

These devices can make the proper allowance for the different circumferences of outer and inner sheets in cylindrical boilers. Horizontal punches for flanged boiler-heads or fire-boxes or for angle- or tee-iron are also in use. They are called for because of the special limitations imposed by some shapes. Fig. 75 illustrates one type of such tools:

In limited use is also a type of shear for boiler-plate, the plane of whose stroke is oblique to the horizon. The idea of this is to shear the edge of the plate upon a bevel and remove the necessity of edge-planers to make ready the sheet for caulking.

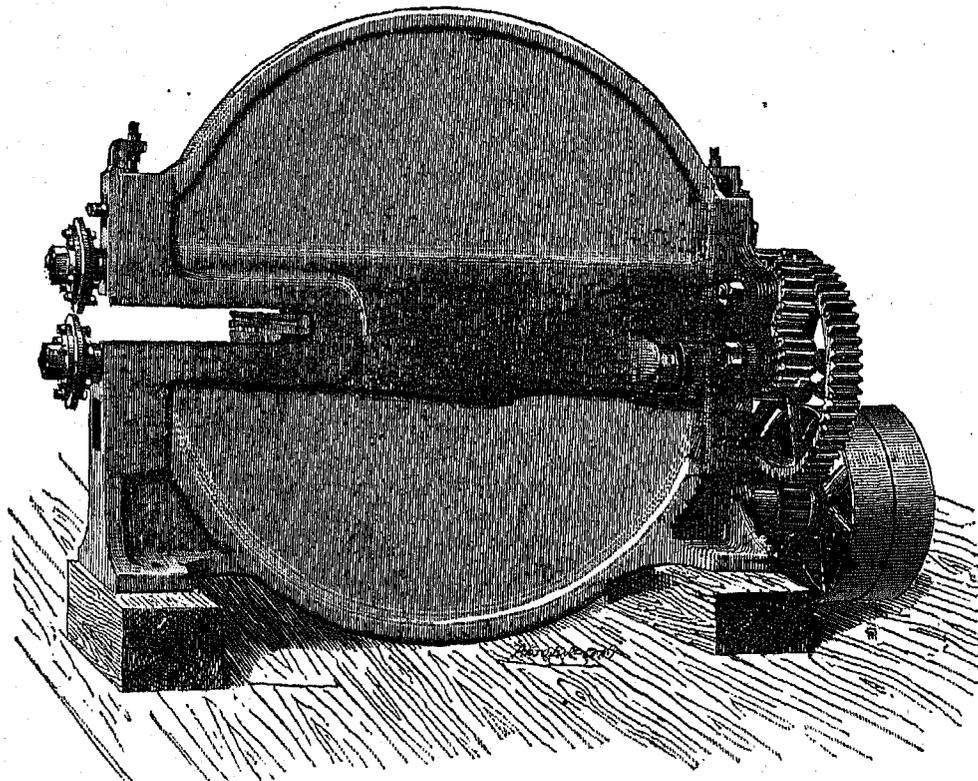


Fig. 76.

In the class of rotary shears but few large examples are seen. Two disks of steel slightly beveled and over-lapping are driven by power, and the plate to be sheared is fed against their point of contact. The disks can be brought together as they wear, both being driven by expansion gear linked to the spindles of the cutters, and can be set axially for different spaces at the cutting-point. They meet their chief application for light iron or other sheet-metal work, since they will cut a curved line. The disadvantage for heavier plate is that the knives grow jagged and chatter and mar the work. They are not very extensively in use at this date.

Fig. 76 gives an illustration of one design for large work, up to $\frac{3}{8}$ of an inch thick.

Punches and shearing-presses are extensively used in drop-forging work for trimming or

broaching the work after leaving the dies. They are also used to produce a cold-press finish upon pieces which would otherwise have to be milled. The double-connection presses are used for this class of work. In the sheet-metal presses, and in those used for the manufacture of drawn goods, shearing is also done, but these tools are beyond the province of this discussion. These tools belong either to the crank class or to a special class of roller-cam presses.

§ 15.

C.—TOOLS ACTING BY PARING.

To this class belongs the majority of the tools of the finishing- or fitting-shop. It includes all those in which the desired figure is produced at the working point by the scraping or cutting action of a wedge-pointed tool. Since they act upon the cold metal and remove relatively small amounts of material in the cut, these tools are much better adapted for working to exact dimensions than those acting by compression or shearing. They can also produce an ornamental finish upon the material which they shape. These features adapt them for the needs of the shop from which the completed work is to be delivered.

Paring-tools belong to two classes. The first includes those in which the relative motion of tool and work is circular or spiral. These can only produce surfaces of revolution, and include lathes, drills, and boring-machines. The second class includes those in which the relative motion of tool and work is rectilinear. These will produce plain surfaces by planers, shapers, and slotters, and also curved surfaces made up of straight line elements by the two latter tools.

The greater part of revolving machinery is made up of surfaces of revolution. The cylinder of these is by far the most important. The lathe will therefore be discussed first.

§ 16.

HORIZONTAL ENGINE LATHES.

The essential parts of a lathe are the bed, the head-stock, the tail-stock, and the arrangements for holding or supporting the tool. This latter device is called the slide-rest or carriage.

It is the primary function of a lathe to produce a truly cylindrical surface, with plain heads perpendicular to the axis, upon the rough material presented to it. The motion of the point of the tool must therefore be truly parallel to the axis of the tool; this latter must be a true straight line, and the secondary motion of the tool must always be at right angles to this line.

The first condition must therefore be stiffness in the bed of the tool. Under the strain of the cut it must not bend downward nor yield laterally. The bed is usually of cast iron, made of two girders of approximate I-section, whose flanges shall give the necessary vertical strength. The newer tools are built with much greater depth of bed than the earlier forms had. To secure lateral stiffness, the two girders front and rear are connected by interior cross-girts about 2 feet apart. These bind the two sides together, and are put near enough to each other to avoid any spring between them. Small lathes are mounted upon legs at sufficient intervals; the lathes of larger swing must be bedded upon a foundation upon which the bed rests directly.

