheels employed to change the revolutions of a lead-screw, or feed motion.

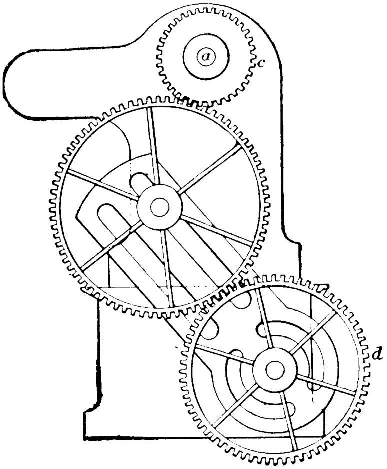

Fig. 82.

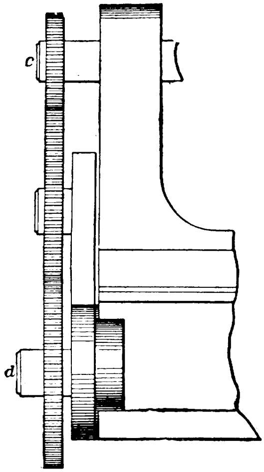

Fig. 83.

There are two ways of arranging the wheels: 1st, with two change-wheels; 2d, with four change-wheels.

Fig. 82 shows the two change-wheels, *c* and *d;* the middle wheel serves only to connect the two; *c* is the wheel on the spindle *a; d* is that on the leading screw.

Fig. 83 is a side view of this two-change-wheel.

The distance between the spindle and the leading screw of a lathe does not generally admit of cutting a

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screw of more than ten threads to the inch, with *two* wheels, as the wheel on the leading screw would be too large, and that on the spindle too small.

In the same way, for cutting coarse-pitched screws, such as half a turn to the inch, the second method is generally used, or else the wheel on the leading screw would

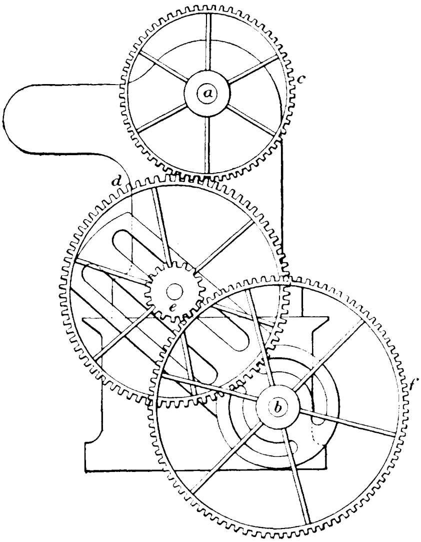


Fig. 84.

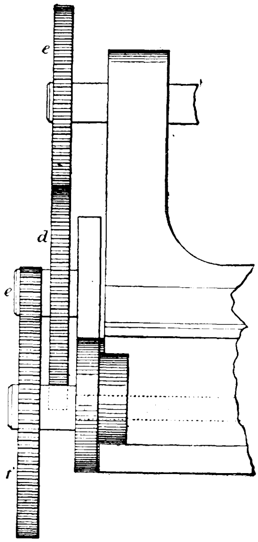


Fig. 85.

be too small, and that on the spindle too large. Thus the second method is employed for cutting screws of coarser pitch than one-half a thread, and finer than ten threads to the inch, and the first method for screws of a pitch intermediate between one-half a thread and ten threads to the inch.

Fig. 84 shows the second arrangement with four change-wheels, *c*, *d*, *e*, *f*; *c* is the wheel on the spindle, *d*

CHANGE-WHEELS.

and *c* are the wheels on the stud, *f* is the wheel on the leading screw *b*.

Fig. 85 is a side view of the arrangement with four change-wheels.

The rule for calculating the size of the change-wheels to cut threads of different pitches is really a very simple one, though frequently a source of difficulty to the student. It may be expressed as a simple proportion sum, thus:

As the pitch of the leading screw is to the pitch of the screw to be cut, so is the number of teeth in the wheel on the spindle to the number of teeth in the wheel on the leading screw.

Putting this in fractional form, we have:

$$\frac{\text{Pitch of leading screw}}{\text{Pitch of screw to be cut}} = \frac{\text{Wheel on spindle}}{\text{Wheel on leading screw.}}$$

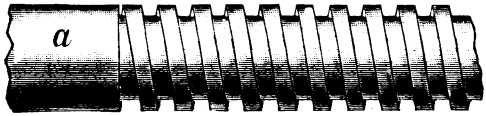


Fig. 86.

EXAMPLE I.—Suppose that the lathe has a leading screw, *a*, with four threads to the inch; what wheels will be required to cut a screw, *b*, having eight threads per inch?

Fig. 87.

NOTE.—It simplifies matters by using the number of threads per inch in the two screws instead of the pitch, as in most cases it enables us to use whole numbers instead of fractions for figures.

SCREW-CUTTING IN THE LATHE.

Now, substituting these figures in the above fractions, we get

$$\frac{4}{8} = \frac{\text{Wheel on spindle}}{\text{Wheel on leading screw}},$$

therefore, any two wheels in the proportions of four to eight will answer the purpose; if we multiply both these figures by the same number we do not alter the proportions at all; therefore, by multiplying both by five we get twenty and forty, as two suitable wheels, or multiplying by ten we get forty and eighty, or multiplying by fifteen we get sixty and one hundred and twenty, any of which pair will give the desired result.

Selecting the last pair, put the sixty wheel on the spindle and the one hundred and twenty wheel on the leading screw, and gear the two together by inserting an intermediate wheel, which may be whatever size will fit it best.

EXAMPLE 2.—Suppose a screw of eleven threads per inch is to be cut in the same lathe, the leading screw has four threads to the inch, as before, then the proportion required between the wheels is $\frac{4}{11}$, so that (multiplying by ten), a forty and a one hundred and ten wheel will be correct, or (multiplying by five), a twenty and a fifty-five wheel, or any wheels having the same ratio.

