CHAPTER XXI.—THREAD CUTTING.—BROACHING PRESS.

IN Fig. 1809 is represented a front view of a patent die stock for threading pipe up to six inches in diameter. In the figure the three bits or chasers are shown locked in position by the face plate, which is shown removed in Fig. 1810. Fig. 1811 shows the machine with the face plate removed, the bit or chasers having pins in them which fit into the slots in the face plate, so that by rotating the plate the chasers may be set to size.

The head carrying the chasers is revolved by means of the gear-wheel and pinion, and Fig. 1812 represents a ratchet lever for revolving the pinion, and is useful when the pipe is in the

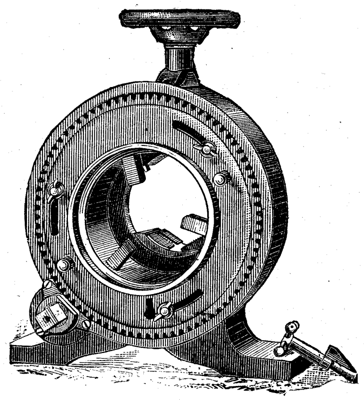

Fig. 1809.

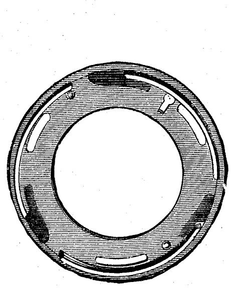

Fig. 1810.

ground and the die stock is used to cut it off and thread it without lifting it from its position.

The method of gripping the pipe is shown in Fig. 1813, in which the machine is represented as arranged for operating by belt power, the pinion being operated by a worm and worm-gear.

Referring to the pipe-gripping vice it is seen in the figure that the back of the machine is provided with ways in which the gripping jaws slide. The lower jaw is adjusted for height to suit

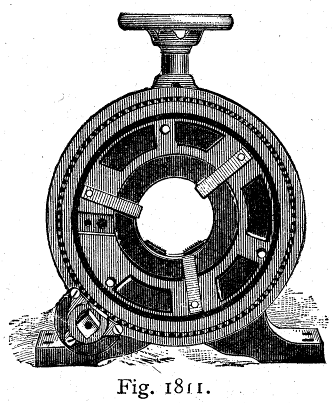

Fig. 1811.

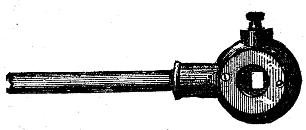

Fig. 1812.

the size of pipe to be operated upon, and is firmly locked in its adjusted position. It is provided with an index pointer, and the face of the slideway is marked by lines to suit the different diameters of pipe, so that this jaw may at once be set to the proper height to bring the pipe central to the bits. The lower jaw being set, all that is necessary is, by means of the hand wheel, to operate the upper one to firmly grip the pipe. Fig. 1814 shows the front of the machine when arranged for belt power.

The No. 1 die stock threads pipe from one to two inches in diameter, but has no cut-off. The large gear has cut teeth, and the pinion is of steel, working in gun-metal bearings. The gripping jaws are fitted with cast-steel faces, hardened.

By a simple change the stock may be used to cut left-hand as well as right-hand threads, this change consisting in putting in left-hand bits and in replacing the right-hand screw ring with a left-hand one. After a piece of pipe has been threaded, all that is necessary is to turn the head in the opposite direction, and the

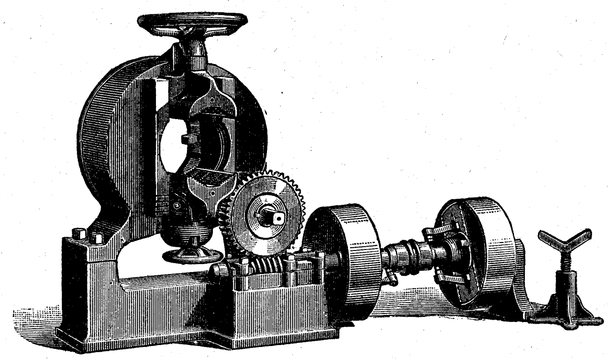

Fig. 1813.

bits retire from the pipe thread, so that the pipe may at once be withdrawn, which preserves the cutting edges of the bits as well as saves the time usually lost in winding the dies back.

In threading machines the bolt (or pipe, as the case may be) may be revolved and the die held stationary, or the die may be revolved and the pipe held from revolving, the differences between the two systems being as follows, which is from *The American Machinist*:—

Fig. 1815 may be taken to represent a machine in which the pipe is held and the die revolved, and Fig. 1816 one in which the pipe is revolved and the dies are held in a head, which allows them to move laterally to suit the pipe that may not run true, while it prevents them from revolving.

In the former figure the bolt or pipe is shown to be out of line with the die driving spindle, and the result will be that the thread will not be parallel with the axis of the pipe. Whereas in

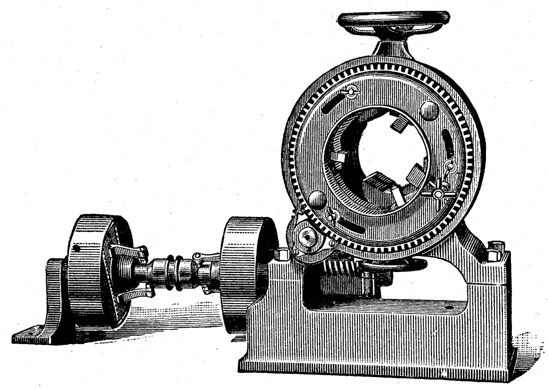

Fig. 1814.

Fig. 1816 the thread will be true with the axis of the work, because the latter revolves, and as the die is permitted more lateral motion it can move to accommodate itself to the eccentric motion of the work, if the latter should not run true.

If the end of a piece of pipe is not cut off square or at a right angle to the pipe axis, and the die has liberty to move, it will thread or take hold of one part, the longest one, of the pipe circumference first, and the die will cant over out of square with the pipe axis, and the thread cut will not be in line with the pipe axis.

The two important points in operating threading machines is

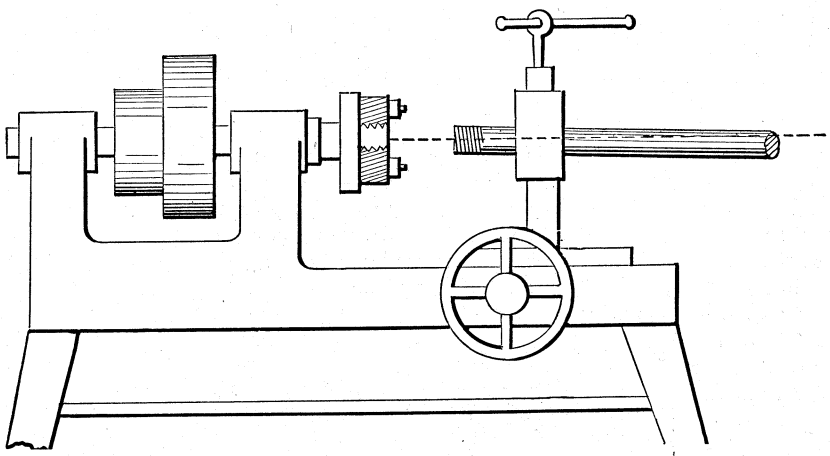

Fig. 1815.

to keep the dies sharp and to well lubricate them with oil. When dies are run at a maximum speed and continuously at work they

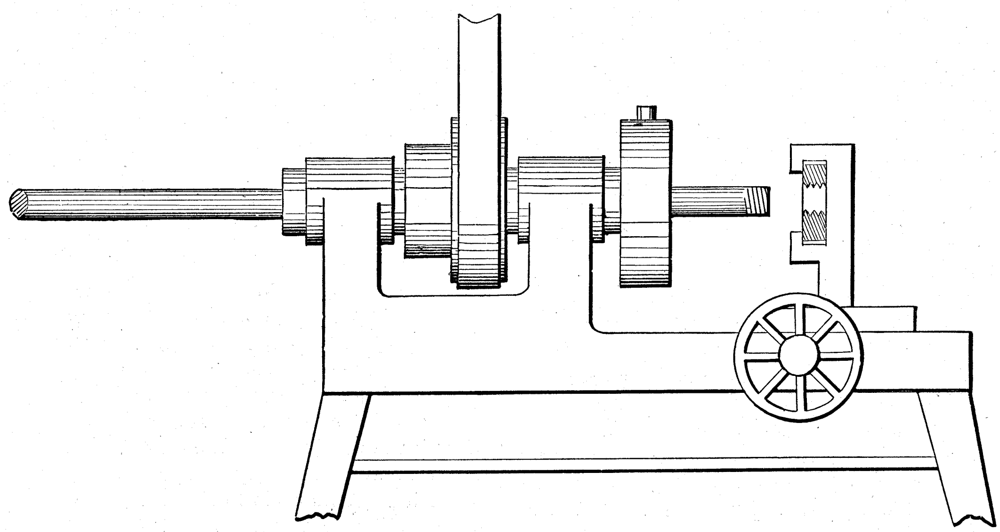

Fig. 1816.

should be sharpened once or, if the duty is heavy, twice a day, a very little grinding sufficing.

In nut tapping the oil lubrication is of the utmost importance, and is more difficult because the cuttings are apt to clog the tap flutes and prevent the oil from flowing into the cutting teeth.

When the tap stands vertical and the nuts are put on at the upper end (the point of the tap being uppermost), the cuttings are apt to pass upwards and prevent perfect lubrication by the descending oil. When the taps stand horizontally, gravity does not assist the oil to pass into the nut, and it falls rapidly from the tap, hence it is preferable that the tap should stand vertical with its point downwards, and running in oil and water.

In machines which cut the bolt threads with a solid die, it is obvious that after the thread is cut upon the bolt to the required distance, the direction of rotation of the bolt or die, as the case may be, requires to be reversed in order to remove the bolt from the die, and during this reversal of rotation the thread upon the bolt is apt to rub against and impair the cutting edges of the chasers or die teeth.

To obviate this difficulty in power machines the dies are sometimes caused to open when the bolt is threaded to the required distance, which enables the instant removal of the finished work, and this saves time as well as preserving the cutting edges of the die or chaser teeth.

In machines in which the bolt rotates, the machine must be stopped to take out each finished bolt and insert the blank one, which is unnecessary when the bolt is stationary, because so soon as the bolt is threaded to the required distance the dies may open automatically, the carriage holding the bolt at once withdrawn and a new one inserted.

When the dies open automatically the further advantage is secured that the bolts will all be threaded to an equal distance or length without care on the part of the operator.

A hand machine for threading bolts from $\frac{1}{4}$ inch to $\frac{3}{4}$ inch in diameter is shown in Fig. 1817. It consists of a head carrying a live spindle revolved by hand, by the lever shown at the right-hand end of the machine, being secured to the live spindle by a set-screw, so that the handle may be used at a greater or less leverage to suit the size of the thread to be cut; on the front end of this spindle are the dies, consisting of four chasers held in a collet that is readily removable from the spindle, being held by a spring bolt which, when pressed downwards, frees the collet from the spindle.

The work is held in a pair of vice jaws operated by the hand wheel shown, and this vice is moved endwise in its slideways on the bed by means of the vertical lever shown. The bolt being stationary, the small diameter of the die enables it to thread bent or crooked pieces, such as staples, &c.

For bolts of larger diameter requiring more force than can be

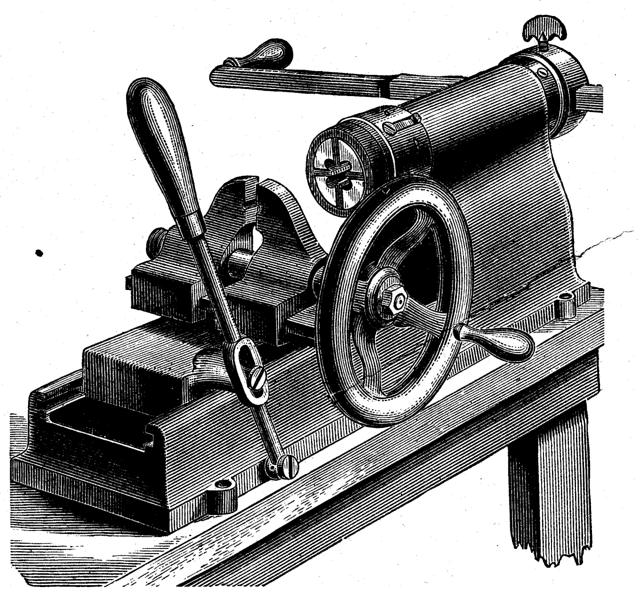

Fig. 1817.

exerted by a hand lever, a geared hand bolt cutter is employed.

In Fig. 1818 is represented a hand bolt cutter. In this cutter the bolt is rotated, being held in a suitable chuck. The revolving spindle is hollow in order to receive rods of any length, and is operated by bevel-wheels as shown, so as to increase the driving power of the spindle by decreasing its speed of rotation. To provide for a greater speed of rotation than that due to the diameters of the bevel-pinion and wheel, the lever is made to slide through the pinion, effecting the same object and convenience as described for the machine shown in Fig. 1817.

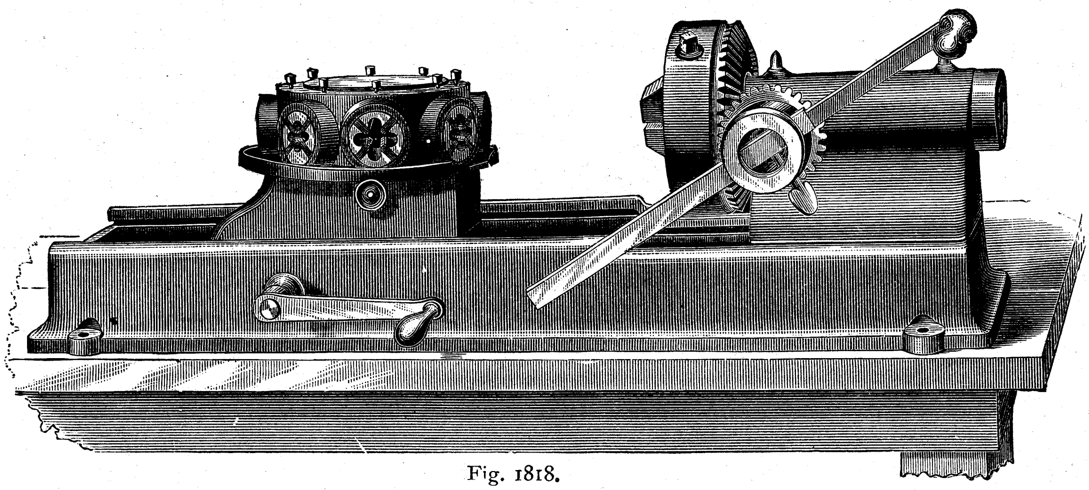

Fig. 1818.