Upon the top of this bed will be the guiding lines for the movable tail-stock and tool-carriage. The finished upper surface of a lathe-bed is called its shears. There are two types of practice with reference to the form of track upon which the sliding parts shall move. In one type the shears are finished off flat, and in the other there are four parallel tracks upon the shear, of inverted V-form, truncated on top.

The advantages of the flat-top shear are its extended bearing surface on the bottom of the carriage and the ease with which the true flat surface may be produced. The large surface reduces the pressure per unit of area, insuring lubrication, and therefore retarding the wear of the sliding surfaces. If hollow places are worn in the shears, the tool-point will fall at those points, producing untruth in the cylinder which is being cut.

The objections to the flat shear are that the tail-stock must move easily in the opening between the shears, that it may be adjusted for work of differing length. For this ease of motion some play must be left between the two sides of the bed and the guiding surfaces of the tail-stock. This play will be enough to vitiate the truth of the cylinders cut by the lathe. Its effect has been avoided by one designer, whose lathes have a V-track upon the under side of one shear. The clamping device fits over this V from below, and when the tail-stock is clamped it is

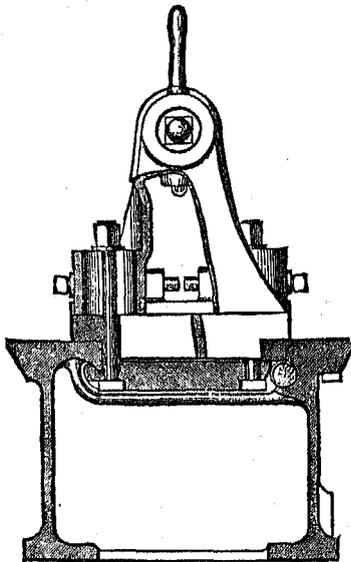


Fig. 77.

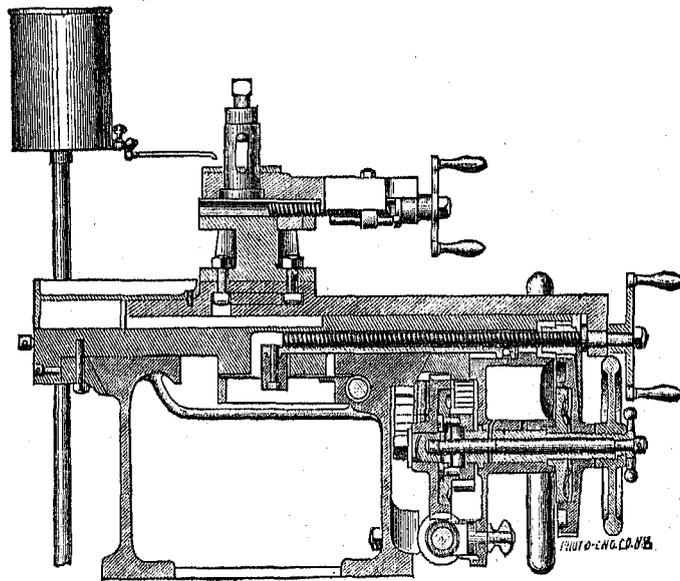


Fig. 78.

certain to be drawn always into the same relation with this V, and the axis of the lathe will be always in one line (Fig. 77). In other designs the stock is kept up to one side by adjustable brass taper gibs, reducing the lost motion to a minimum. The guiding of the tail-stock by the inner edges of the shears is practically universal in the flat shear designs. The carriage or saddle carrying the tool-holder will be guided upon the outer edges (Fig. 78). Otherwise, the wear on the surfaces nearest to the head being the greatest, the untruth of the axis would be increased by the lateral wear due to the carriage-motion.

A second objection to the flat shear is that it opposes its strongest resistance to the vertical components of the strain on the tool-post, while the horizontal components are only taken up by gibs. In turning large work upon a

small lathe, where the point of the tool is over the shear, the vertical components will be the greatest. Upon a large lathe also, where the shears will be wide and the carriage and attachments heavy relatively to the strain of the cut, the vertical components will be in excess. But in a lathe cutting work of small diameter, whether facing, boring, or turning, the strain on the tool-post is oblique, passing downward at an angle from the center which varies with the swing of the lathe, and will average perhaps 30° . This strain tends to force the tool downward and outward. The downward strain is resisted by the broad shear; the lateral strain comes upon the gib at the rear only (Fig. 78). This latter strain is not opposed by surfaces at right angles to it nor by surfaces of large area. The freedom for sliding upon the fitted surfaces must also be in this lateral direction, which at the same time is the direction in which untruth will produce the greatest effect to mar the work.

The further objections which have been urged against the flat shear that they make it harder to move the carriage, and that chips from the work get ground into the ways, may be dismissed with a word. The ways will not be clogged when the tool is taken care of as it should be; and a new form of flat shear with a lower step for the tail-stock motion is an effectual preventive of the latter difficulty, even if it were a real one, with shears in one plane only.