If a fractional number of threads is to be cut, such as $9\frac{1}{2}$ threads per inch, exactly the same plan is adopted. The proportion is $4 : 9\frac{1}{2}$; multiplying both by ten, we get forty and ninty-five as suitable wheels.

Similarly, if the leading screw have two threads per inch, and it is desired to cut twelve threads per inch, the

CHANGE-WHEELS.

proportion is 2:12. Multiplying both by ten, we get twenty and one hundred and twenty as being suitable wheels.

It is sometimes difficult to measure the exact number of threads per inch in places where there is a fractional part of a thread included, as, for instance, five and a quarter threads per inch. It is then better to measure such a length of the screw as contains an exact number of threads, and compare it with the number of threads in a similar length of the leading screw. A screw with five and a quarter threads per inch will have twenty-one complete threads in a distance of four inches. If the leading screw has four threads to the inch, it will clearly have sixteen complete threads in four inches. Therefore the relation between the two screws is 16:21. Multiplying both of these by five, we get eighty and one hundred and five as the wheels necessary to cut such a thread.

The calculations so far refer to a simple train of wheels. Cases frequently arise, however, especially with fine pitches, in which the wheels calculated in this way are not available. If the leading screw has four threads to the inch, and it is required to cut a screw of forty threads to the inch, the proportion is 4:40. Multiplying both by five, we get twenty and two hundred as the necessary wheels, but in all probality the lathe to be operated is not fitted with a two hundred wheel. A compound train of wheels, that is, four change-wheels, as shown in fig. 84, must therefore be selected.

To calculate these, proceed as follows: The proportion, as already stated is $\frac{4}{40}$. Split each number up into two separate numbers, which, if multiplied together, will produce the original number, thus $\frac{4}{40}=\frac{2}{5}\times\frac{2}{8}$. Multiplying each of these numbers by 10, we get $\frac{20}{50}\times\frac{20}{80}$. This means that a wheel on the spindle, gearing into a 50 wheel on the intermediate stud, and another 20 wheel on the intermediate stud, gearing into an 80 wheel on the leading screw, will give the desired result.

It will be more easily understood if the student considers the fact that the first 20 wheel, *c*, gearing into the 50 wheel, *d*, reduces the speed in the proportion of 2½ to 1, and the second 20 wheel, *e*, gearing into the 80 wheel, *f*, on the leading screw again reduces this speed in the proportion of 4 to 1, making a total reduction in speed of 10 to 1, which is the proportion between the thread to be cut and the thread on the leading screw, *i. e.*, 4 to 40.

A few other examples are worked out to assist the reader to thoroughly grasp the rule.

EXAMPLE 1.—Leading screw two threads per inch, required the wheels to cut twenty-five threads per inch.

$$\frac{2}{25}=\frac{2\times 1}{5\times 5}$$

Multiplying each pair of numbers by the same figure, we get $\frac{20\times 10}{50\times 50}$ as one set of wheels, or using different multipliers we get $\frac{30\times 25}{75\times 125}$ as another set of wheels, either of which will cut the desired threads. The respective wheels may be identified by comparing the above fractions with the following:

$$\frac{\text{Driving wheel on spindle}\times\text{driving wheel on stud}}{\text{driven wheel on stud}\times\text{driven wheel on leading screw.}}$$

CHANGE-WHEELS.

The figures in the fractions of all the examples correspond to the wheel here indicated in the same position.

EXAMPLE 2.—Leading screw two threads per inch, required the wheels to cut nineteen threads per inch.

$$\frac{2}{19}=\frac{2\times 1}{9\frac{1}{2}\times 2}=\frac{20\times 40}{95\times 80}$$

as one set of wheels, or $\frac{20\times 35}{95\times 70}$ as another set of wheels.

EXAMPLE 3.—Leading screw four threads per inch, required the wheels to cut thirty-three threads per inch.

$$\frac{4}{33}=\frac{2\times 2}{3\times 11}=\frac{40\times 20}{60\times 110}$$

as one set of wheels, or $\frac{30\times 20}{45\times 110}$ as another set of wheels, either of which would do.

EX. 4.—Leading screw four threads per inch, required the wheels to cut seventeen and a half threads per inch.

If there are seventeen and a half threads in one inch of the screw to be cut, there are thirty-five threads in two inches. In two inches of the leading screw there are eight threads, so that the proportion is $\frac{8}{35}$

$$\frac{8}{35}=\frac{2\times 4}{5\times 7}=\frac{20\times 40}{50\times 70}$$

as one set of wheels, or $\frac{40\times 60}{100\times 105}$ as another set, which will cut the desired pitch.

If any doubts exist as to the correctness of the calculations for a set of wheels, the result may easily be tested by multiplying the number of teeth in the driving wheels together and the number of teeth in the driven wheels

SCREW-CUTTING IN THE LATHE.

together, and placing these totals one above the other, in the form of a fraction. Then reduce this fraction to its lowest terms, and the figures obtained should correspond with the ratio of the leading screw to the screw to be cut, expressed in its lowest terms. Thus, to prove the second