The threading dies are held in collets carried by a head or cylinder mounted horizontally on a carriage capable of being moved along the bed by means of a rack and pinion, the latter being operated by a handle passing through the side of the bed as shown. The cylinder also carries a collet adapted for recessed plates so as to receive square or hexagon nuts of different sizes for tapping purposes, the taps being held in the rotating chuck. The collets are capable of ready and separate extraction, and by removing the collet that is opposite to the one that is at work, the end of a bolt may pass if necessary entirely through the head or cylinder threading the work to any required length or distance.

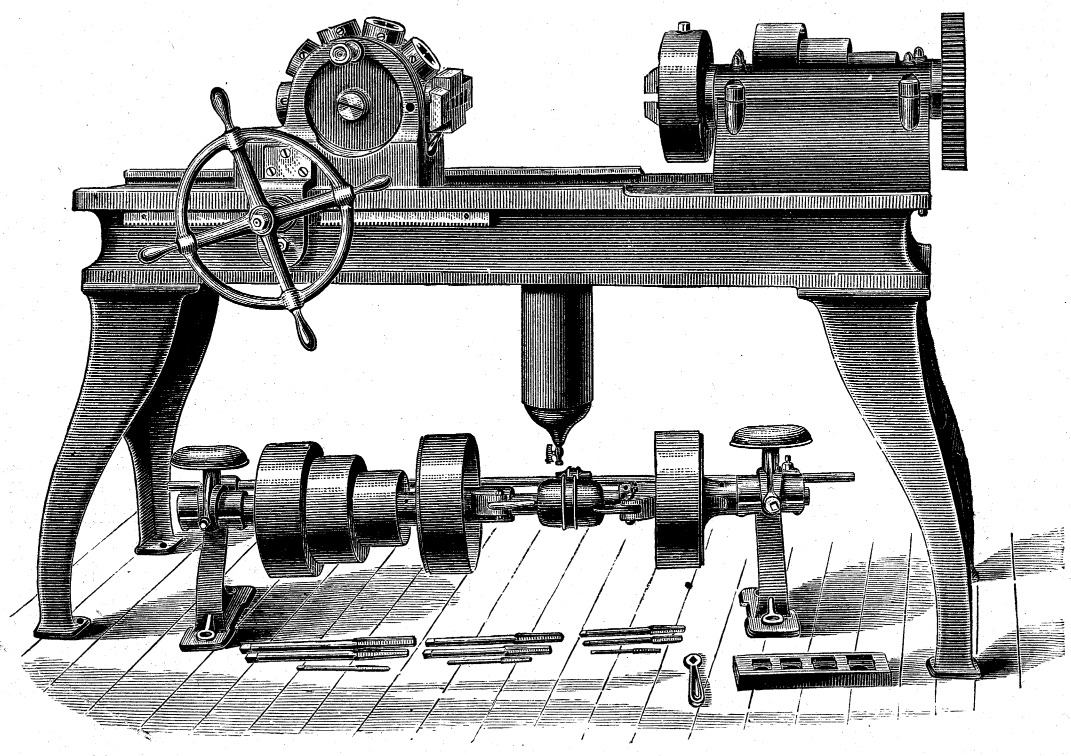

Fig. 1819.

To insure that the die shall stand axially true with the revolving spindle, bolt holes are drilled in the lower part of the cylinder, and a pin passes through the carriage carrying the head, and projects into these holes, which are so situated that when the pin end projects into a hole and locks the head a collet is in line with the spindle.

The dies consist of four chasers inserted in radial slots in collets held in place and bound together by a flat steel ring, which is let into the face of the collet and the external radial face of the chasers, and secured to the collet by screws. One chaser only is capable of radial motion for adjusting the diameter of thread the die will cut, and this chaser is adjusted and set by a screw in the periphery of the collet.

The other two chasers being held rigidly in a fixed position in the ring act as back rests and cut to the diameter or size to which they are made, or according to the adjustment of the first chaser. The shanks of the collets are secured in the cylindrical head by means of either a bolt and key or by a set-screw.

The chasers are sharpened by grinding the face on an ordinary grindstone or emery wheel.

The chasers are numbered to their places and are so constructed that if a single chaser of a set of three should require renewal, a chaser can be obtained from the manufacturers that will match with the remaining two of the set, the threads on the one falling exactly in line with those on the other two, whereas in other dies the renewal of one chaser involves the renewal of the whole number contained in the die. This is accomplished by so threading the dies that the thread starts from the same chaser (as No. 1) in each set.

In Fig. 1819 is represented one of these machines, which is intended for threads from $\frac{3}{8}$ to 1 inch in diameter. It is arranged to be driven by belt power, being provided with a pulley having three steps; on this pulley spindle is a pinion operating a gear-wheel on the die driving spindle, as shown.

The oil and cuttings fall into a trough provided in the bed of the machine, but the oil drains through a strainer into the cylindrical

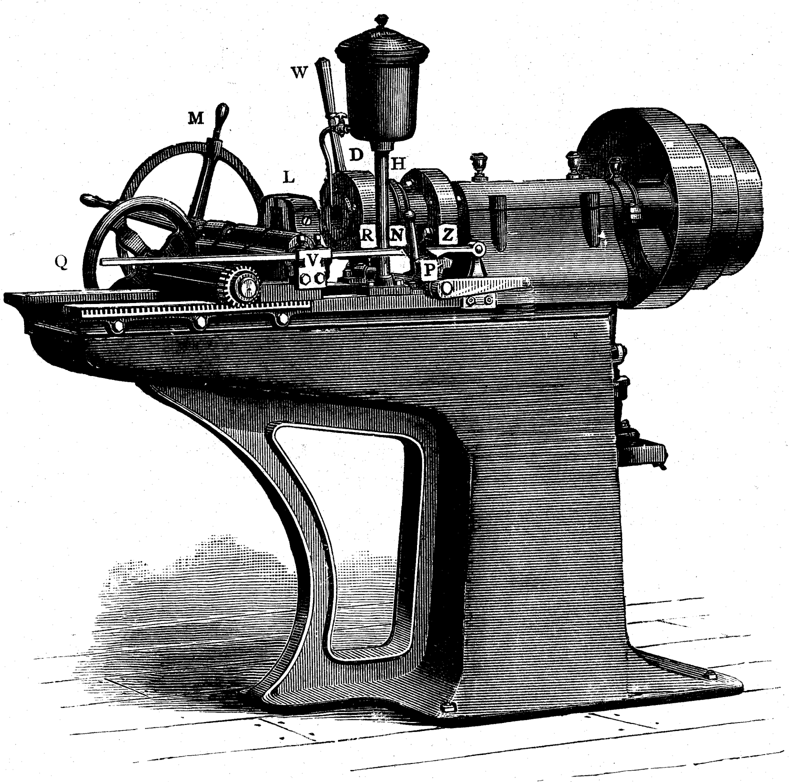

Fig. 1820.

receiver shown beneath the bed, whence it may be drawn off and used over again.

In Fig. 1820 is represented a bolt threading machine which is designed for bolts from $\frac{3}{16}$ to 1 inch in diameter.

The bolt to be threaded is gripped in the vice L, operated by hand by the hand wheel M, and is moved by hand up to the head

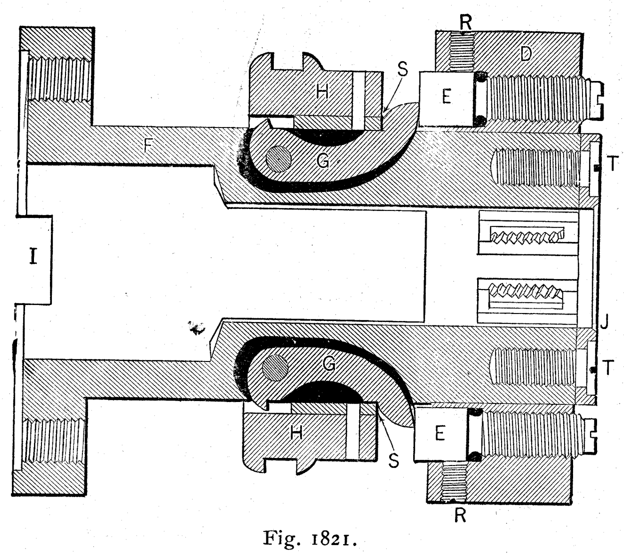

Fig. 1821.

D, by the hand wheel Q operating the pinion in the rack shown at the back of the machine. When the dies or chasers have cut or threaded the bolt to the required distance, the threading dies are opened automatically as follows:—

At H is a clutch ring for opening and closing the threading chasers, and at N is the lever operating the shoes in the groove of the clutch ring. This lever is upon a shaft running across the machine and having at its end the catch piece P; at Z is a catch for holding P upright against the pressure of a spring that is beneath the bed of the machine, and presses on an arm on the same shaft as the catch piece P. On the back jaw of the vice L is a bracket carrying a rod R, and the bolt or work is threaded until the end of rod R lifts catch Z, when the before-mentioned spring pulls lever N and clutch ring H forward, opening the dies and therefore stopping the threading operation. The length of thread cut upon the work is obviously determined by adjusting the distance rod R projects through V. The handle W is upon the same shaft as catch piece P and clutch lever N, and therefore affords means of opening the dies by hand.

The operation of the machine obviously consists of gripping the work in vice L, moving it up to the head D by the hand wheel Q, setting the rod R to open the dies when the bolt is threaded to the required length, and moving the vice back to receive a subsequent piece of work.

The construction of the head D and clutch and ring H is shown in Figs. 1821 and 1822.

The body F is bolted by the flange I to a face plate in the live spindle or shaft of the machine, and through slots in this body pass the holders or cases C containing the chasers or dies. Upon F is the piece D provided with a slot to receive the die cases and a tongue to move them. This slot and tongue, which are shown at E′, are at an angle to the axis of F; hence if D be moved endways upon F the cases and dies are operated radially in or through the body F. To operate D laterally or endwise upon F the clutch ring H and the toggles G are provided, the latter being pivoted in the body F, and H being operated endwise upon F by the lever shown at N in the general view, Fig. 1820. The amount to which the dies will be closed is adjustable by means of the adjusting screws E, which are secured in their adjusted position by the set-screws R, Fig. 1821; it being obvious that when H meets the shoulder S of G and depresses that end of the toggle, head D is moved to the right and the dies are closed when the end of G meets E, and ceases to close when G

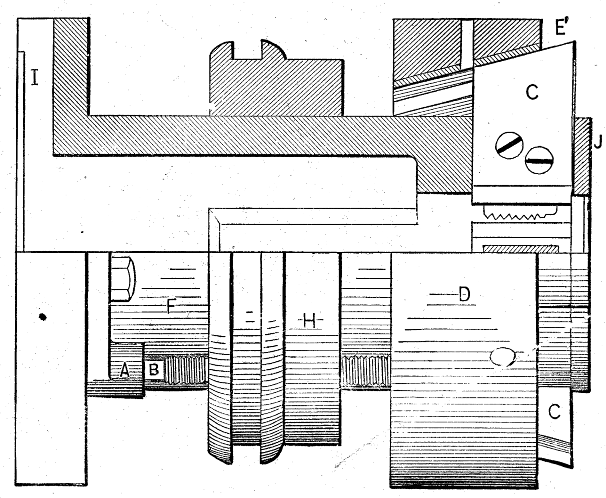

Fig. 1822.

has seated itself in F and can no longer move E. The backward motion of the clutch ring H, and therefore the amount to which the dies are opened, is regulated by the screw B and stop A in Fig. 1822, it being obvious that when B meets A the motion of H and D to the left upon F ceases and the dies are fully opened. The amount of their opening is therefore adjustable by means of screw B. J is simply a cap to hold the dies and cases in their places.

In the end view, Fig. 1823, E,E are the adjustment screws for the amount of die closure, and B,B those for the amount they will

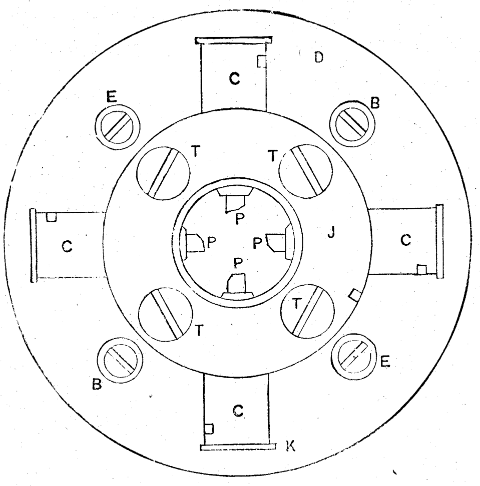

Fig. 1823.

open to, T representing the screws for the cap J, which is removed for the insertion and extraction of the dies and die cases.

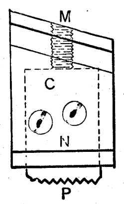

Fig. 1824.

The construction of the dies P and cases C is shown in Fig. 1824. Two screws at N secure the dies in their cases and a screw M adjusts them endways so as to set them forward when recutting them. By inserting the dies in cases they may be made of simple pieces of rectangular steel, saving cost in their renewal when worn too short.

Fig. 1825 shows the machine arranged with back gear for bolts from 2 to $2\frac{1}{2}$ inches in diameter, the essential principles of construction being the same as in Fig. 1820.

In Fig. 1826 is represented a single and in Fig. 1827 a double "rapid" machine, constructed for sizes up to $\frac{5}{8}$ inch in diameter, the double machine having a pump to supply oil to the dies. This pump is operated by an eccentric upon the end of the shaft of the cone pulley.