The advantages of the V- or track-shears consist, first, in its opposing a resistance normal to the oblique pressure due to a cut on a small cylinder. Upon the top of the bed are four raised rails, of inverted V-form, truncated on top. These V's are of varying angle, around 60° as a mean. The sides of the V's which face the

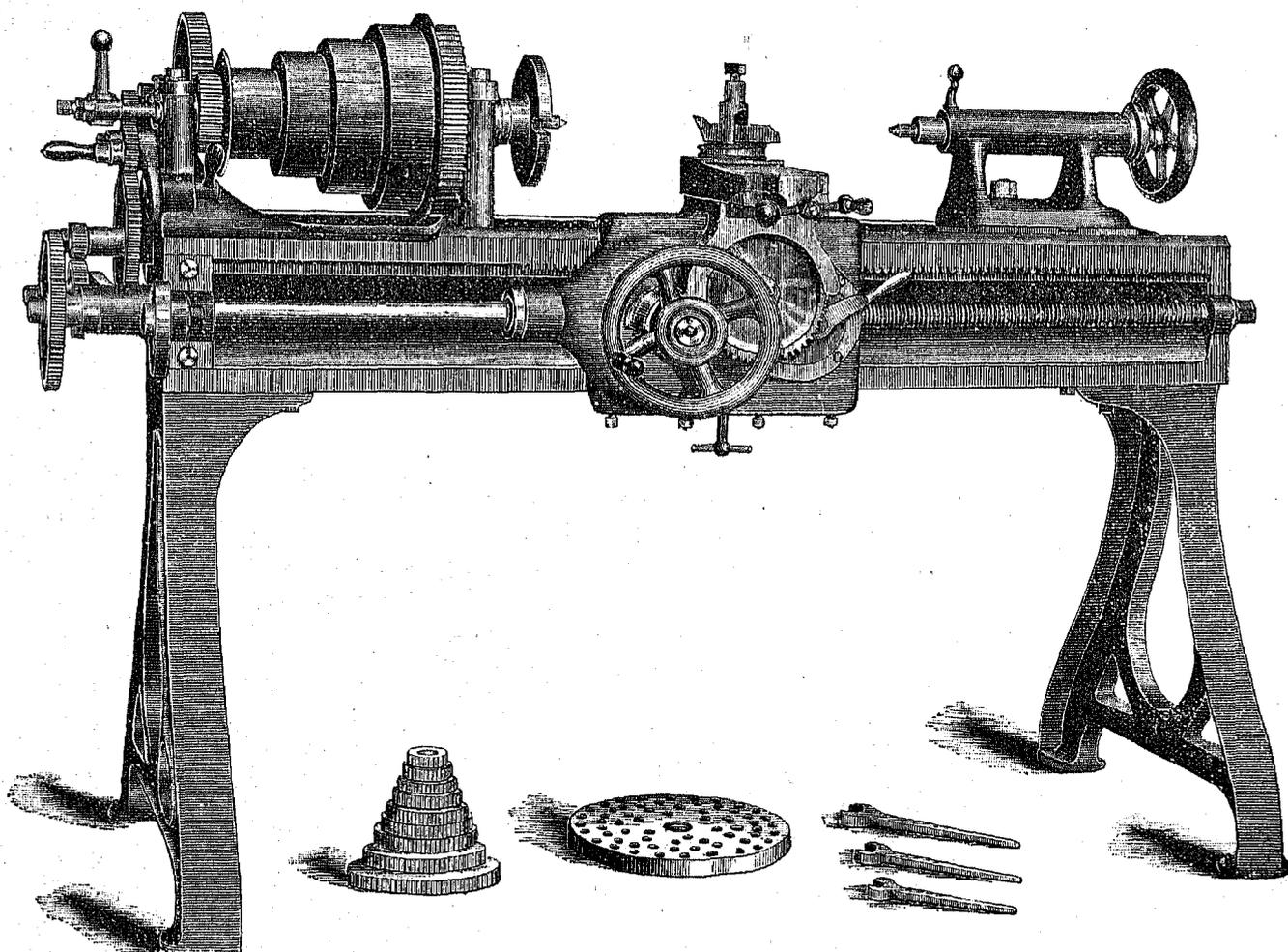


Fig. 79.

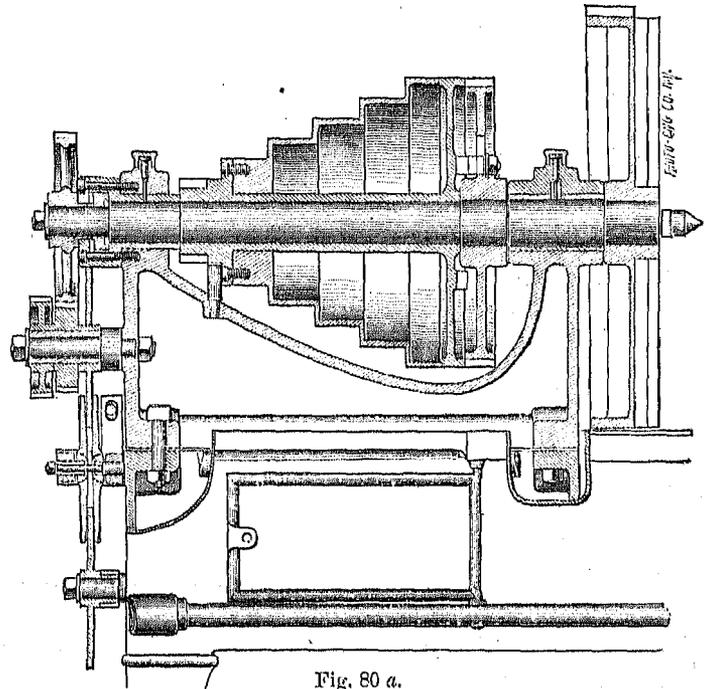
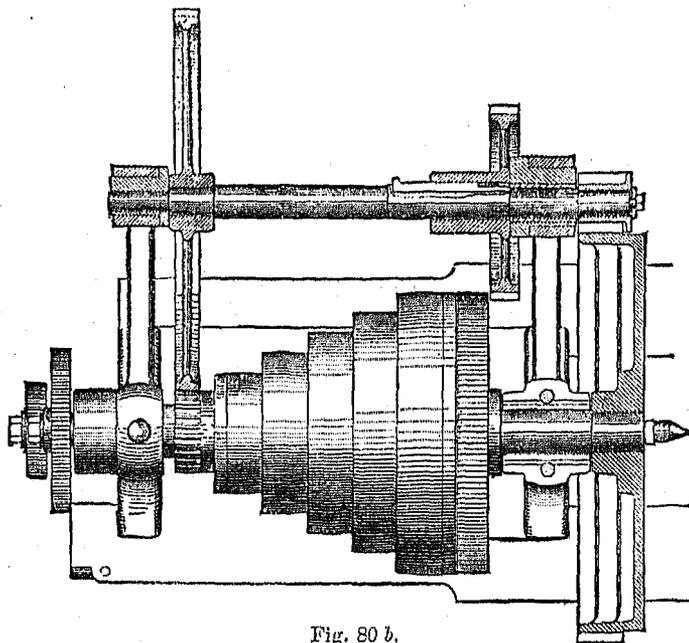
back of the tool on each shear are about normal to a strain which presses down obliquely at an angle of about 30° . In some cases of large lathes the angle of the track is about 90° ; in others it is 75° . The carriage is carried upon the outer pair of V's, resting upon them in grooves planed in its lower side. It is kept from rising by gibs under the flange of the bed-top, and its own weight secures all the freedom required for ease of motion, without lateral play. The tail-stock travels by similar grooves upon the inner pair of V's, thus securing at all times a perfect alignment with the head-stock. Moreover, the clamping of the tail-stock upon the V's holds the frame from spreading, and acts as a rigid cross-stay where the strain of the dead-center comes. Its freedom of motion is secured by its vertical yielding only. When the tool is at work, therefore, is the time when all its parts come most exactly into line, provided the shear-tracks are perfectly parallel.