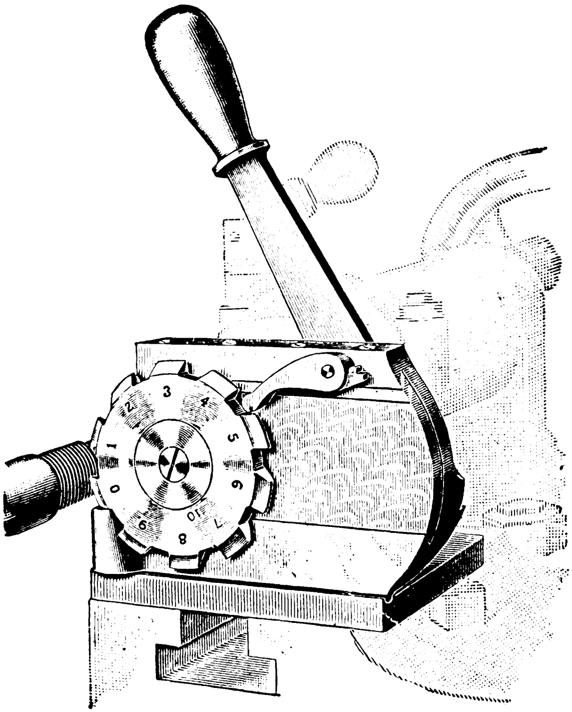


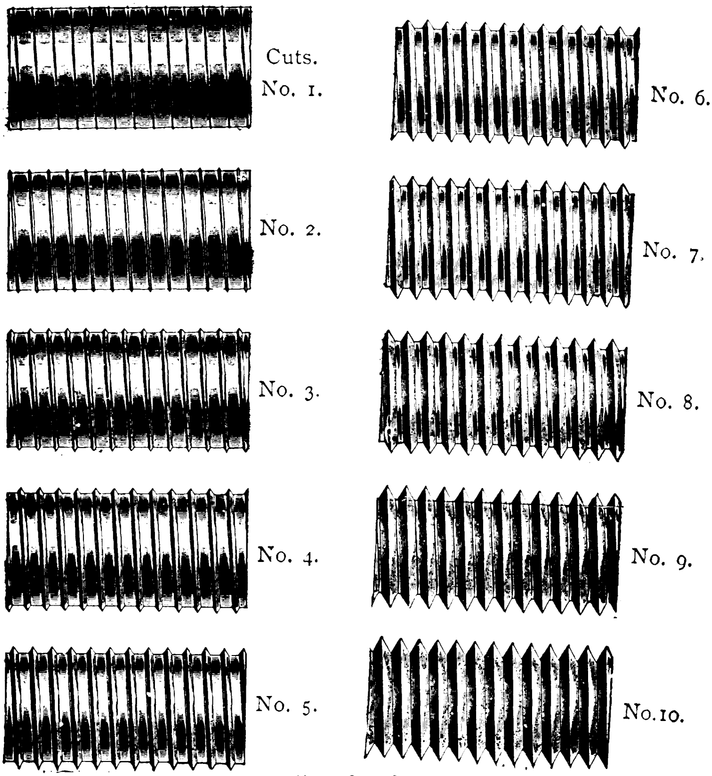
Fig. 88.

wheels obtained in example (1), we have thirty and twenty-five as drivers, and 75 and 125 as the driven wheels. $30 \times 25 = 750$, and $75 \times 125 = 9,375$. $\frac{750}{9375}$ reduced to its lowest term $= \frac{2}{25}$, which represents the ratio of the leading

CHANGE-WHEELS.

screw (two threads per inch) to the screw to be cut (twenty-five threads per inch).

It should be remembered that the "drivers" are those wheels which impart motion, and the "driven"



Figs. 89–98.

wheels are those which receive motion. The wheel on the spindle is a "driver," while the wheel on the leading screw is a "driven" wheel; the wheel on the intermediate stud, which gears with the spindle wheel, is a "driven" wheel, and the other wheel, on the intermediate stud, which imparts motion to the wheel on the leading screw, is a "driver."

Fig. 88 shows a specially devised tool in operation, cutting a screw-thread on the lathe; the tool consists, as will be seen, of a disc of steel having ten distinct teeth on its rim, these teeth are graded for cutting the thread in distinct operations of the tool.

The cutter is mounted on a hand-sliding rest, which is bolted to the ordinary lathe carriage, and the tool is adjusted to each cut by the hand lever. Fig. 99 shows a separate view of the cutter.

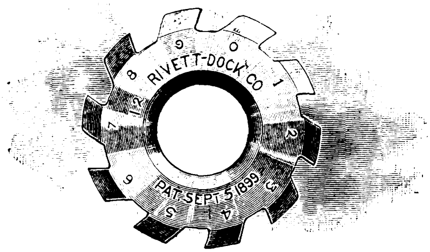


Fig. 99.

Figs. 89–98 show a screw as it would appear after each cut has been performed. Commencing at No. 1, the thread is finished in ten trips, each of which removes an exact depth of stock. The first tooth, No. 1, makes a shallow cut the full width of the thread; each following tooth cuts deeper (as well as narrower), until the last one (No. 10), with its cutting point, does the finishing.

When fine work, such as for taps, etc., is required, the pawl is thrown back out of action, the micrometer adjustment used, and another trip taken across the thread. Advancing the lever one hole in the micrometer adjustment brings the cutting point a fraction of a thousandth of an inch forward. Successive trips with advance of lever will give the finest finish possible to a thread.

The heel of the tooth in action rests upon a stop, so that it can be ground until but an eighth of an inch in thickness, and still retain the full strength and power to do the work; a square is employed against the face of the cutting disc, and the thread angles are ground from this face.

When once set, neither tool nor cross-slide adjustment need to be changed in cutting the screw or any number of screws in exact duplication.

This form of tool requires very little grinding, as the point of the tool is reserved and only used in the finishing or last cut.

Ingenuity on the part of the lathe builders has resulted in the design of a simple contrivance by which the gears which are mounted under the head can be instantly set to cut any required thread at the will of the operator, without delay of calculating or of changing the gears. The mechanism consists of a set of gear wheels, usually ten, mounted on a shaft called the "change gear shaft," which is placed in the bed under the headstock of the lathe.

By an arrangement consisting of a sliding or tumbling gear, any of these ten fixed gears can be brought into operation; these combine with a set of intermediate gears located outside of the head, also varied in their arrangement by a lever mechanism, to vary the speed of the lead

SCREW-CUTTING IN THE LATHE.

screw to cut any of the following forty threads or feeds per inch.

Fig. 100 shows an index plate for the "change gear shaft"; this is usually attached to the front of the lathe, "handy" to the two levers to which reference is made.