The construction of the head of this machine is shown in Fig. 1827A. Z is the live or driving spindle, upon which is fast the head A. In A are pivoted at M the levers L which carry the dies

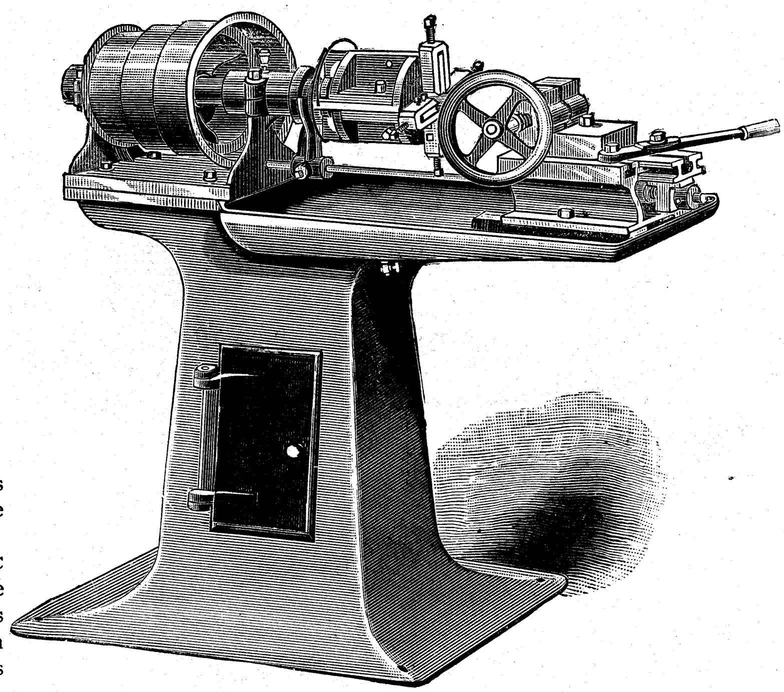

Fig. 1826.

D, which are secured in place in the levers by the set-screws B and adjusted to cut to the required diameter by the screws E. The levers L are closed upon the clutch C by means of the springs R and S, each of these springs acting upon two diametrically opposite levers, hence the action of the springs is to open the dies D. The clutch C has a cone at T and slides endways upon the live spindle Z. The clutch lever and shoes are upon a shaft

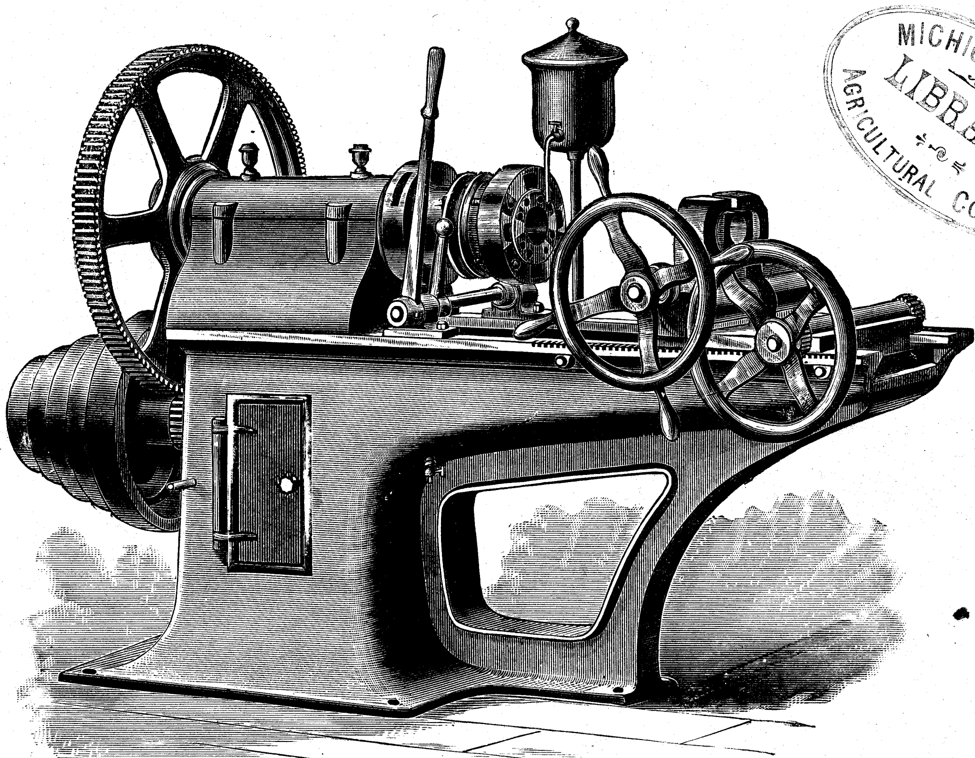

Fig. 1825.

running across the machine and actuated by a rod corresponding to the rod R in Fig. 1820. When the clutch and levers L are in the position shown in the figures the dies are closed for threading the bolt, and when this threading has proceeded to the required distance along the work, clutch C is moved by the aforesaid rod

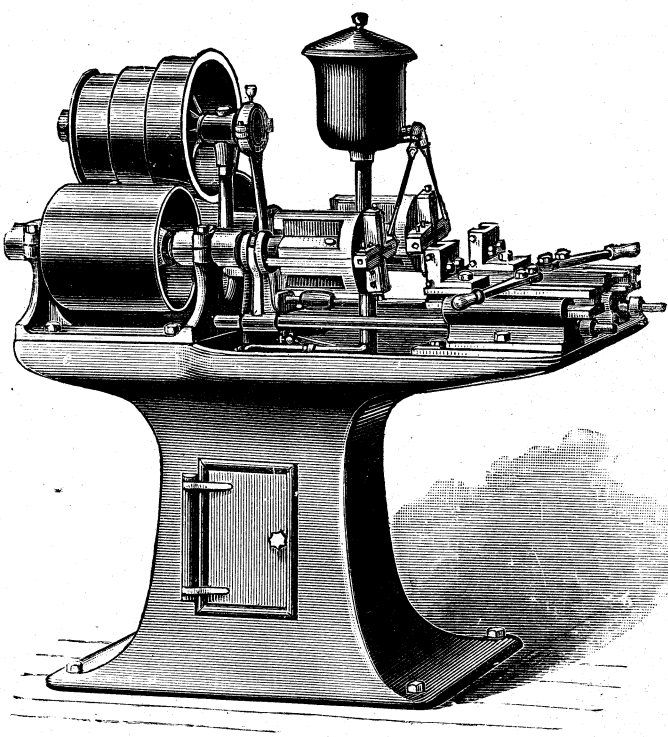

Fig. 1827.

and lever in the direction of arrow W, and the springs R,S close the ends P of lever L down upon the body X of the clutch opening the dies and causing the threading to cease.

Fig. 1828 represents a " double " rapid machine for threading work up to four inches in diameter, and therefore having back threaded to the required length and the bolt withdrawn without losing the time that occurs when the dies require to run backward to release the work, and also preventing the abrasion and wear that occurs to the cutting edges of the die bits or chasers when revolved backward upon the work. This head is operated by the upright lever shown in the figure, this lever being connected to the clutch shown upon the live spindle. The details of construction of the clutch and of the head are shown in Figs. 1830, 1831, 1832, and 1833 The work to be threaded is gripped between jaws operated by the large hand wheel shown, while the vice moves the work up to or away from the head by means of the small hand wheel which operates pinions geared with racks on each side of the bed of the machine as clearly shown in the figure.

Fig. 1830 is a longitudinal section of the head, and Fig. 1831 an end view of the same. P are the threading dies or chasers held in slots in the body *a* by the annular ring face plate K. The ends of the dies are provided with **T**-shaped caps T fitting into corresponding grooves or slideways in the die ring B, and it is obvious that as the heads of their caps are at an angle therefore sliding the ring B along *a* and to the right of the position it occupies in the figure will cause the dies P to close concentrically towards the centre or axis of the head *a*. At C is a ring capable of sliding upon *a* and operated by the upright lever shown in the general view in Fig. 1829.

The connection between the die ring B and the clutch ring C is shown in Figs. 1832 and 1833, the former being also a longitudinal sectional view of the head, but taken in a different plane from that in Fig. 1830. The barrel or body *a a* of the head is provided with two diametrically opposite curved rocking levers which are pivoted in recesses in *a a*. The clutch ring C envelops body *a* and passes between the curved ends of these rocking levers. The upper of the two rocker levers shown in the engraving connects with a lever E, which connects to a stud or plunger P, threaded to receive the adjusting screw I, which is threaded into the die ring B. Obviously when C is moved to the right along *a* it operates the rocking lever and causes B to move to the right and to close the dies upon the work. The amount of die closure, and therefore the diameter to which the dies will thread the work, is adjustable by means of the adjusting screw I, which has a coarse thread in B

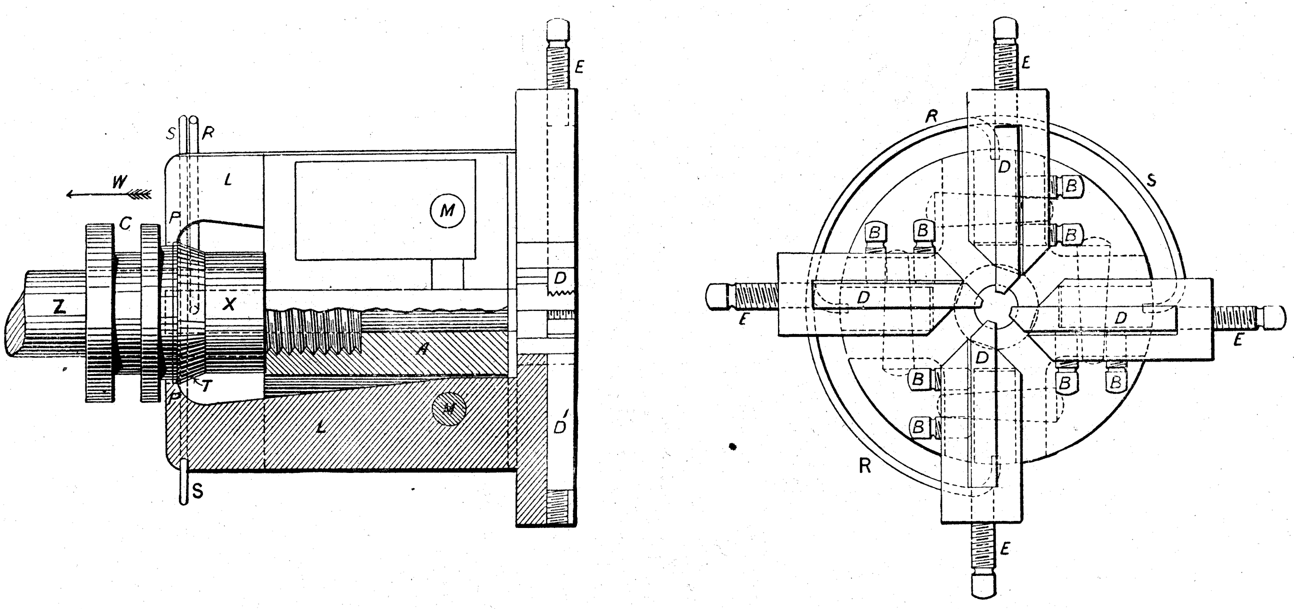

Fig. 1827A.

gear so as to provide sufficient power. The gauge rod from the carriage here disengages a bell crank from the end of the long lever shown, and thus prevents the spring to operate the cross shaft and open the dies.

In Fig. 1829 is represented a bolt threading machine or bolt cutter, which consists of a head carrying a live spindle upon which is a head carrying four bits or chasers that may be set to cut the work to the required diameter, and opened out after the work is and a finer one in P, hence screwing up I draws B to the left and farther over the plunger P, thus shortening the distance between the centre of the curved lever and limiting the motion of B to the right. On the other hand, unscrewing I moves B to the right, and it is obvious that in doing this the cap T in Fig. 1830 is forced down by the groove in B and the dies are moved endwise towards the axis *a a*, or in other words, closed.

It will be clear that a greater amount of power will be necessary to hold the dies to their cut than to release them from it, and on that account the lower curved rocking arm D connects through E to a solid plunger G, the screw H abutting against the end of G

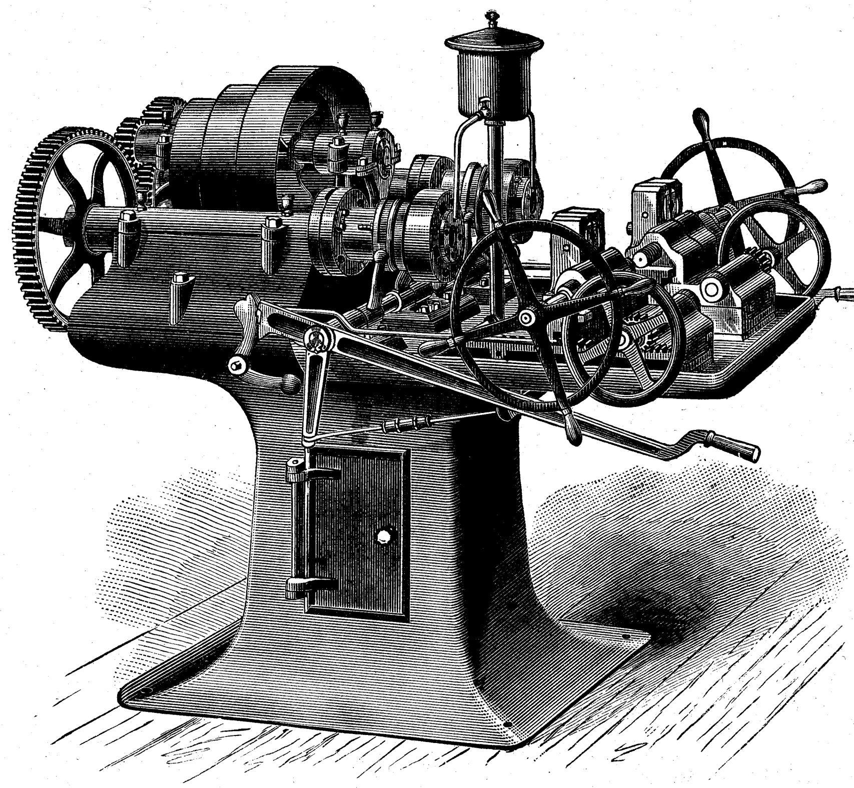

Fig. 1828.

and not threading into it, because G is only operative in pushing B forward in conjunction with P, while P pulls B backward, the duty being light. It is obvious, however, that after the adjustment screw I is operated to set the dies to cut to the proper diameter,

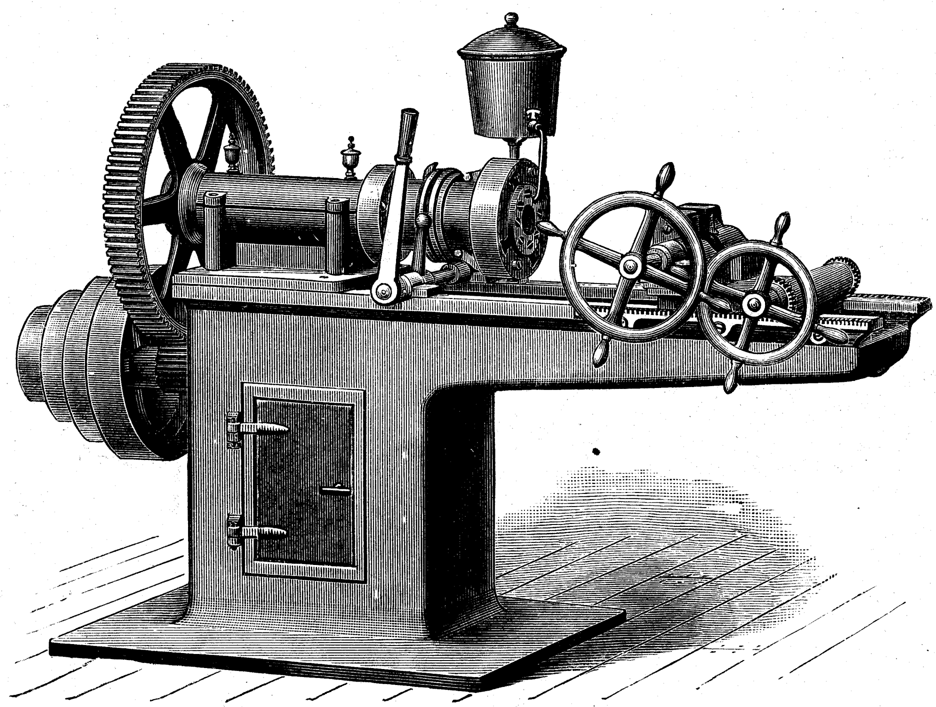

Fig. 1829.

adjustment screw H must be operated to bring the ring B fair and true upon *a a* and prevent any lateral strain that might otherwise ensue.