Against the V-shears stand the diminished surface for wear by vertical strains, the danger to them from blows, the difficulty of keeping them lubricated, and the expense of accurately fitting them to parallelism and to the grooves in carriage and poppet-heads.

The V-shear is the characteristic American type. It is preferred among all the New England manufacturers, where the tools are built for general work and for jobbing, where small diameters will predominate. Around Philadelphia the flat shear is popular, where the tools are built more for large and heavy work, where the downward pressure will be in excess. For axle or shafting lathes and others, where one diameter is to be prevalent, the shears may be so proportioned as to bring the bulk of the strain vertical, and the flat shear will then be preferable. For large tools in best practice, the moving parts will travel upon three shears instead of upon two only (Fig. 119). This may reduce the swing of the tool slightly, but the gain in stiffness more than compensates for the loss.

One form carries the slide-rest upon the front of the bed only (Fig. 79). This gives large swing over the shears. The carriage does not wear the track of the tail-stock.

Upon the bed of the lathe will be the head-stock and tail-stock, the former carrying the rotating or live center, and the latter the stationary or dead-center. The head-stock will be bolted to the bed securely. The tail-stock must slide along the bed to accommodate work of differing lengths, and should clamp securely fast to the bed with the center in the true axis of the tool. For lathes of small swing Fig. 80 *a* illustrates the general construction of the head-stock in section and in plan. The essential feature of the head-stock is the live-spindle. This is made of steel up to certain sizes, hardened and ground true. Upon the truth of this spindle depends the truth of all work done in the lathes. Any errors in it will repeat themselves, especially in work chucked to the face-plate. In small lathes this spindle turns in hardened steel split boxes. For the larger sizes composition boxes, and cast-iron boxes with babbitted pockets, divide the manufacturers about equally. Many would prefer cast iron alone if they could always insure lubrication. The front journal is always made cylindrical in best practice. Conical journals are apt to "seize" from some variation in temperature and will become cut out of true. Older practice had a collar upon each side of the journal. Newer practice leaves off the outer collar, and the most advanced designers leave off both shoulders and control the end play of the spindle from the outer end. In this system the front or inner journal controls the sidling or lift of the spindle only, and any changes of temperature cannot impair the fit or cause lost motion endwise. To take up the thrust of the tool against the work when facing or when feeding heavily toward the head it is necessary to have some sort of step at the outer end of the spindle. Where the single-shoulder system is in use the rear end turns in a cylindrical box, which is closed at the outer end. Through this closed end passes a hardened steel screw whose axis coincides with that of the spindle. This tail-screw either bears directly against the hardened end of the spindle or else through a washer. The washer is sometimes a disk of hardened ground steel, but in most frequent practice a washer of rawhide is employed. This causes less difficulty from the danger of cutting if it gets dry by accident, and is increasingly popular. The difficulty is the lack of uniformity of the hide. The tail-screw is secured from working loose by a jam-nut against the box, and any degree of closeness of fit longitudinally is obtainable. One designer uses a washer of vulcanized paper fiber, and one uses composition. There are advantages connected with

Fig. 80 *a*.Fig. 80 *b*.

through a washer. The washer is sometimes a disk of hardened ground steel, but in most frequent practice a washer of rawhide is employed. This causes less difficulty from the danger of cutting if it gets dry by accident, and is increasingly popular. The difficulty is the lack of uniformity of the hide. The tail-screw is secured from working loose by a jam-nut against the box, and any degree of closeness of fit longitudinally is obtainable. One designer uses a washer of vulcanized paper fiber, and one uses composition. There are advantages connected with

the practice of confining the spindle from end motion in both directions from the tail end. A type of such designs is shown by Fig. 80*b*. Near the end of the spindle is secured a hardened steel ring or collar, which is ground true and runs between similar washers, from which lost motion can be taken up. When kept well oiled by keeping an oil-cellar full these disks run without liability to stick or jam.