THDS	KNOB	THDS	KNOB	THDS	KNOB	THDS	KNOB
18	2	9	2	4½	2	2	1
19	3	9½	3	4¾	3	2¼	2
20	4	10	4	5	4	2½	4
22	5	11	5	5½	5	2¾	5
23	6	11½	6	5¾	6	2⅞	6
24	7	12	7	6	7	3	7
26	8	13	8	6½	8	3¼	8
28	9	14	9	7	9	3½	9
30	10	15	10	7½	10	3¾	10
32	11	16	11	8	11	4	11
		FEEDS					
80 To 40		40 To 20		20 To 10		10 To 5	

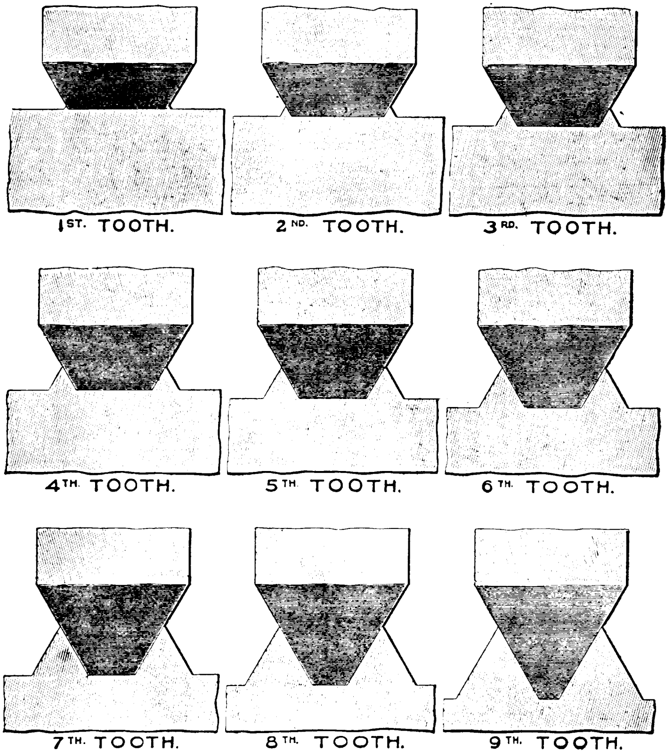
18-Inch Index Plate.

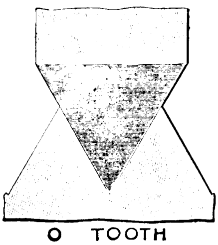
Fig. 100.

EXAMPLE.—Should the operator desire to cut 12 threads per inch, he engages the sliding gear on the lead screw intermediates, opposite the table showing 20 to 10 threads per inch, and then places the lever in front of the lathe head, which carries the sliding or tumbling gear into the hole marked "7," as indicated in the index plate opposite 12, the number of required threads; the tool is then ready for operation.

The gears required are obtained by moving two levers only; one being on the intermediate gear of the lead screw, the other being outside the headstock.

CHANGE-WHEELS.





Section of seven-pitch V-thread, enlarged four times, showing the regular ten cuts taken by the Rivet-Dock thread tool shown in fig. 88.

Figs. 101–110.

SCREW-CUTTING IN THE LATHE.

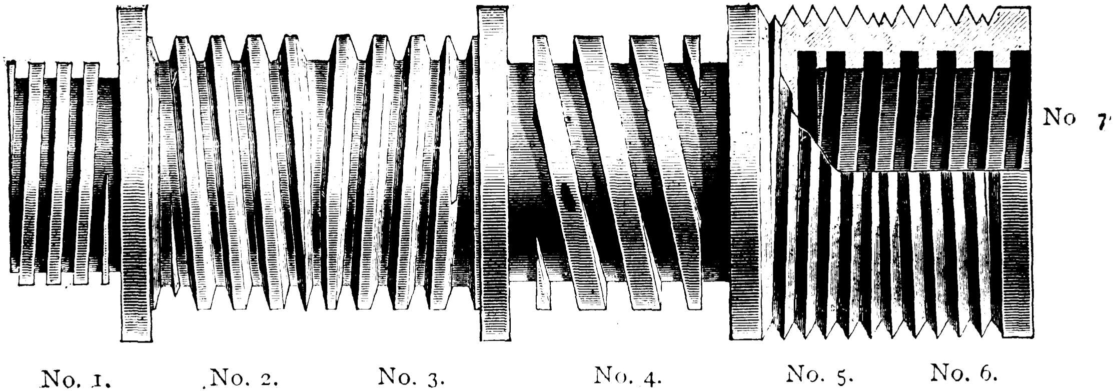


Fig. 111.

The above figure represents an external screw cut in a lathe without "change-wheels," and with the work constantly in motion and effected through the use of an automatic-stop on the carriage. No. 7 in the figure shows an internal thread cut to the shoulder by the same contrivance.

CHANGE-WHEELS.

The gauge, fig. 112, is used as a standard for grinding tools to cut threads according to the United States Standard.

The angles are 60 degrees, and the flat surfaces at top and bottom of threads are equal to one eighth of the pitch.

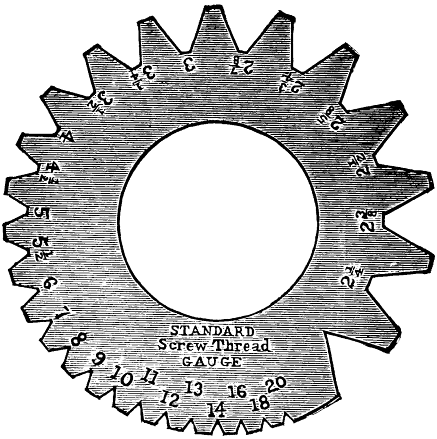


Fig. 112.

Fig. 113 shows a center gauge of United States Standard, 60 degrees; the method of setting a screw cutting tool by its use is shown in illustrations, figs. 114–116, on page 137.