These two adjustments being made the clutch ring C is operated to the left to its full limit of motion to open the dies and to its full limit to the right to close them.

It will be seen, by the lines that are marked to pass through the pivoting pins of the rocking lever D, that the joints marked 2 in Fig. 1832 are below these lines, and as a result the links E form in effect a toggle joint locking firmer in proportion as the strain upon them is greater.

Fig. 1834 represents a bolt threading machine having two heads each of which is capable of threading bolts from ½ up to 1½ inches in diameter.

The levers for operating the clutch rings are here placed

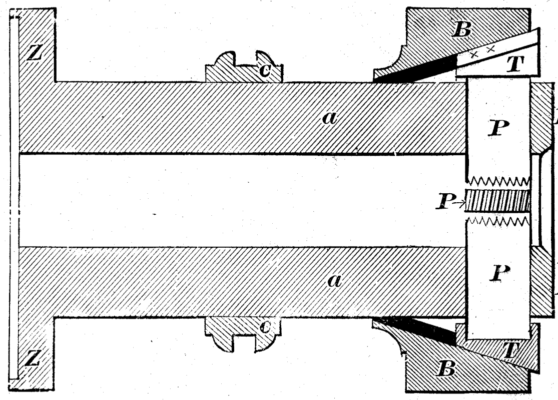

Fig. 1830.

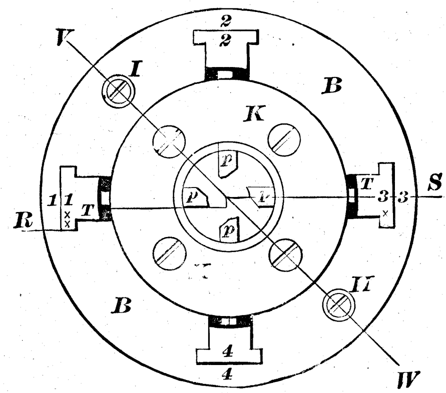

Fig. 1831.

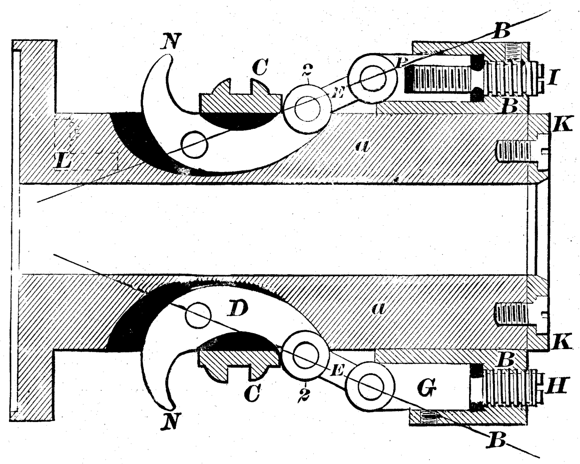

Fig. 1832.

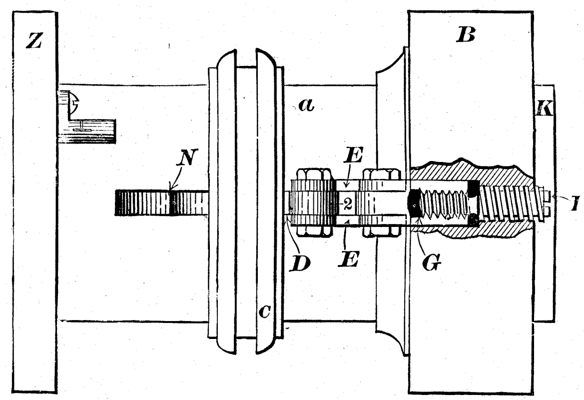

Fig. 1833.

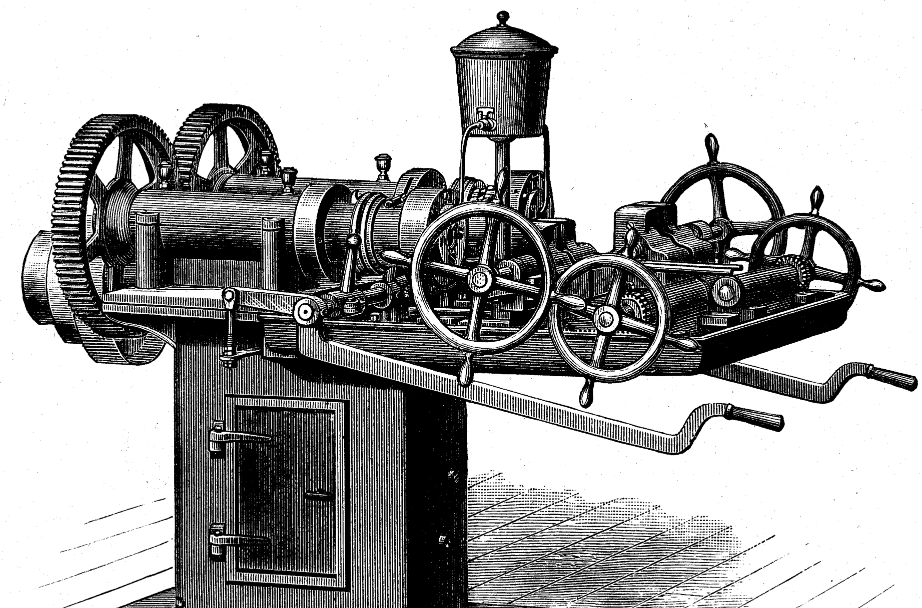

Fig. 1834.

horizontal, so that they may extend to the end of the machine and be convenient to operate, and a pump is employed to supply oil to the dies.

The capacity of a double machine of this kind is about one ton of railroad track bolts per day of 10 hours' working time.

In American practice it is usual to employ four cutting dies, bits, or chasers, in the heads of bolt threading machines, while in European practice it is common to employ but three. Considering this matter independently of the amount of clearance given to the teeth, we have as follows :—

If a die or internal reamer the cutting points of which were all equidistant from a common centre, were placed over a piece of work, as a bar of iron shown in Fig. 1835, and set to take a certain cut, as shown by the circle outside the section, it is evident that if revolved, but left free to move laterally, or "wabble," the cutter would tend to adjust itself at all times in a manner to equalize the cutting duty—that is, if the die had two opposite cutting edges or points, and the piece operated upon were not of circular form, then, when one cutter reached the part that was not round, it would have either more or less cutting to do than before, and hence, the opposite cutter having the same amount, the tendency would be for the two cutting edges to travel over and equalize the cuts, and hence the pressure. With three cutting points, no two being opposite, the tendency would all the while be to equalize the cuts taken by all three ; with four, spaced equally, the tendency would always be to equalize the cuts of those diametrically opposite ; with five, the tendency would be to equalize the duty on each, and so on. Thus it will be noticed that there is a difference between the acting principle of a die having an even or an odd number of cutters, independent of the

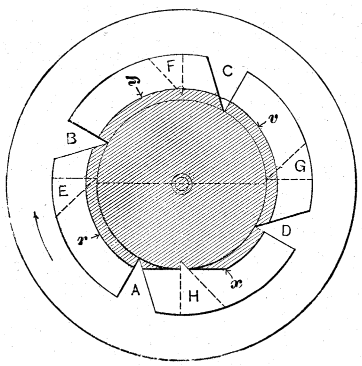

Fig. 1835.

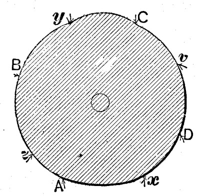

Fig. 1836.

difference in the actual number of cutting edges, or points, as we are now considering them.

To take an example, in Fig. 1835 is represented a die having four cutting points, placed upon a piece of iron of a round section, with the exception of a flat place, as shown. Now, in this position each one of the cutting points A, B, C, and D, is in contact with the true cylindrical part of the work only ; hence, if the die were set to take the amount of cut shown, each point would enter the iron an equal distance, and the inner circle through the points would be the smallest diameter of the die. Upon revolving the die in the direction denoted by the arrow, an equal cut would continue to be taken off, and hence the circular form maintained, until cutter D had reached the edge x of the flat, the opposite one B, being at y (A at r and C at v), proceeding as D moved from x towards A, its cutting duty would continually become less and its pressure decrease, but as it is the cutting pressure of D that holds the opposite point B to its cut, as the pressure in D, after reaching x, continually becomes less, the die would gradually travel over so as to carry D toward the centre and cause it to take more cut, while B, on the opposite side, would travel out a corresponding distance and take less, thus keeping the duty equalized until the cutter D had reached H, the lowest part of the flat, when the die would have moved the greatest distance off the centre, assuming the position shown by dotted lines. Thus the cutting point at H has passed inside the true circle that all the cutters commenced to follow, while F has passed outside. Meanwhile, as H and F have shifted over, E and G have, of course, moved an equal amount and in the same direction, but the diameter of E and G being at right angles to that of H and F, the distances of E and G from the centre would be changed but an infinitesimal amount ; hence, they would virtually continue to follow the true circle, notwithstanding the deviation of the other pair. As the die continues to revolve and H passes toward A, the lateral motion is reversed, the die tending to resume its original central position, which it does upon the completion of another quarter of a revolution, when the cutter that started at D has passed to H and finally to A. A cutting has now been removed from the entire circumference of the iron, leaving it of a form shown approximately in Fig. 1836, where A z, B y, C v, and D x, are the four true circular portions

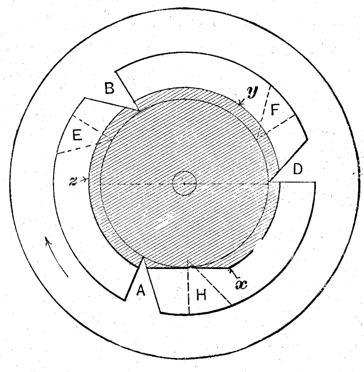

Fig. 1837.

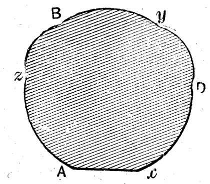

Fig. 1838.

cut respectively by the points A, B, C, and D, before the flat place was reached. After the flat place was reached x A is the depression cut by D, y C the elevation formed by B, and z B and v D are the arcs, differing almost imperceptibly from the true circular ones cut by A and C.

Fig. 1837 represents a die having three instead of four cutting points—that is, the point C of Fig. 1835 is left out, and the remaining ones A, B, and D, are equally spaced. This, placed upon a similar bar and taking an equal cut, would produce a truly circular form until D had reached x—with A and B at z and y—after which the die would move laterally, tending to carry D toward the centre of the work and A and B away from it, so as to equalize the cuts on all three. Hence, when D had reached H and the three-cutter die attained the position shown by dotted lines in Fig. 1837, H would have made an indentation inside the true circle, while E and F have travelled away from it, thus forming protuberances. From H to A the lateral movement is reversed, and finally upon the completion of a third of a revolution, the die is again central and a cut has been carried completely around the bar, leaving it as shown in Fig. 1838. Comparing this with Fig. 1836,

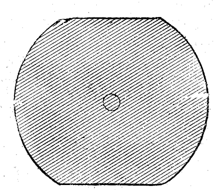
Fig 1839.

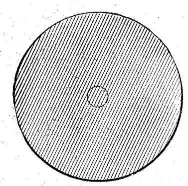
Fig. 1840.

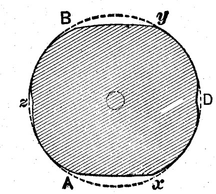

Fig. 1841.

it will be seen that there are three truly cylindrical portions—viz., A z, B y, and D x—instead of four in Fig. 1836, but each one is longer ; that there is a depressed place, x A, of equal length to that in Fig. 1836, and two elevations, z B and y D, each of equal length to the one (y C) in Fig. 1836.

Now, suppose the bar to have an equal flat place on its opposite side, becoming of a section shown in Fig. 1839, upon applying the dies and pursuing a similar course of reasoning, the die with four points would reduce the bar to the size and shape shown in Fig. 1840, or a true cylinder, while the triple-pointed cutter would produce the form shown in Fig. 1841, which is a sort of hexagon, coinciding with the true circle in six places—A, z, B, y, D, and x—while between A and z, and opposite, between y and D, there is an elevation ; also from z to B and from D to x. A flattened portion, A x, with a similar one B y, opposite, completes the profile. Suppose, now, that a bar of the form shown in Fig. 1842, having two flat places not opposite, be taken, and the four-cutter and three-cutter dies are applied. The product of the four is shown in Fig. 1843, and that produced by the three-cutter die in Fig. 1844. The section cut with four coincides with the true circle at four points, A, B, C, D, and differs from it almost imperceptibly at z, y, v, and x. There are two elevations between A and B and between B and C; also two depressions between C and D and between D and A. The section from the three-cutter die is the perfect circular form between A z, B y, and D x, with a projection from z to B and two depressions from y to D and from x to A. The four-die, applied to a section having three flats like Fig. 1845, would produce Fig. 1846, which does not absolutely coincide with the true circle at any point, although the difference is inconsiderable at A, z, y, C, v, and x; three equidistant sections A z, y C, and v x, are elevated and the three alternate ones depressed.