To insure that a lathe-spindle shall always run true, even after wear has begun, beside taking up the end play, is the object of the spindle-journal invented by one of the New England builders. The box is a split cylinder of gun-metal, with conical screw-threads cut on the outside at the ends. Two cheese-nuts fit upon these screws, and by turning them down the box is closed up concentrically upon the journal. A wooden pin prevents the nuts from closing the splits too closely. At the rear box, beside this arrangement, is a bearing-step for motion in one direction, and a pair of jam-nuts bearing against a washer prevent motion in the other direction. The chief point with regard to these thrust bearings is that they have sufficient area. Otherwise they will be apt to wear into rings and cut the surfaces. One designer using steel disks makes them a

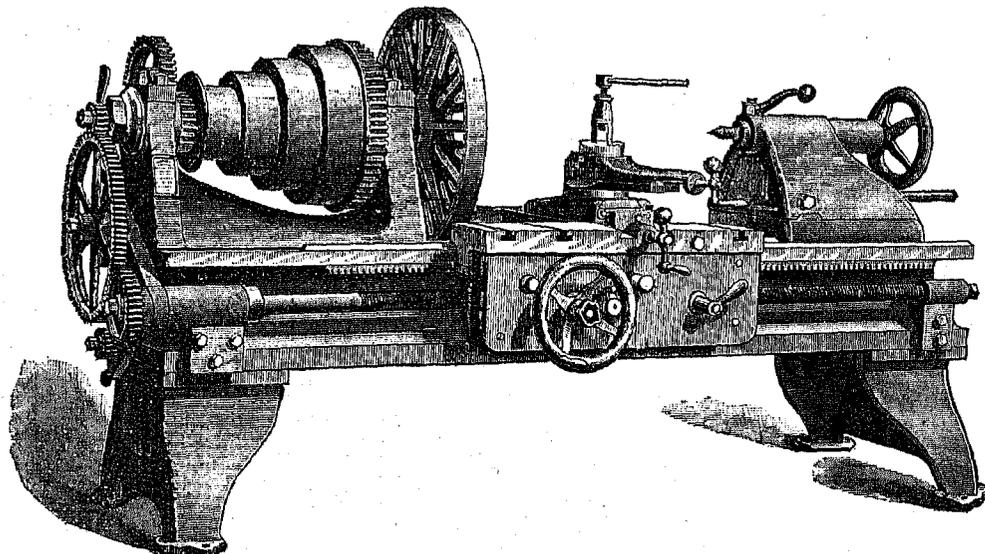


Fig. 81.

little smaller than the cell in which they lie. They will turn freely, and yet, being eccentric to the spindle, they must be worn flat uniformly, and will tend to bring up oil from the bottom of the cell upon the step. The advantage of discarding the prevalent step-screw is that the pinion for the feed-gear for the carriage can be put directly upon the end of the spindle. Otherwise this pinion must be inside the head casting, and the latter must be perforated to allow an idle spindle to pass through it, with gears outside and inside. This weakens the head and prolongs the span of the spindle between journals. The alternative way, retaining the step-screw, is to mount the latter upon a separate cross-piece at the tail, supported upon pillar-studs tapped into the end of the head. The Pond box (Fig. 81) permits the spindle to pass through freely, since the thrust is taken up on a steel ring shrunk on the spindle. A hollow steel sleeve flanged at the inner end screws against this ring through the end of the box. The box is hollowed into a chamber around the ring and flange, which is filled with oil up to the horizontal diameter. For the largest sizes of lathes, where the spindle will be massive enough to be made of cast iron, the thrust will be taken up by the collars upon it. The faces of the boxes will often be recessed and babbitted in these designs. One designer of light lathes (Fig. 82) uses a cylindrical box externally, so that the box may be replaced when worn, without replanning the head, to bring the spindle in the center. The boxes are split, and a conical-pointed screw in the crack prevents cramping on the journals.

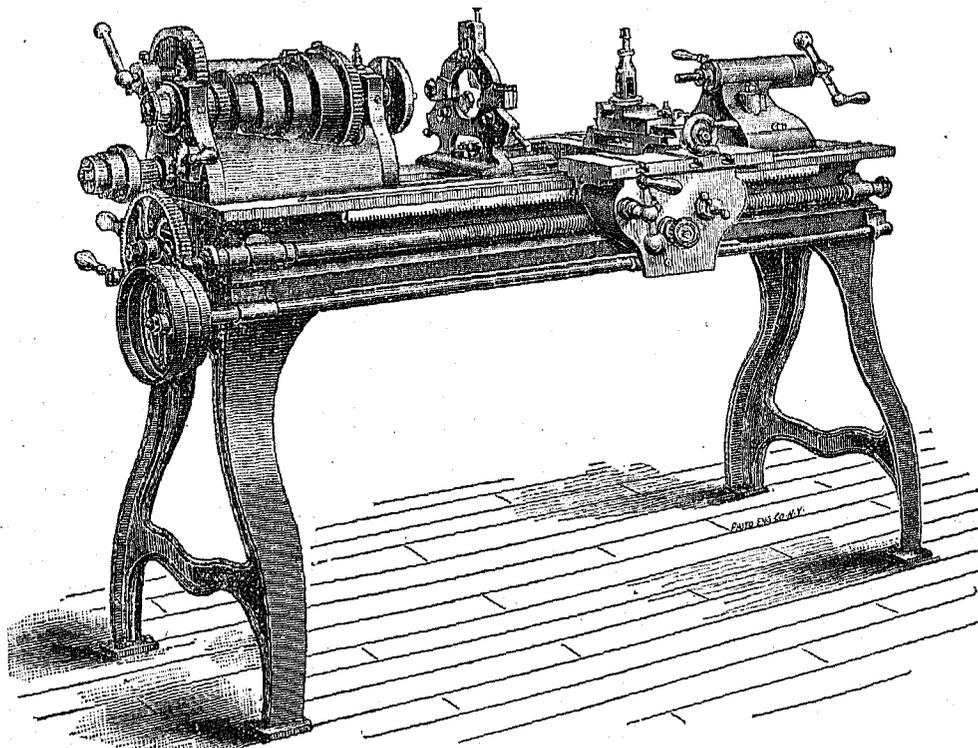


Fig. 82.

The shape of the casting in which the boxes for the spindle are supported will be seen from the various cuts. The top surface curves upward toward the tail, giving effective depth to resist the strains at that part. In one design the hollow underneath the casting is braced by stiffening ribs. The differences required for the lathes of larger swing are solely due to their larger size. The aim of the recent changes of design has been to secure the greatest stiffness and strength against the strains to which the head is exposed.