This gauge is also used for a guide in grinding screw cutting-tools. The table on the gauge (see full size cut) is used for determining the sizes of tap drills for V-threads

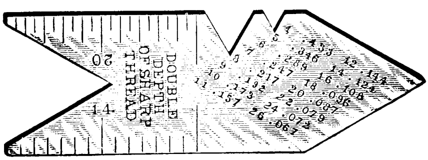
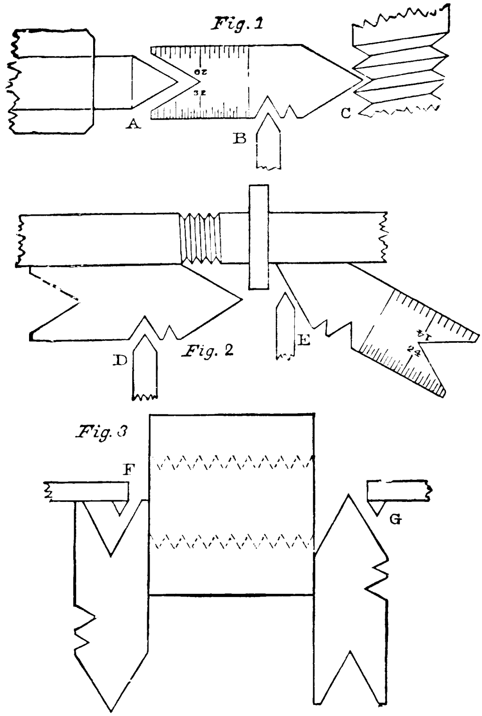


Fig. 113.

SCREW-CUTTING IN THE LATHE.

and shows in thousandths of an inch the double depth of thread of taps and screws of the pitches most commonly used.



Figs. 114-116.

NOTE.—In *Fig. 1*, at *A*, is shown the manner of gauging the angle to which a lathe centre should be turned; at *B*, the angle to which a screw thread cutting tool should be ground; and at *C*, the correctness of the angle of a screw thread already cut.

In *Fig. 2* the shaft with a screw thread is supposed to be held between the centres of a lathe. By applying the gauge as shown at *D*, or *E*, the thread tool can be set at right angles to the shaft and then fastened in place by the screw in tool post, thereby avoiding imperfect or leaning threads.

In *Fig. 3*, at *F* and *G*, the manner of setting the tool for cutting inside threads is illustrated.

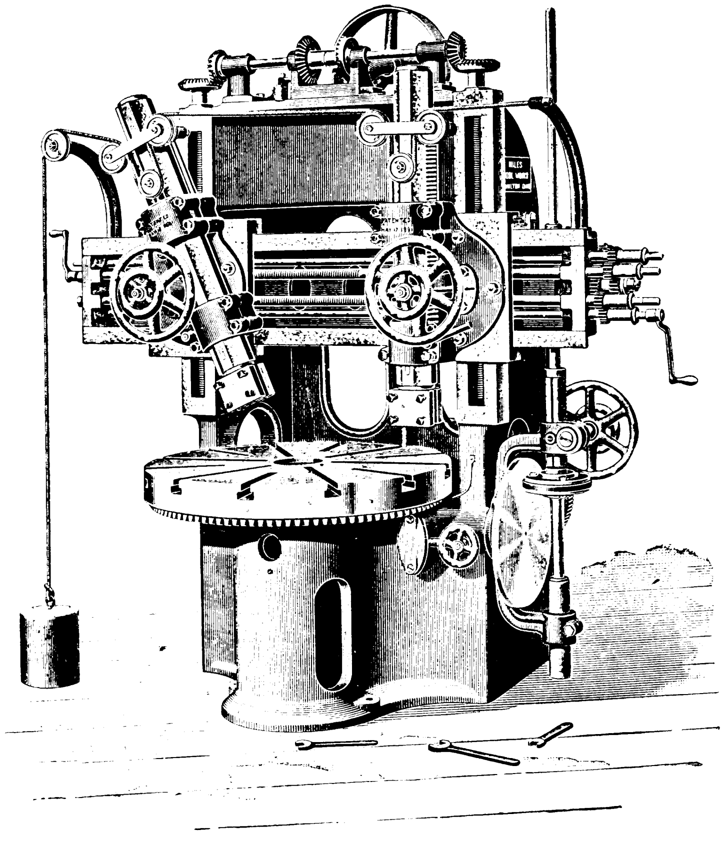


Fig. 117.

BORING OPERATIONS.

The operation of *boring* is the enlarging and trueing of holes already formed, and differs from *drilling*, which applies to making holes in solid stock.

Boring can be divided into two classes: 1, horizontal; 2, vertical Horizontal boring is done in a lathe in two ways: 1, the work rotates and the cutting tool is stationary; 2, the work is stationary and the cutting tool rotates.

Vertical boring is generally performed in special machines; in light work, *the cutting tool revolves*, as in drilling, the work being stationary; in heavy boring, *the work is revolved*, and the cutting tool is stationary except for feed motions.

Vertical boring machines having suitable automatic traverse for the cutting tool are largely used for turning and surfacing work which rotates; these machines are known as boring and turning mills, and may be described as revolving planing machines.

The most simple form of boring in a lathe is done on the chuck or face-plate, to which the work is fixed and rotated to a stationary tool in the saddle or carriage. When the hole is deep and the tool has to project beyond the holder, it is liable to spring, and the work itself, being overhung on the headstock, is liable to jar; in such cases, the work is more advantageously attached to the carriage of the lathe, and a bar used, as shown in fig. 118. This is designed to pass through the work and revolve between the lathe centers, as shown in figs. 120 and 122, the carriage feeding the work to the rotating cutter.