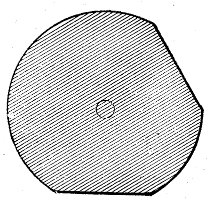

Fig. 1842.

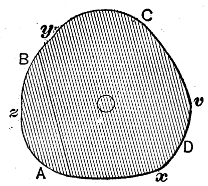

Fig. 1843.

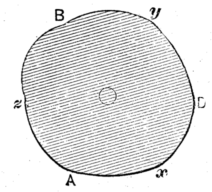

Fig. 1844.

The three-cutter die would in this case cut the perfectly circular form of Fig. 1847.

Now, suppose both of the dies to have been made or set to some certain diameter—in fact, presume them to be made by taking a ring of steel having a round hole of the required diameter, say 1 inch, and removing the metal shown by the dotted lines, Fig. 1848, and leaving only the four cutting points in one case (and the three in the other). Then it is evident that our dies are both of the same diameter, and likewise both of the assumed diameter, or 1 inch; then it is fair to presume that the plugs or sections just cut by either one of the dies should enter a round hole of the same diameter as the dies; but it is obvious that only two, Figs. 1840 and 1847, will do so, all the rest being considerably too large, from their irregularity of form, notwithstanding the fact that the diameter of any of those cut by four cutters is never more than that of the die, while any one of the equal radii, taken at equal distances on any of the forms cut by the three-cutter die, will not

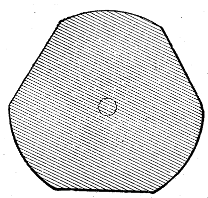

Fig. 1845.

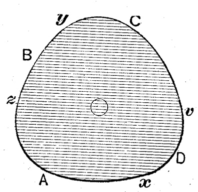

Fig. 1846.

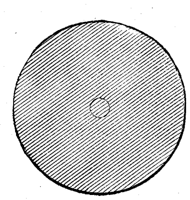

Fig. 1847.

exceed the radius of the die. Now, six of the pieces being too large when referred to the standard of a round hole of the size of the die, while two are of the correct size, it is obvious that if the four-die, for example, which cut Fig. 1846, were reduced enough to make Fig. 1843 just enter the standard, that, Fig. 1840, which is now just correct in size and form, would, when cut, be altogether too small. The same would be the case also with the three-cutter die.

Now let us consider the two productions (Figs. 1840 and 1847) that answer the requirements, the two different sections (Figs. 1839 and 1845) from which they were cut, and also the other two pieces (Figs. 1841 and 1846) that were cut from the same bars at the same time The general shape of Fig. 1839, is oval or four-sided, and while the four cutters operated upon it to produce perfectly circular work, the three cutters reproduced the general shape started with, only somewhat modified, as Fig. 1841 plainly shows. Upon the blank, Fig. 1845, the general shape of which is triangular, the very opposite is the case, for the three cutters now produce a perfect circle, while the four modify only the figure that they commenced to operate upon.

Considering that every irregular form may be approximated by a square, an equilateral triangle, or in general by either a parallelogram or a regular polygon, it will be found that from a flat, oval, or square piece of metal the four cutters will produce a true circle; from a triangular piece the three; from a heptagon neither will do so, while from a hexagon both the three and four

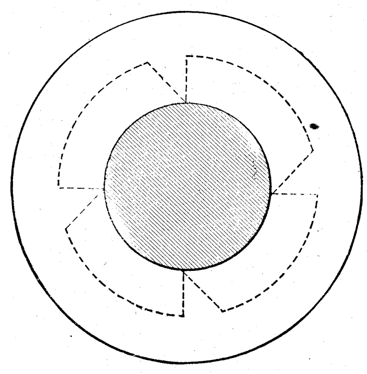

Fig. 1848.

cutters are calculated to do so. Following in the same manner, and increasing the sides, it will be found that the four cutters will produce a true circle from every parallelogram, whether all the sides are equal or not, while the three cutters will produce a true circle also from every regular polygon the number of sides of which is a multiple of three—that is, four cutters would operate correctly upon a figure having 4, 6, 8, 10, 12, &c., parallel sides, while the three would do so upon a figure having 3, 6, 9, 12, 15, &c., equal sides. Thus, for regular forms varying between these two series neither one would be adapted. Hence, if the general form of the work is represented by the first series, the four cutters are the best; if the general and average form of the material to be operated upon corresponds to the second series, then the three dies are the best adapted, so far as their two principles of action, mentioned at the outset, are concerned; hence, if it is considered that the material or bars of metal to be wrought vary from a circular form indifferently, then there is no choice between an even and an odd number merely on that account.

Placing the same dies that cut these six irregular figures upon their respective productions would not serve to correct their form; as, for instance, if the die that cut Fig. 1846 were revolved around it—even if set up or reduced in diameter to take a cut—it would remove an equal amount all round and leave the same figure still.

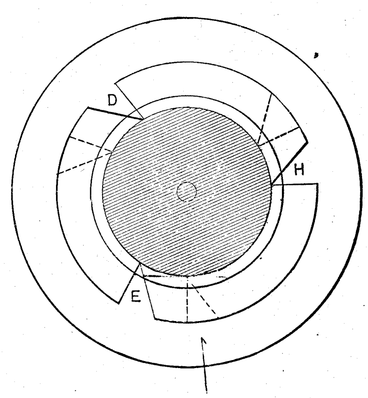

Fig. 1849.

Similarly with, say, Fig. 1841, cut by the three; but if the three were run over Fig. 1846, cut by the four, it would tend to correct the errors, and likewise if the four were run over Fig. 1841, the tendency would be to modify the discrepancies left by the three that cut it.

As regards the number of cutting points, suppose that there were a certain number, as three, shown in Fig. 1849, all taking an equal cut; then, when the position indicated by the dotted lines was reached, where cutter H runs out, the entire duty would be only two-thirds as much as it was, and the die would shift laterally in the direction of the arrow enough to equalize this smaller amount of duty on all three, or make H, E, and D each cut two-thirds as much as at first. With four as shown in Fig. 1850 when H reached the depression where its cut would run out, the entire duty would be three-fourths of what it was at first, and the die would travel laterally in the direction of the arrow sufficiently to equalise the pressure upon H and F, and upon E and G. With five, as shown in Fig. 1851, in similar position the entire duty would be four-fifths as much; with six, five-sixths, and so on. Thus it can be seen that the variation between the least amount to be cut and the full amount is relatively less, the greater the

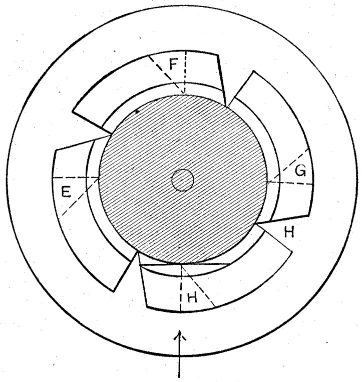

Fig. 1850.

number of cutting points that it is divided between, and hence the lateral movement would be less; therefore the general tendency of an increase in the number of cutting points would be to promote true work.

Hence, from these considerations it appears that it is not material whether the number is odd or even merely on that account; so four would be preferable to three only on account of being one more, and, in turn, five would be better than four, and six better than five, and so on. It is found, however, that bar iron usually inclines to the elliptical form, and that an even number is, therefore, preferable.

Thus far the cutting edges of the die have been assumed to be

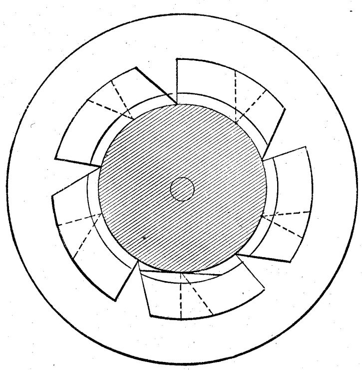
Fig. 1851.

points equidistant about a circle—that is, it has been supposed to have absolute clearance, so that its movements would be regulated entirely by the depth of cut taken, in order to ascertain the inherent tendency to untruth caused by an odd or an even, a greater or a less, number of cutters. This tendency is, of course, modified in each case by the amount of clearance.

The position of the dies in the head and with relation to the work is, in bolt cutting machines, a matter of great importance, and in all cases the dies should be held in the same position when being hobbed (that is, having their teeth cut by the hob or master tap) as they will stand in when put to work, and the diameter of the hob must be governed by the position of the dies in the head. If they are placed as in Fig. 1852 the diameter of the hob must be $\frac{1}{32}$ inch larger than the diameter of bolt the dies are intended to thread, so that the point or cutting edge may meet the work first and the heel may have clearance, it being borne in mind that the clearance is less at the tops than it is at the bottoms of the teeth, because of their difference in curvature. In this position the teeth are keen and yet retain their strength, acting somewhat as a chaser. If placed in the position shown in Fig. 1853 the hob or master tap must be $\frac{1}{32}$ inch smaller than the diameter of bolt they are to thread, so as to give the teeth clearance. In this case the dies are somewhat harder to

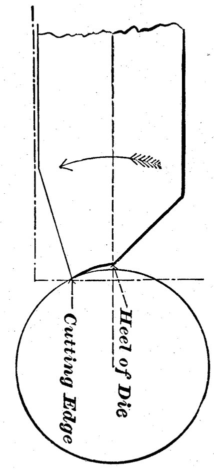

Fig. 1852.

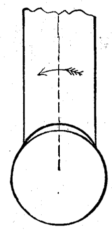
Fig. 1853.

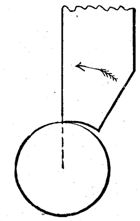
Fig. 1854.

feed into their cut and do not cut quite so freely, but on the other hand they work more steadily as the bolt is better guided, while left-hand dies may be used in the same head. If placed as in Fig. 1854 they must be cut with a hob $\frac{1}{32}$ inch larger in diameter than the bolt they are to thread, so that the teeth will have less curvature than the work, and will, therefore, have clearance. In this position the dies do not cut so freely as in Fig. 1852.

The dies should be broad enough to contain at least as many teeth as there are in a length of bolt equal to its diameter, and should be thick enough to withstand the pressure of the cut without perceptible spring or deflection.

The cutting edges of dies may be brought in their best cutting position and the dies placed in radial slots in the head by forming the dies as in Fig. 1855. Face X is at an angle of 18° to the leading or front face of the die steel, and the heel is filed off at an angle of 45° and extends to the centre line of the die. This gives a strong and a keen die, and by using a hob $\frac{1}{32}$ inch

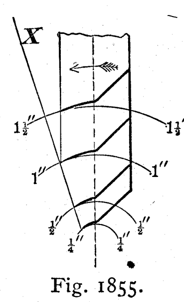

Fig. 1855.

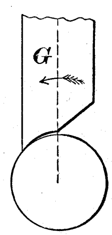

Fig. 1856.

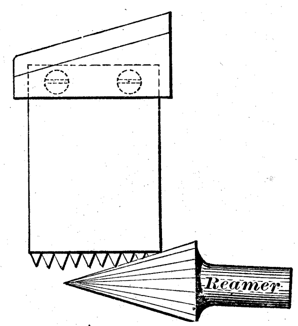

Fig. 1857.

smaller than the diameter of bolt to be cut, the clearance is sufficiently maintained.

The heel of the die should not when the cutting edge is in front extend past the axis of the work, but should be cut off so as to terminate at the work axis as denoted by the dotted line G in Fig. 1856.

In hobbing the dies it is necessary that they be all of equal length so that the hob may cut an equal depth in each, and may, therefore, work steadily and hob them true. After the dies are hobbed their front ends should be reamed with a taper reamer as in Fig. 1857, chamfering off not more than three threads, and the chamfered teeth must then be filed, just bringing the front edges up to a cutting edge, but filing nothing off them, the reamed chamfer acting as a guide to file them by.

This will cause each tooth to take its proper share of the cut, thus preserving the teeth and causing the dies to cut steadily. Back from the cutting edge towards the heels of the teeth the clearance may gradually increase so that the heel will not meet the work and cause friction.

The chasers or dies are obviously changed for each diameter of bolt, and it follows that as the chasers all fit in the same slots in the head they must all be made of the same size of steel whatever diameter of bolt they are intended to cut, and this leads to the following considerations.

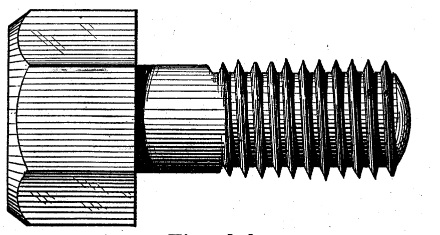

Fig. 1858.

Suppose the capacity of the machine is for bolts between $\frac{1}{4}$ inch and $1\frac{1}{4}$ inches in diameter, and the size of the chaser or die will be $1\frac{1}{4}$ inches wide and $\frac{1}{2}$ inch thick.

The width of a die or chaser should never be less than the diameter of bolt it is to thread, so that it may contain as many threads as are contained in a length of bolt equal to the bolt diameter. Now the $1\frac{1}{4}$-inch chaser equals in width the diameter of bolt it is to cut, viz. $1\frac{1}{4}$ inches; but if the chaser for $\frac{1}{4}$-inch bolts was threaded parallel and left its full width it would be five times as wide as the diameter of the bolt and the thread cut would be imperfect, because the chasers alter their pitches in the hardening process, as was explained with reference to taps, and it is found that the error induced in the hardening varies in amount and sometimes in direction; thus of the four chasers three may expand and become of coarser pitch, each varying in degree from the other two, and the other may remain true, or contract and become of finer pitch.

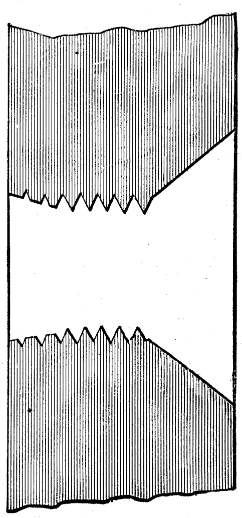

Fig. 1859.