Upon the live-spindle turns freely the nest of cone-pulleys. This is a series of belt-wheels of different diameters, made necessary by the variety of work to be done upon the tool. The cutting-edge of the tool can act at different speeds upon brass, cast iron, wrought iron, and steel, and a given speed must not be exceeded upon the circumference of cylinders of very different diameters. This variation is most easily accomplished by the use of two nests of cone-pulleys, one on the counter-shaft and the other on the tool. The two nests are complementary, with the sum of the diameters of each pair in the series equal to a constant quantity. The same belt can be used on all, but it

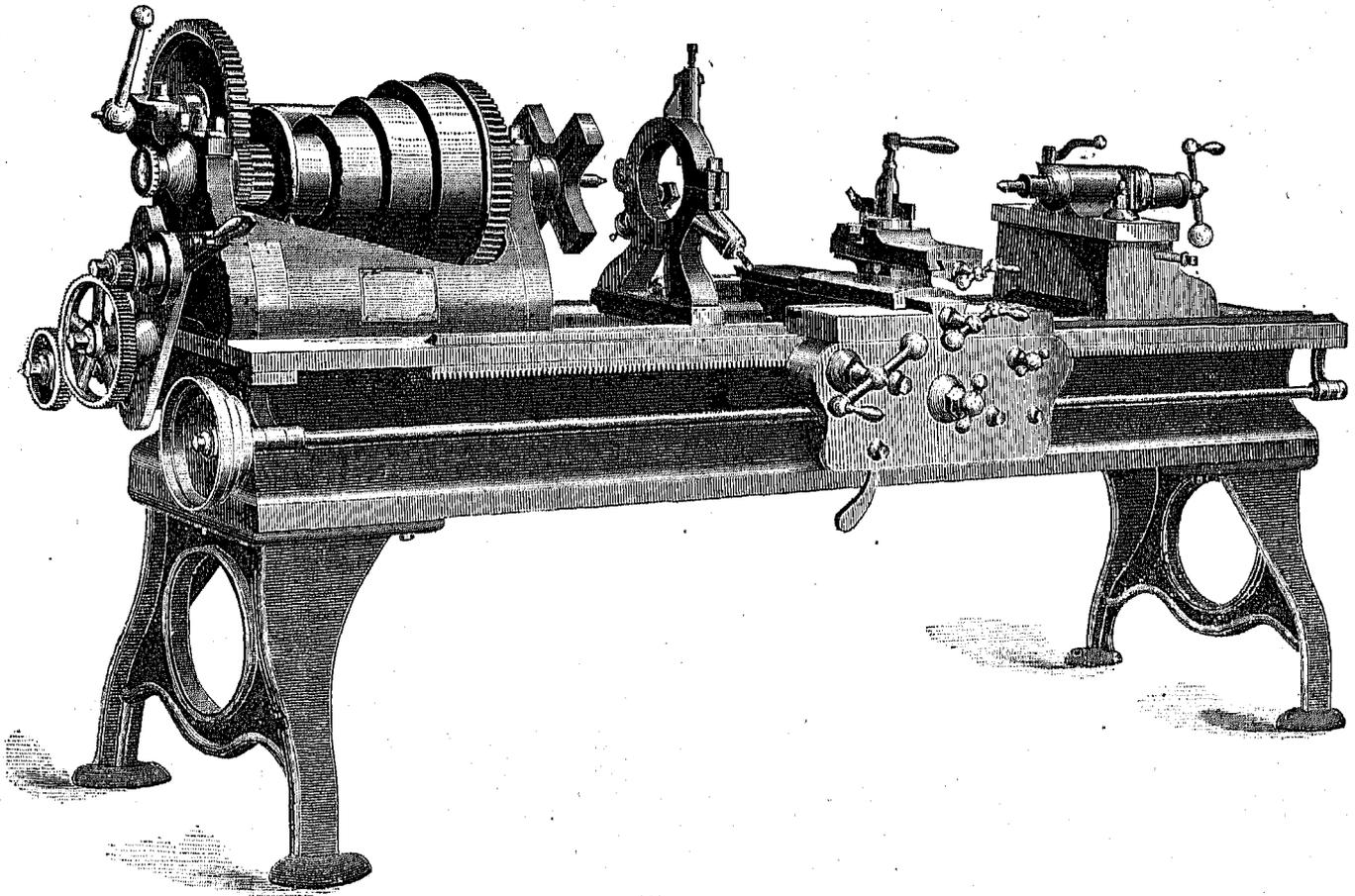


Fig. 83.

will run at different speeds, and therefore produce different speeds of rotation of the work. There are usually four pulleys in the cone. Three only are put on the small sizes, while the very large have five, six, or seven. The faces of the pulleys are most frequently flat; those of a few builders are made crowning. The pulleys are made in one hollow casting, with a long sleeve for the spindle to pass through. The end of the sleeve in larger cones is braced to the large pulley by a spider cast with the cone. For ease of fitting, the sleeve is often cut away in the middle of its length and bears on the spindle at its ends only. The pulleys are sometimes turned on the inside, to insure a perfect balance and smooth running. At the small end of the cone a flange is often put to prevent the belt from running off into the gears. If no flange is used, a guide-pin may be put below, into the casting, to serve the same purpose.

Beyond the flange is a small pinion, either cast as part of the cone or secured to it by screws. This pinion is to drive the "back-gear", or "double-gear", as it is called. This consists of a shaft holding a large and a small gear-wheel, which may carry the motion around the cone-pulleys to a large gear in front of them. This large gear is secured to the live spindle. It will be seen that when the small gear on the cone-pulley drives the large gear on the back-gear shaft, the latter will move at a speed much lower than that due to the cone-pulleys. When again this motion is further reduced, because a small pinion on the back-gear shaft drives the large gear on the spindle, the speed of the work will have been very much lessened. The back-gear usually reduces the speed of the spindle to one-sixth or one-tenth of that due to the cone-pulleys. The back-gear shaft is hollow, and turns upon an interior spindle which passes through it. At each end of this spindle an eccentric-pin is turned, which fits into bearings in

the head-casting. It will be seen that if the spindle be turned through 180° it will move the back-gear shaft bodily sidewise through a distance equal to twice the eccentricity. This distance need only be made a little more than the depth of the gear-teeth to furnish a most simple means of engaging and disengaging the shaft with its two gears. Some designers make the eccentricity larger, so as to require less angular motion of the back-gear lever to engage the wheels. The difficulty with this system is that the gear will throw itself out if the bearings are an easy fit.