In some cases, it is found needful to fix the work without any motion, the boring bar having both rotary and feed motion combined; such a boring bar is shown in fig. 119. *K* is a stout, strong bar, usually of cast-iron, because it does not "spring" as readily as wrought-iron; the cutting tool *L* is fixed to a sleeve *H* sliding on bar *K* by

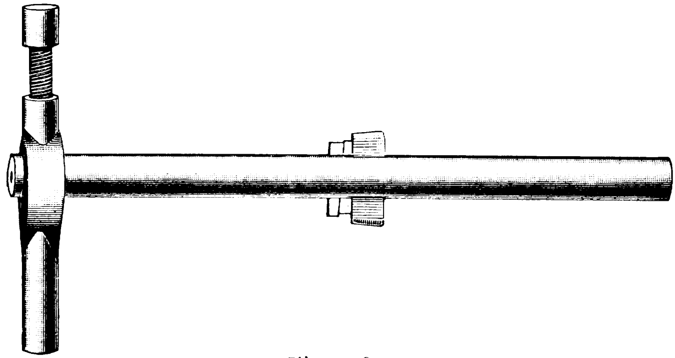


Fig. 118.

means of the feed screw actuated by the handle *G*, or automatically by the provision *I* at the other end, as shown; the work to be operated on is securely fixed between the clamps or bearings *F* and *J*, the splined boring-bar *K* is rotated by the worm-wheel *E*, which is operated by the worm *D* connected to the driving-pulley or sheave *A*.

This is a portable tool, useful for boring cylinders, etc., without removing them from their beds, as it can be fixed at any angle or position; it may also be used between the centers of the lathe instead of the plain boring bar shown in fig. 118.

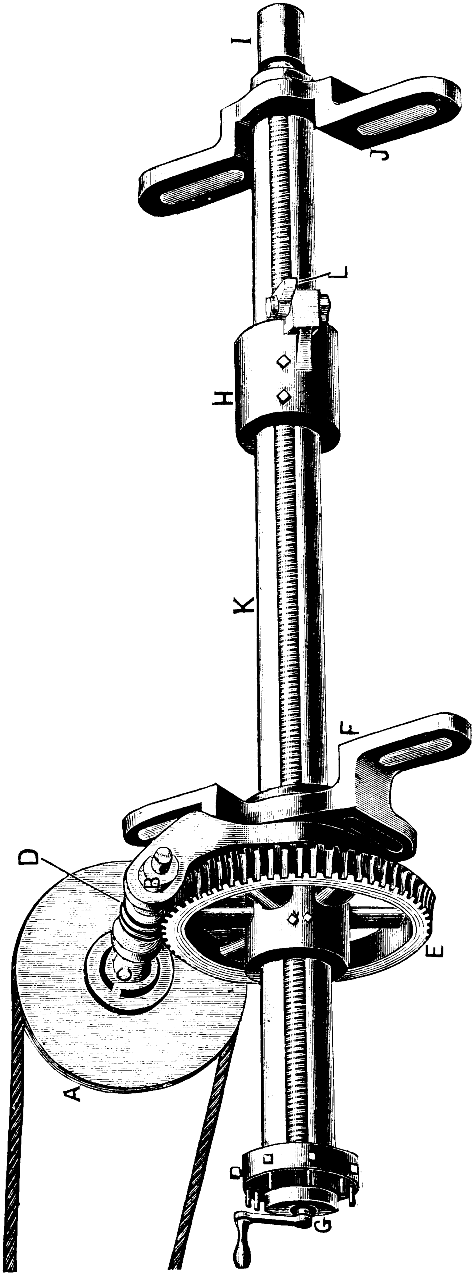


Fig. 119.

TURNING AND BORING.

Special horizontal boring machines are made which differ from the ordinary lathe in that the work-table is constructed with three movements, one being in a vertical and two in the horizontal plane; when the work has been set vertically, the work-table is moved crosswise and lengthwise

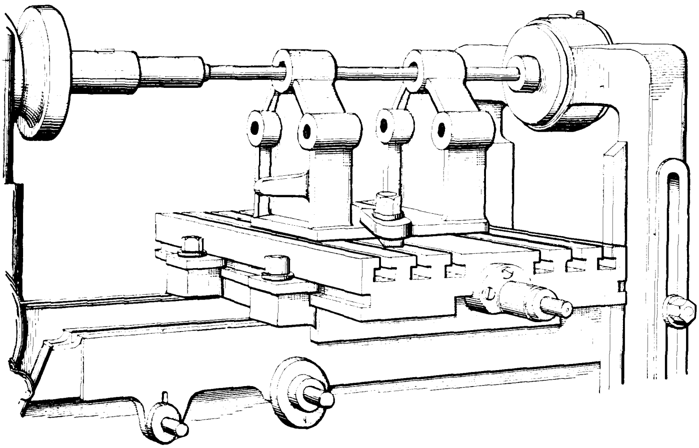
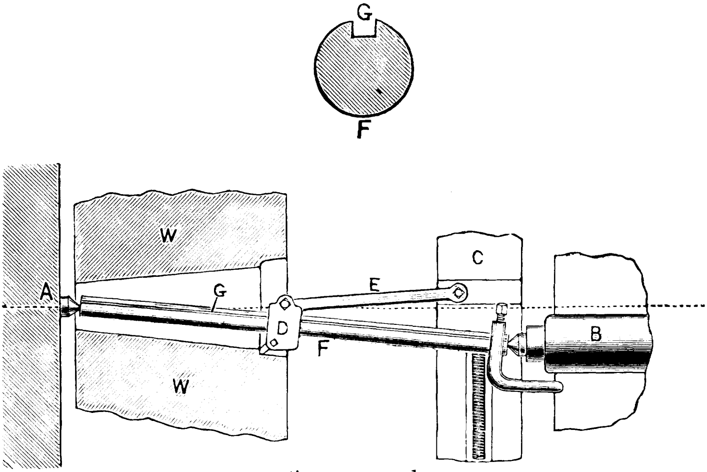


Fig. 120.

until the horizontal setting has been found; no blocking of any kind is needed; such an arrangement is shown in fig. 120.

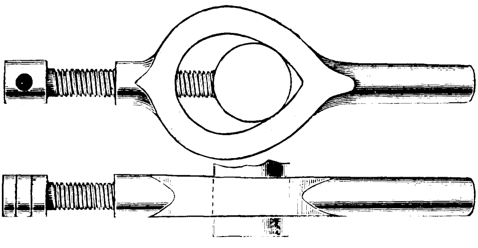
Boring of taper holes in a lathe is illustrated by the arrangement shown in fig. 122; this is used when neither attachment, compound rest nor reamers are available; *A* is the headstock of the lathe, and *W W* the piece of work mounted on the face-plate.