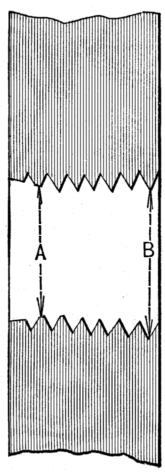

Fig. 1860.

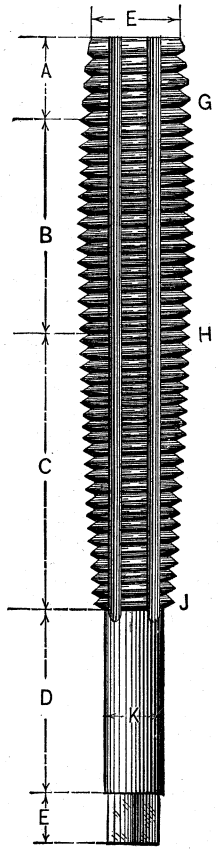

Fig. 1861.

As a rule the dies expand, but do not so equally. The more teeth there are in the die the more the pitch error from the hardening; or in other words, there is obviously more error in an inch than there is in half an inch of length. Suppose then that we have a die for 20 threads per inch, and as the chaser is $1\frac{1}{4}$ inches wide, it will contain 25 teeth, and the amount of pitch error due to $1\frac{1}{4}$ inches of length; and this amount not being equal in all the chasers, the result is that the dies cut the sides of the thread away, leaving it sharp at the top but widened at the bottom, as shown in Fig. 1858, weakening it and impairing its durability while placing excessive duty on the dies and on the machine.

A common method of avoiding this is to cut away all the teeth save for a width of die equal to the diameter of the bolt, as shown in Fig. 1859. An equally effective and much simpler plan is to form the dies as in Fig. 1860, the diameter at the back B being slightly larger than that at the mouth A, so that the back teeth are relieved of cutting duty. This enables the dies to undergo more grindings and still retain sufficient teeth. For example, the chamfer at A may be ground farther towards B, and still leave in action sufficient teeth to equal in width of chaser the diameter of the bolt. To enable the threading of dies in this manner the hobs or master taps employed to thread them are formed as in Fig. 1861, the proportions of the master taps for the different sizes of bolts being as given in the following table:—

Diameter of bolt.	—	—	Length at A.	Length at B.	Length at C.	Length at D.	Length at E.
$\frac{1}{4}$	Dia. from G to H $\frac{15}{64}$	At J $\frac{7}{32}$	$\frac{1}{2}$	1	1	$1\frac{1}{2}$	$\frac{1}{2}$
$\frac{5}{16}$	" " $\frac{19}{64}$	" $\frac{9}{32}$	$\frac{1}{2}$	1	1	$1\frac{1}{2}$	$\frac{1}{2}$
$\frac{3}{8}$	" " $\frac{23}{64}$	" $\frac{11}{32}$	$\frac{1}{2}$	1	1	$1\frac{1}{2}$	$\frac{1}{2}$
$\frac{7}{16}$	" " $\frac{27}{64}$	" $\frac{13}{32}$	$\frac{1}{2}$	1	1	$1\frac{1}{2}$	$\frac{1}{2}$
$\frac{1}{2}$	" " $\frac{31}{64}$	" $\frac{15}{32}$	$\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$\frac{3}{4}$
$\frac{5}{8}$	" " $\frac{39}{64}$	" $\frac{19}{32}$	$\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$\frac{3}{4}$
$\frac{3}{4}$	" " $\frac{47}{64}$	" $\frac{23}{32}$	$\frac{1}{2}$	$1\frac{1}{2}$	2	$1\frac{1}{2}$	$\frac{3}{4}$
$\frac{7}{8}$	" " $\frac{55}{64}$	" $\frac{27}{32}$	$\frac{1}{2}$	$1\frac{1}{2}$	2	$1\frac{1}{2}$	$\frac{3}{4}$
1	Dia. at G $\frac{31}{32}$	At J $\frac{1}{100}$ less	$\frac{1}{2}$	4	4	$1\frac{1}{2}$	1
$1\frac{1}{8}$	" $1\frac{3}{32}$	—	1	4	4	$1\frac{1}{2}$	1
$1\frac{1}{4}$	" $1\frac{7}{32}$	—	1	4	4	$1\frac{1}{2}$	1
$1\frac{3}{8}$	" $1\frac{11}{32}$	—	1	4	4	$1\frac{1}{2}$	1
$1\frac{1}{2}$	" $1\frac{15}{32}$	—	1	4	4	$1\frac{1}{2}$	$1\frac{1}{4}$
$1\frac{5}{8}$	" $1\frac{19}{32}$	—	1	5	5	2	$1\frac{1}{2}$
$1\frac{3}{4}$	" $1\frac{23}{32}$	—	1	5	5	2	$1\frac{1}{2}$
$1\frac{7}{8}$	" $1\frac{27}{32}$	—	1	6	6	2	$1\frac{3}{4}$
2	" $1\frac{31}{32}$	—	1	6	6	2	$1\frac{3}{4}$

All over 2 in. same length as the 2 in. Shanks J turned to bottom of last thread.

The cutting speeds for the dies and taps are as given in the following table, in which it will be seen that the speeds for bolt factories are greater than for machine shops. This occurs on account of the greater experience of the operators and the greater care taken in lubricating the dies and keeping them sharp:—

Diameter of bolt.	Revolutions of dies for machine shops.	Revolutions of dies for bolt factories.	Diameter of bolt.	Revolutions of dies for machine shops.	Revolutions of dies for bolt factories.
inch.			inch.		
$\frac{1}{8}$	450	600	$1\frac{5}{8}$	33	48
$\frac{1}{4}$	230	300	$1\frac{3}{4}$	30	45
$\frac{3}{8}$	150	200	$1\frac{7}{8}$	28	40
$\frac{1}{2}$	100	150	2	25	38
$\frac{5}{8}$	75	125	$2\frac{1}{8}$	23	36
$\frac{3}{4}$	65	100	$2\frac{1}{4}$	22	34
$\frac{7}{8}$	55	85	$2\frac{3}{8}$	21	32
1	45	75	$2\frac{1}{2}$	20	30
$1\frac{1}{8}$	42	65	$2\frac{5}{8}$	18	25
$1\frac{1}{4}$	40	60	$2\frac{3}{4}$	15	20
$1\frac{3}{8}$	38	55	$2\frac{7}{8}$	12	18
$1\frac{1}{2}$	35	50	3	10	15

Taps same speed as dies.

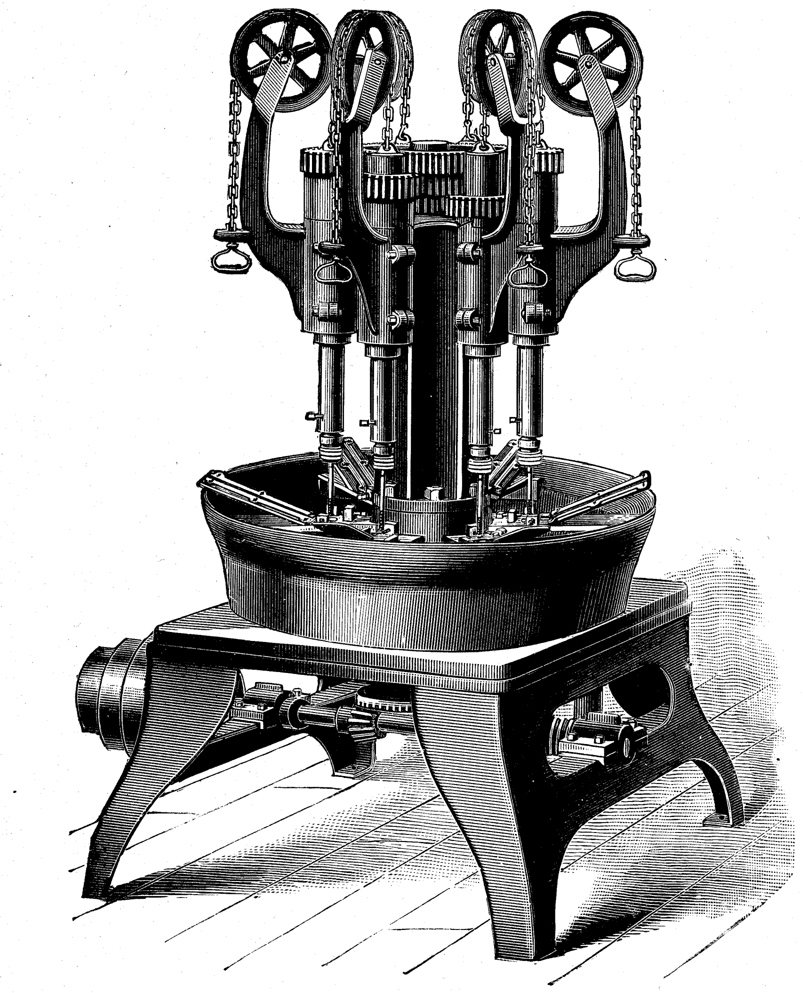

Fig. 1864.

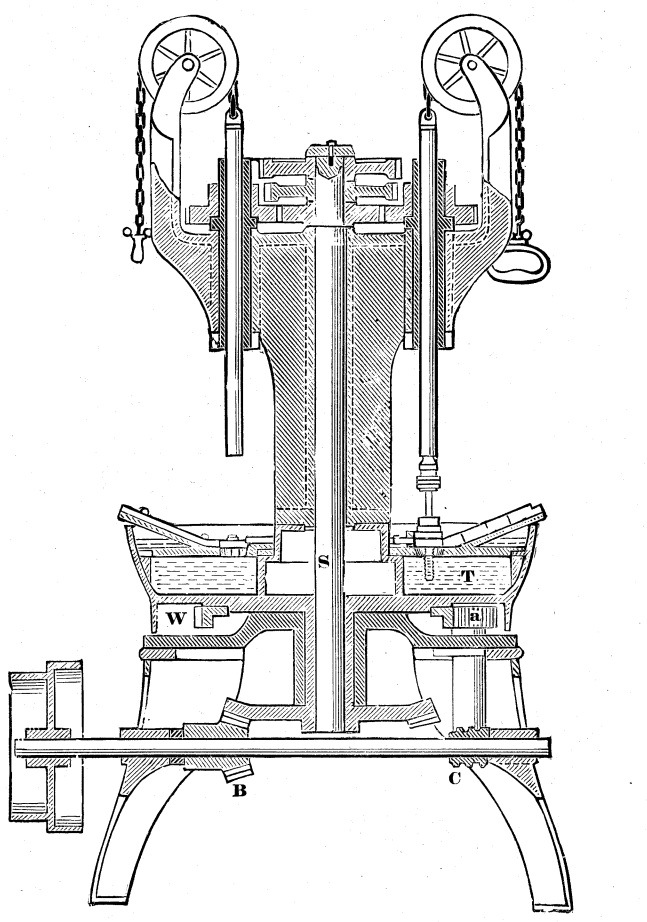

Fig. 1865.

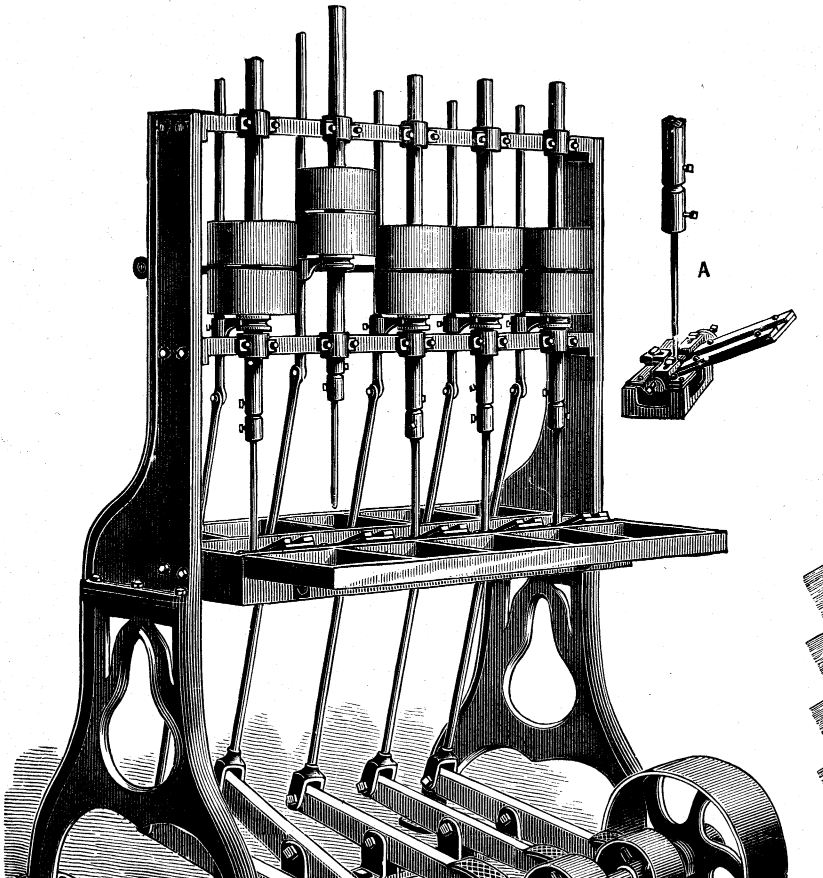

Fig. 1866.

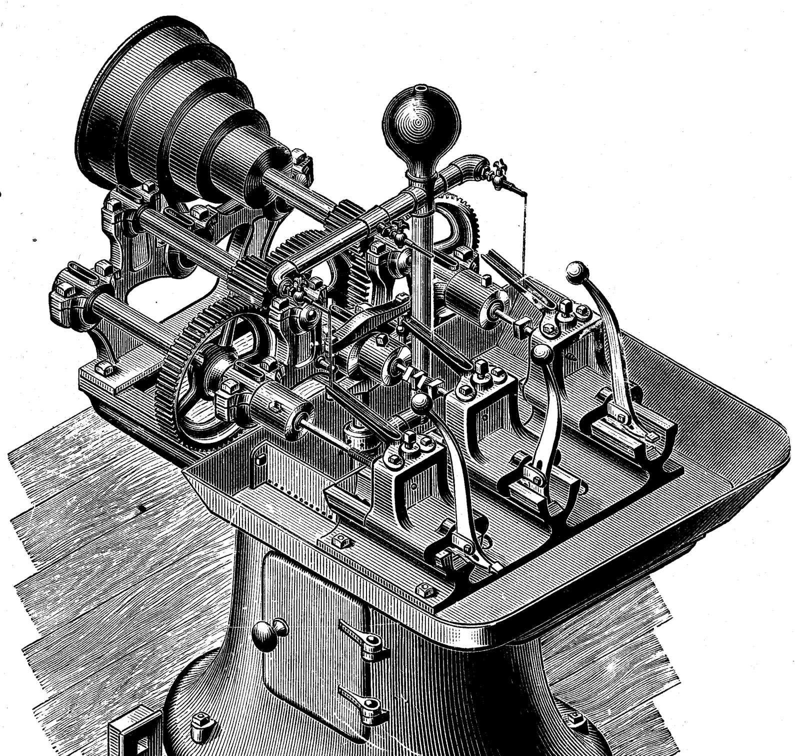

Fig. 1867.