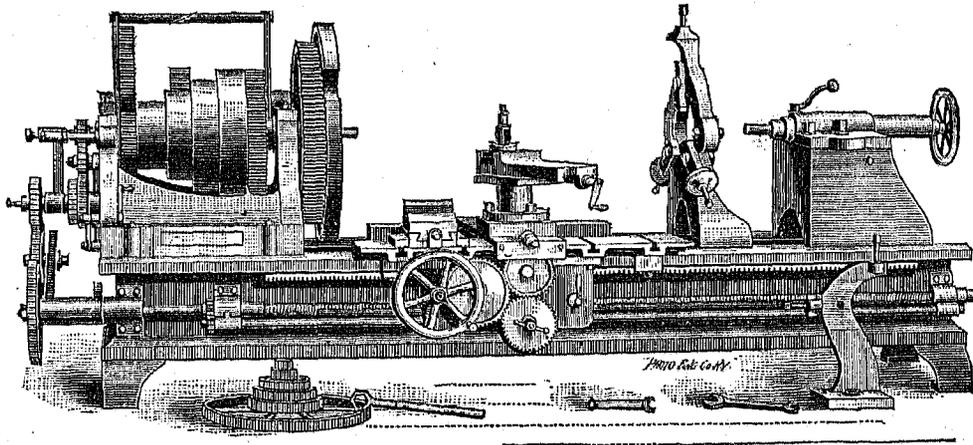


Fig. 84.

The strain of the gear is a lifting push, and if it takes the eccentrics at a favorable angle it will turn them. Most builders put the eccentric-pins so as to be on the line of centers when in gear. One maker turns the pins a little farther (Fig. 83), so that the strain which tends to separate the gear is opposed by the lower stop. Such an arrangement could not possibly throw out. The engaging-lever on large lathes is often doubled (Fig. 84). Some largest lathes, where the double-gear will be always in use except when

polishing, have the composition boxes movable on their seats, so that they can be slipped sidewise, and are then held by a key.

Many of the larger lathes are also triple-gearled. Beside this back-gear combination, there are often teeth cut upon a circle larger in diameter than the gear which is fast to the spindle. These teeth will be upon the back of the face-plate, and will be driven from a smaller gear on the back-gear shaft prolonged, or else indirectly from it through idle gears (Fig. 85). In these large lathes the face-plate is never removed, since it is inconveniently heavy, and the work can very readily be driven by it. Where the face-plate is driven directly, it is necessary that both pinions on the back-gear shaft should be movable lengthwise on their splines, since they both must not be in gear at once with wheels of different diameters fast to the spindle. Where the power is transmitted through idle wheels, the slip-gear may be the one on the back-gear shaft only. It may slip out of gear with the spindle-wheel and into gear with the face-plate train, with an interval between their planes from which neither will be driven. Sometimes the whole back-gear shaft slides lengthwise and is held in place by a pin, taking into grooves cut in the shaft. The idle-wheel system is specially desirable where the face-plate teeth would come on its periphery. It is much better to make the face-plate teeth internal upon an annular flange in this case (Fig. 85), both for cleanliness, for safety, and to prevent interference with the chucking of large flat work. In many large lathes the cone-pulley spindle drives internal gear on the face-plate through an ordinary back-gear combination. The cone-pulleys are not on the live-spindle in this case (Fig. 86). Where the face-plate is larger than the gear-circle desired the teeth on the latter may be external. Some lathes for special classes of work are driven directly from a pinion on a splined shaft to teeth on the periphery of the face-plate.

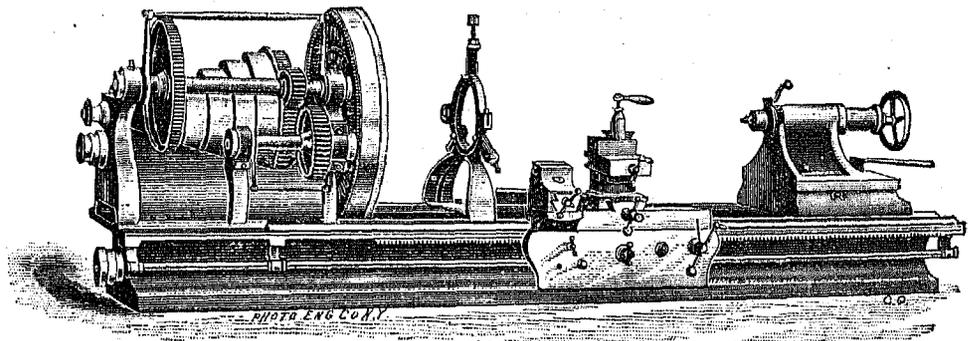


Fig. 85.

When the lathe is to be driven at speed for polishing or the like the back-gear shaft will be turned out and the cone-pulley will be clamped to the large gear fast to the spindle. This clamping is effected by a bolt passing through a slot in the plate of the fast gear-wheel. This bolt will cause a short slide to catch between jaws upon the inside of the cone-pulley, so that when the bolt is tightened the cone-pulley and gear become as one; or they may be clamped together by a regular friction device. For some special classes of manufacture, where the work, for example, is to be chucked, faced, polished, and drilled centrally, the back-gears and two speed-changes are all controlled by friction-clutches, so that the speeds may be changed without loss of time to stop the tool and shift belts or loosen nuts. One firm put several lathes upon the market in which the back-gear wheels were made with

helical teeth. The object of this was to cause more even working of the spindle and to lessen the vibrations of the work when driven through gears. It was not found to compensate for the trouble in shaping the teeth, and has been abandoned.