Now, set over the tail-stock *B* the same as if turning, an outside taper the same as the hole to be bored. Fit up a boring-bar *F*, of as large diameter as practicable, with a key-way *G*, and a traveling-head *D* carrying a cutter. Connect this traveling-head to the cross-carriage of the lathe *C* by the link *E*. Set a lathe-dog (see figs. 123 and 124) on



Figs. 121 and 122.

the outer end of the bar to prevent the bar from turning. Use the usual power longitudinal feed of the lathe, and adjust the cutter in the traveling-head for size the same as



Figs. 123 and 124.

for cylinder boring. This is a satisfactory way of taper boring where the conditions are suitable for the method.

THE BORING MILL.

The boring mill is essentially a vertical face-plate lathe, without the defects of the horizontal construction, *i. e.*, the

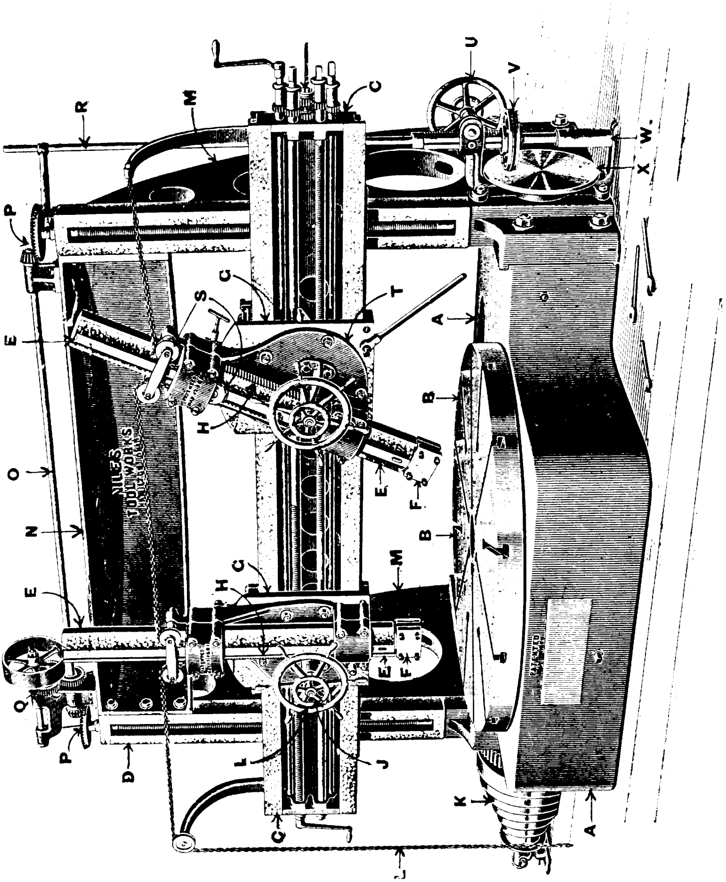


Fig. 125.

difficulty of setting and securing the work, and the necessity of heavy overhanging parts, etc.

BORING OPERATIONS.

Fig. 125 shows a boring mill, in which the horizontal table *B* is driven by internal bevel-gearing from a belt-cone *K*, the power being increased by external spur-gearing. The bed *A* is cast in one piece and well ribbed and braced for all stresses; the "housings" *M* are of hollow section, having wide palms where connected to the bed, to which they are fixed by bolts passing through reamed holes; a cross-brace *N*, at the top, stiffens the whole structure; the cross-rails *c*, *c*, are of box-girder form, having wide slide surfaces for the saddles *b*, *b*, and for the "housings;" power gears *Q* are used for elevating the cross-rails; the saddles *b*, *b*, are made "right" and "left," to permit the tool-bars *E*, *E*, to come close together; these tool-bars are octagonal in section, held in adjustable capped bearings, and will swing to any angle, being counter-weighted in all positions, and having convenient adjustment by racks *H*, *H*, and hand pinion wheel *I*, which have a power feed at all angles by friction nut *J*, *J*.

P, *P*, are the gears for elevating the cross-rails; the friction disc *X* communicates motion to rod *R* through the friction wheel *V*, which gives the quickest possible adjustment by handwheel *U* while running; a system of double gears at the end of the cross-rail gives vertical and horizontal traverse feeds to the tool; these are instantly reversible by sliding any one of the four slip gears shown in sketch.

The tool holders *F*, *F*, fig. 125, are solid steel forgings, held in the tool-bars by steel shanks and keys; these tool

NOTE.—The names of the parts and the above description are furnished by the makers of this admirable tool.

BORING MILL.

holders will grip tools in any position, and are easily removable for the insertion of cutter-bars or special tools, for which purpose the right-hand bar is set exactly central with the table; the counterweight acts at all angles through the wide bearing surface; in addition, the table has an annular, angular bearing which increases the bearing surface and

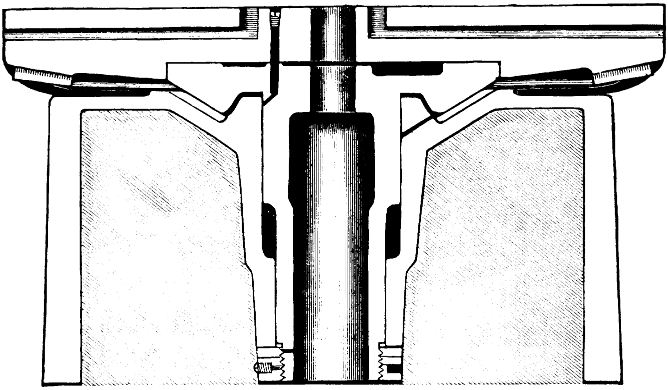


Fig. 126.

gives steadiness of motion; it has also a self-centering tendency, so that the combined weight of the table and spindle, as well as that of the work upon the table, tends to preserve and not destroy the alignment.