In Fig. 1862 is represented a nut threading or tapping machine. The vertical spindles have spring sockets in which the taps are held, so that they can be inserted or removed without stopping the machine. The nuts are fed down the slots of the inclined plates shown on the upper face of the circular base, and the spindles are raised and lowered by the pivoted levers shown. The nuts lie in a dish that contains water up to the

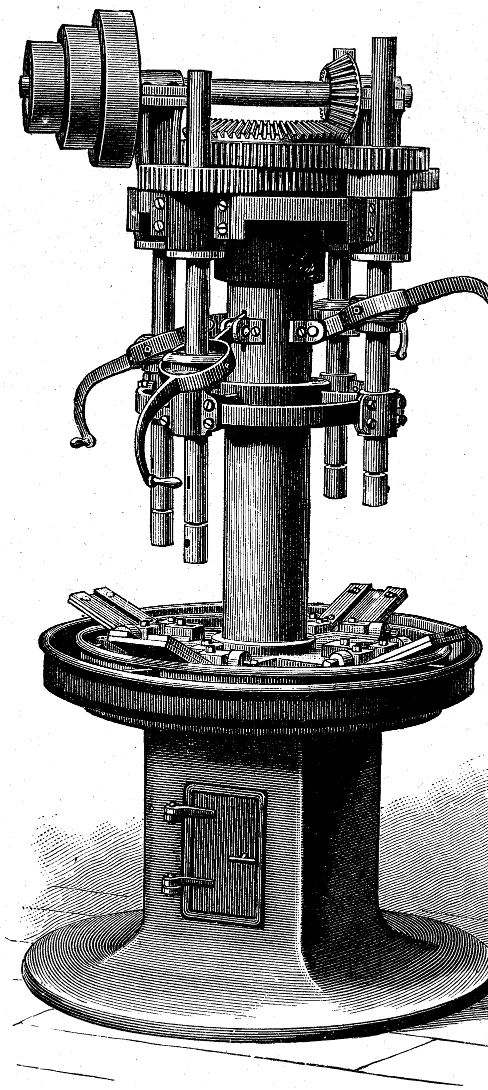

Fig. 1862.

level of the bottom of the nuts, the object being to prevent the taps from getting hot and therefore expanding in diameter. Upon the top of the water floats a body of oil about ½ inch deep, which lubricates the cutting edges of the tap. These machines are also made with six instead of four spindles, which in both machines run at different speeds to suit different sizes of nuts, and which are balanced by weights hanging inside the central hollow column or frame.

Fig. 1863 represents the socket for driving the tap, so devised that when the tap is strung for its intended length with nuts, the top nut releases the tap of itself, the construction being as follows: S is the socket that fits into the driving spindle of the machine; its bore, which fits the stem of the tap easily, receives two headless screws B, a pin P, which is a sliding fit, and the screw A. R is a ring or sleeve fitting easily to the socket, and is prevented from falling off by screw A. The tap is provided with an annular groove G. The flattened end of the tap passes up between and is driven by the ends of screws B, the weight of the collar ring or sleeve R forcing pin P into the groove G, thus holding the tap up. When the tap is full of nuts the top nut meets face V of ring R, lifting this ring upon the socket and relieving pin P of the weight of R, the weight of the tap and the nuts then causes the tap to be released. By this construction the tap can be inserted or removed while the machine is in motion.

In Fig. 1864 is represented a rotary nut tapper, and in Fig. 1865, is also represented a sectional view of the same machine.

The tap driving spindles are driven from a central vertical shaft S, driven by bevel-gear B. The horizontal driving shaft operates a worm C, to drive a worm-wheel in a vertical shaft, which drives a pinion *a*, driving a spur wheel W in the base of the spindle head, by which means this head is revolved so as to bring the successive spindles in front of the operator. A trough is provided at T to cool the tap with oil and water after it has passed through the nut.

Fig. 1866 represents a nut tapping machine designed for light work, the spindles are raised after each nut is tapped by the foot levers and rods shown, the latter connecting to a shoe fitting into a groove in a collar directly beneath the driving pulleys of the spindles.

Fig. 1867 represents a three-spindle nut tapping machine, in which the spindles are horizontal and the nuts are held in three separate heads or horizontal slideways and are traversed by the ball levers shown, and a self-acting pump supplies them with oil. The three spindles are driven by a cone pulley having four changes of speed to suit different diameters of taps.

Pipe Threading Machinery.—In Fig. 1868 is represented a machine for threading and cutting off pipe of large diameter. This machine consists of a driving head corresponding to the headstock of a lathe, but having a hollow spindle through which the pipe may pass. The pipe is driven by a three-jawed chuck, and the threading and cutting off tools are carried on a carriage which has a threading head for ordinary lengths of pipe, and one for short pieces such as nipples,

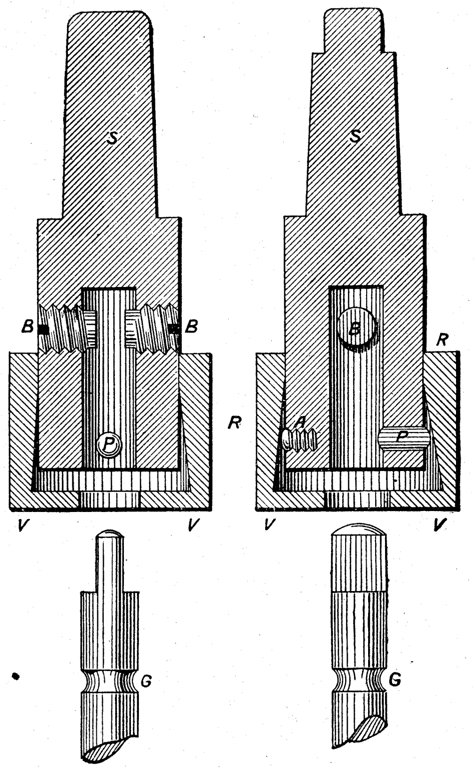

Fig. 1863.

the latter swinging out of the way when not in use. Between these two is a pair of steadying jaws for the pipe. A side view of the front of the carriage is shown in Fig. 1869, H H, &c., representing the threading dies used for nipples. It is movable along a slideway E and pivoted upon its slider. The dies are carried in a chuck G, and are opened or closed by the lever N; at L is the handle for the screw that operates the guide jaws A A.

The threading head at H (right-hand end of Fig. 1868), is represented in Fig. 1870, being pivoted so that it also can be swung out of the way to permit of the removal of the pipe. The dies C are opened or closed by the hand wheel B, operating a worm meshing into a segment of a worm-wheel upon the body of the head, the amount of motion being regulated by the stop screw at F, which therefore regulates the size to which the dies can be closed, and therefore the diameter of thread the dies will cut. The construction of the cutting-off head is shown in Fig. 1871, T representing the cutting tool which is operated by the hand wheel K. The carriage is fed or traversed by means of two pinions operated by the six-handled wheel shown at W, Fig. 1868; these two pinions engaging racks beneath the carriage, and near the

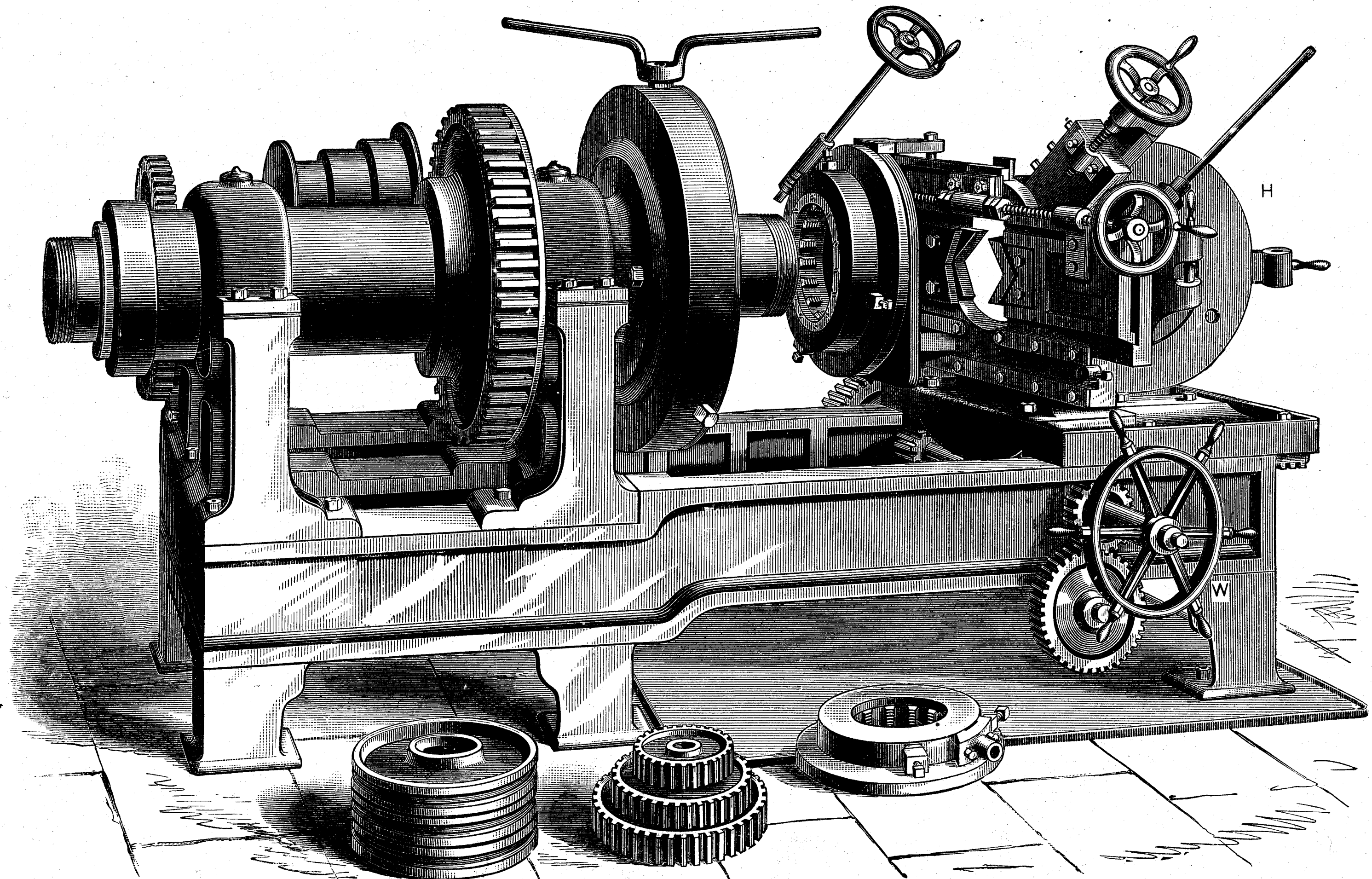

Fig. 1868.

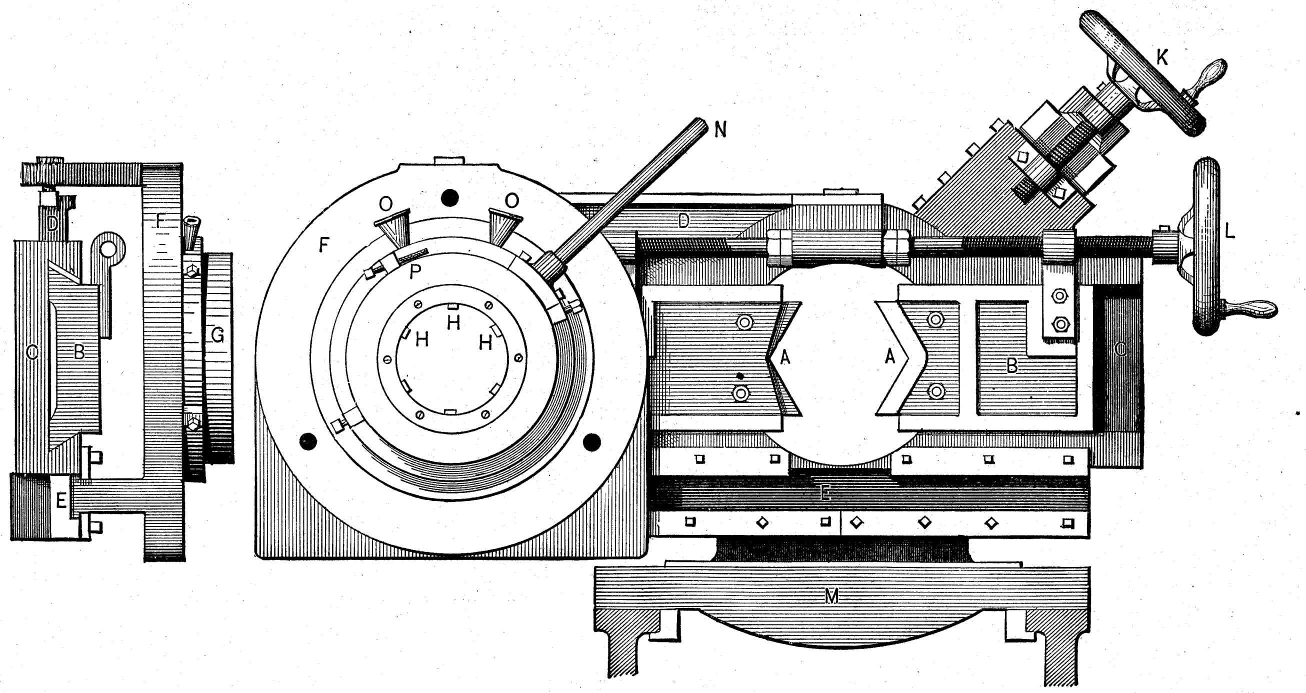

Fig. 1869.

inside edges of the bed, one of them being seen at the extreme right-hand end of Fig. 1868.