The advantages in the boring mill are that the work lies upon the horizontal table, and the total weight of the table and the work is distributed on a large angular bearing provided for that purpose, as shown in section, fig. 126, which gives rigidity and smooth cutting qualities, thus avoiding all jar or trembling, which occur in overhung lathes.

BORING MILLS.

Vertical boring machines are largely taking the place of planing machines for doing "surface" work. The continuous motion of the boring mill gives economy in time saved; an additional advantage is that a cutting-tool on a circular surface, when once it commences the cut, is continuous, whereas, in the planing machine, the tool gets into

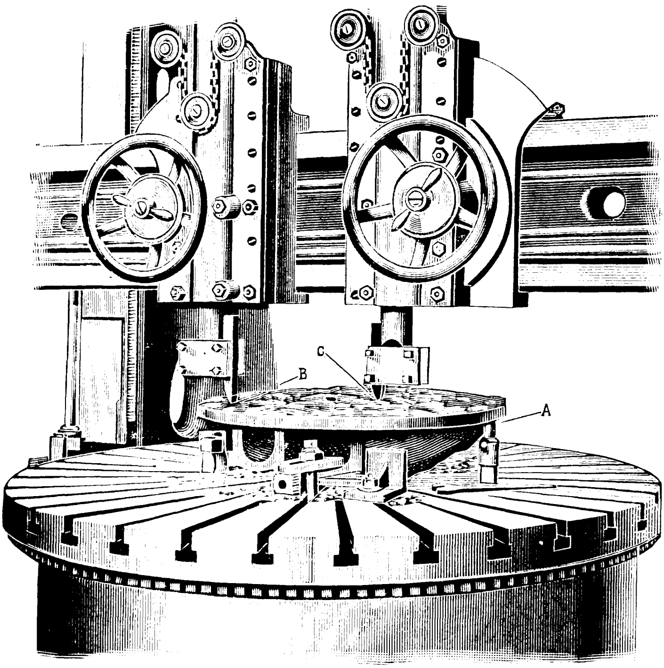


Fig. 127.

and out of the work at each stroke, often causing a ridge at the commencement, or a break-off at the termination, of the cut.

Fig. 127 shows a valve, held by angle-plates on the table, being faced or operated by two tools.

TURNING AND BORING.

Fig. 117 shows a boring mill driven by an external bevel-ring attached to the table. In many boring mills, an internal worm-wheel, geared into a worm on the cone spindle, is used, instead of chain *L* and the sheaves *S*, *S*, and does not pull the swinging tool-bar over, nor does it interfere with the moving saddles.

A section through the center of the revolving table is shown in fig. 126, the center spindle being of large diameter giving toothed gear the advantages claimed for the worm gearing, *i. e.*, steadiness in motion, and the table is closer to the floor level, thus being more convenient for handling heavy work.

When worm gearing is adopted, it is necessary that it and the thrust-bearing should run in a flood of oil, which reduces the friction to a minimum.

On page 149 are shown a set of turning tools for general use in a boring mill.

Fig. 128 being "a skiveing tool."

Fig. 129 is "a round-nose tool."

Fig. 130 is "a boring tool."

Fig. 131 is "a hog-nose roughing tool."

Fig. 132 is "a side tool."

Fig. 133 is "a broad finishing tool."

On page 150 are shown a set of boring tools for finishing cored-holes. Fig. 134 is an adjustable reamer with floating shank, the arrangement of which is shown in section in fig. 135. Fig. 136 is a boring bar with an adjustable cutter. Fig. 137 is a four-lipped roughing drill.

BORING-MACHINE TOOLS.

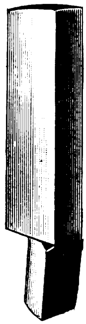


Fig. 128.

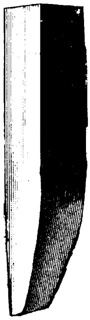


Fig. 129.

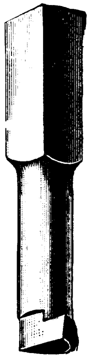


Fig. 130.

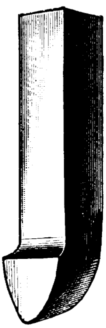


Fig. 131.

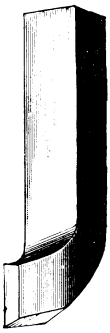


Fig. 132.

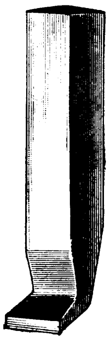


Fig. 133.

BORING MACHINE TOOLS.

A boring mill is practically an endless or continuous planer, that is, a planer without reversing. The convenience and facility with which work can be set on the vertical table, and the ease with which pieces can be secured, are apparent, the weight of the piece being on the machine and not on the securing device.


Fig. 134.

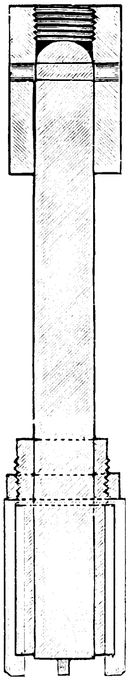


Fig. 135.

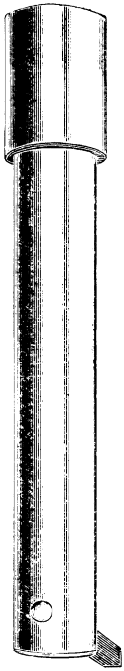


Fig. 136.

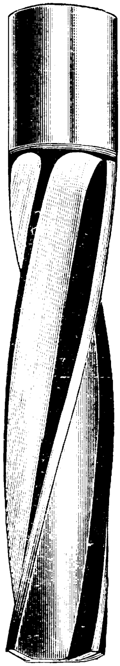


Fig. 137.

Irregular shapes, such as eccentric discs, offset valves, brackets, etc., require no counterbalance in the boring mill, thus saving the time adjusting counterweights, which are seldom satisfactory on the overhung lathe, even when specially designed.