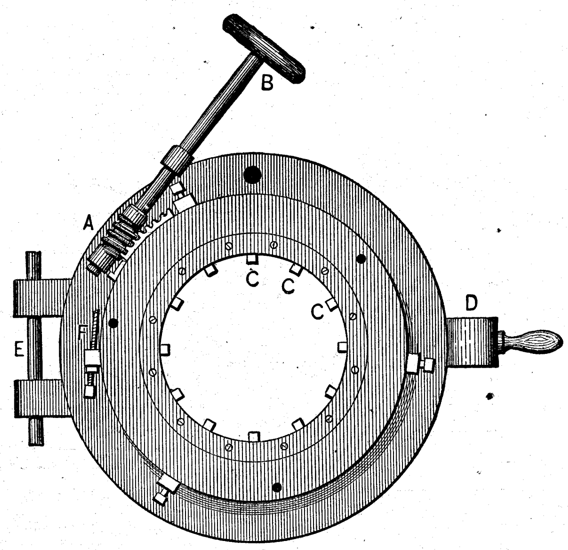

Fig. 1870.

In Fig. 1872 is represented a machine for threading or tapping the fittings for steam and gas pipe. The tap is carried in the end of the vertical spindle, and the work may be held in the vice upon the work table, or if too large the table may be swung out of the way.

The general design of the machine corresponds somewhat to that of a drilling machine.

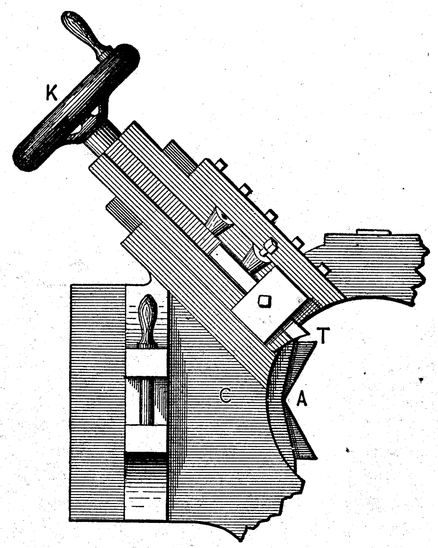

Fig. 1871.

BROACHING PRESS.—Broaching consists in forcing cutters through keyways or apertures, to dress their sides to shape.

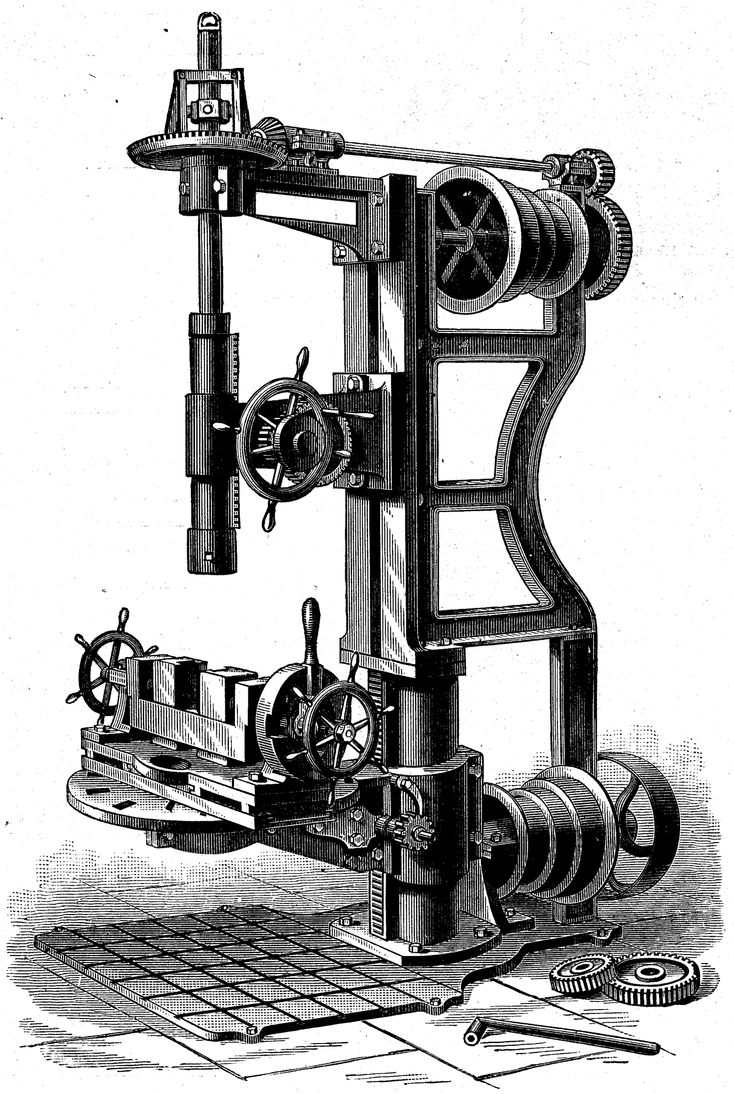

Fig. 1872.

In Fig. 1873 is represented a broaching press. Its driving gear which is within the box frame is so constructed that it may be started and stopped instantly, notwithstanding its heavy fly wheel.

Figs. 1874 to 1877 represent the method of cutting out a keyway by broaching.

In Fig. 1874 A represents the end of a connecting rod having three holes, B, C, and D, pierced through it, their diameters nearly equalling the total finished width of keyway required. The

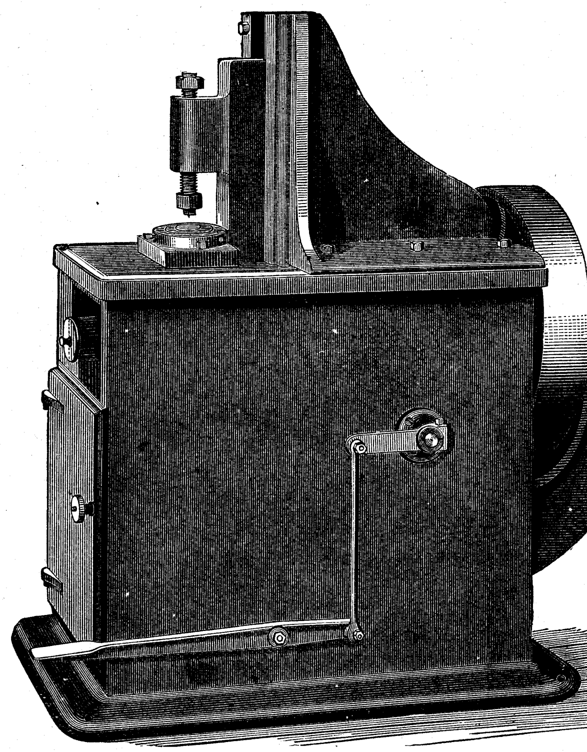

Fig. 1873.

punch D′ is first forced through, thus making the three holes into one.

The V-shape of the end of the cutting punch D′ tends to steady it while in operation, forces the cut outwards into the next hole, preventing them from jambing, and causes the strain upon the punch to begin and end gradually; thus it prevents violent action during the ingress and egress of the cutting punch. This roughing

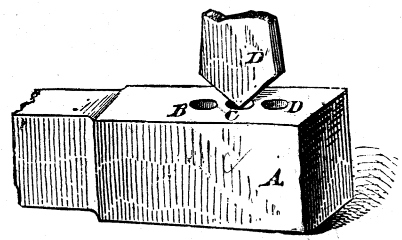

Fig. 1874.

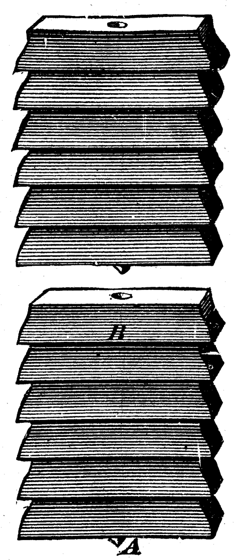

Fig. 1875.

out process dispenses with the use of the hammer and chisel, and saves much time, since it is done at one stroke of the press. The next part of the process is the introduction of a series of broaches such as shown in Fig. 1875, the principles involved being as follow: It is obvious that from the large amount of cutting edge possessed by a single tooth extending all around such a broach, it would be impracticable to take much of a cut at once;

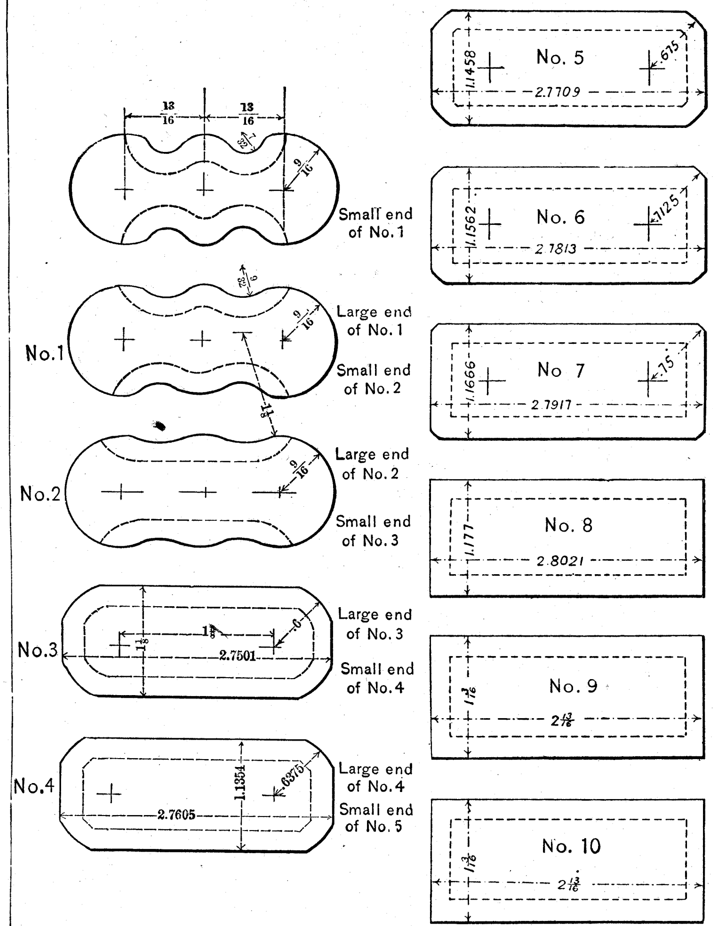

Fig. 1876.

hence a succession of broaches is used, some of them performing

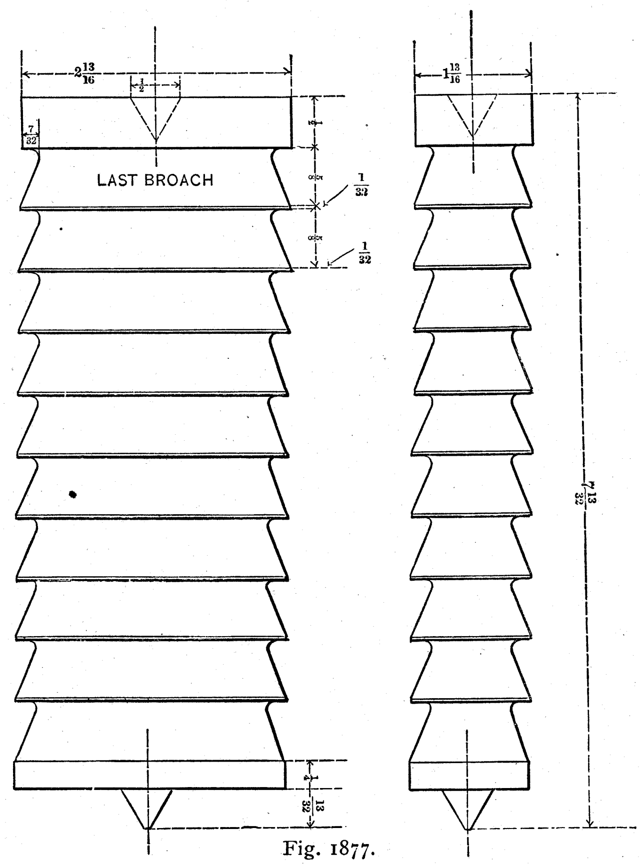

Fig. 1877.

duty on the sides only, others at the ends only, but the last and final broach is usually made to take a very fine cut all over. All these broaches are made slightly taper; that is to say, the breadth of the lower tooth at A in Fig. 1875 is made less than that at B, the amount allowed varying according to the dimensions and depth of the keyway.

The smallest of the set of broaches is entered first and forced through until its end stands level with the upper face of the work. Each broach is provided with a conical teat at one end and a corresponding conical recess at the other, so that when the second broach is placed on top of the first, the teat fitting into the recess below it, will hold the two broaches central one to the other.

The head of each broach is made somewhat conical or tapered, and sets in a corresponding recess in the driving head in the machine, which, therefore, holds the broaches parallel one to the other. A succession of these broaches is used, each requiring one stroke of the press to force it within the keyway, and another to force it out.

The following is an example of broaching, relating to which, the dotted lines shown on the broaches, Fig. 1876, indicate the depths and shapes of the teeth. The small end of each broach corresponds to the large end of the one that preceded it, which is necessary in order to permit it to enter easily. Of the ten broaches used the first two operate to straighten the side walls of the hole, No. 3 being the first to operate upon the circular corners, which are not cut to the rectangle until No. 8 has passed through. But as the duty in cutting out the corners diminishes, the walls and ends of the hole are operated upon to finish them to size; thus broach No. 3 leaves the hole $1\frac{1}{8}$ or 1·125 inches wide, and 2·7501 inches long, which No. 4 increases to 1·1354 inches wide and 2·7605 inches long. This increase of width and depth, or breadth, as it may more properly be termed, continues up to the last or tenth cutter, which is parallel and of the same dimensions as the large end of cutter No. 9. Fig. 1877 gives two views of the No. 10 broach.

Broaches require a very free lubrication in order to prevent them from tearing the walls of the hole, and to enable them to cut easily and smoothly; hence it is found highly advantageous after the teeth are cut to cut out grooves or passages lengthways of the broach, and extending nearly to the bottom of the teeth, which eases the cut as well as affords the required lubrication; but it is obvious that the finishing cutter must not have such oil ways.