Upon the end of the spindle is secured the face-plate. This is simply a disk of cast iron, with radial slots in it, through which bolts and pillars can be passed to secure work to it. The front face of it must be a true plane and perpendicular to the axis of the lathe and of the spindle. It should also be balanced. It is usually screwed upon the end of the spindle, finding a true bearing at the end of the thread. As the lathe always turns in the direction opposite to that of the hands of a watch to one facing the inner end of the spindle, the resistance to the

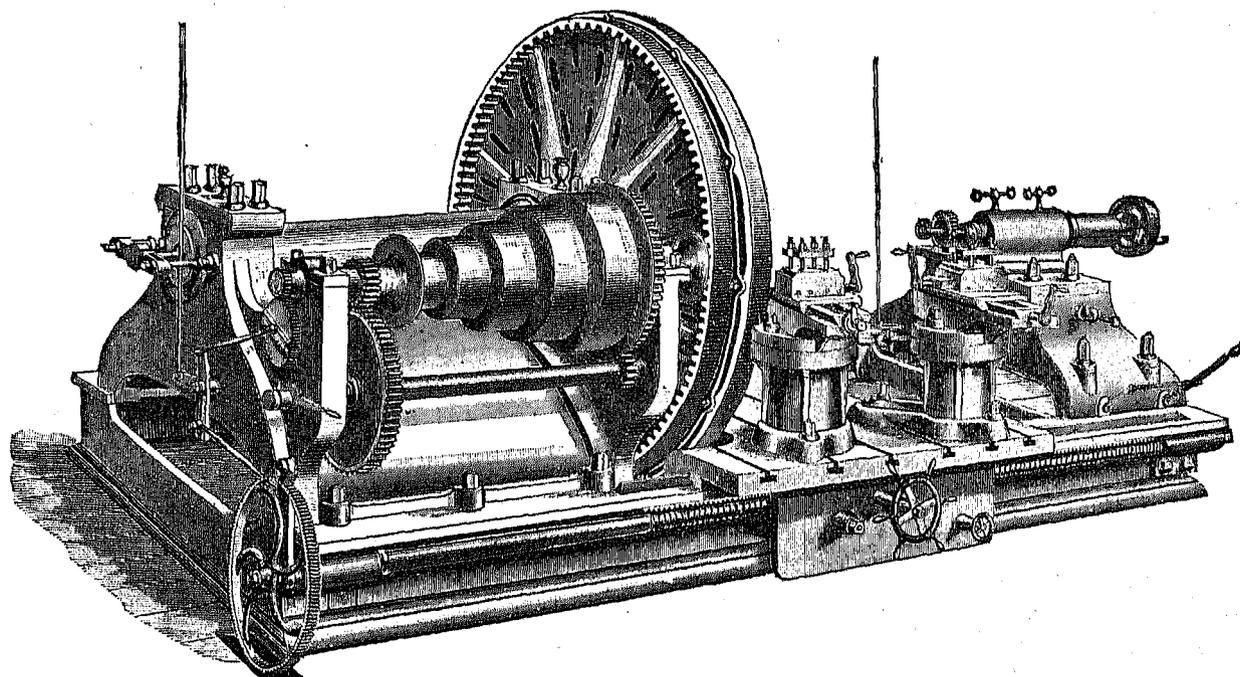


Fig. 86.

cut only screws the plate tighter when threaded on by a right-hand screw. Sometimes, besides the short slots, there are three or four long slots carrying jaws which can be moved upon the plate by screws in the slots. These serve to secure work to the plate, which will then be called a chuck-plate. For rod-work, screw-cutting, and the like, the face-plate is often replaced by a drive-plate, a flat disk with a slot cut on it along a radius to hold the tail of the dogs or drivers (Fig. 82). The four-armed spider is also used for dogged work (Fig. 83). A universal chuck can also be screwed on the end of the spindle when required. Usually the spindle is threaded to its end. In some cases the thread is made much shorter and the end of the spindle made to fit the plate or chucks upon a cylindrical surface left on it beyond the screw. This makes the adjustment of the plate more rapid and lessens the danger of battering the shears in cases where the heavy plate is only released from the screw when it is able to drop.

In the inner end of the spindle is bored the taper hole for the live-center. This, of course, must be truly central, and is made tapering to insure a tight fit at all times and truly in line. The taper is quite long, in order to secure ample bearing for the center when in place. The spindle is often made hollow in small lathes to accommodate lengths of rod, and also to permit the introduction of a rod through the tail-screw by which the center might be driven out when chucks were to be used. Where the centers were made of a long cone fit joined to the short cone center point by a short cylinder this device was very convenient. The newer centers are made with a squared surface outside the fit upon which a wrench can take hold to loosen them. The centers themselves are made of steel hardened at the point and ground truly conical in place. The angle of the cone varies from 60° to about 75° . The former is in many places more general. It is the apex of this cone which determines the axis of the tool, since all surfaces of revolution will turn around the line drawn between the points of the live- and the dead-center as an axis. It is necessary, therefore, not only that both cone centers should themselves be perfectly true, but that both apexes of the cones should remain in the intersection of the same horizontal and vertical planes in whatever part of the bed of the lathe the former may be.

It is the object of the tail-stock to insure the permanence of this axis of the lathe, and to permit considerable variations in its length. There will be a rough adjustment for length of work by hand, and a finer adjustment by a screw, while both must be clamped from moving out of adjustment when in place. The tail-stock is guided from lateral motion by the inner edges of a flat shear, or by the inner tracks of the V-shear.

When at the right position on the bed it is clamped in place by a cross-bearer, which is brought up against the under side of the bed. This clamp may be tightened by one screw from below, by an eccentric-cam, turned by a lever (Fig. 89), or by two or more bolts, one at each side of the casting. On the larger lathes there will be more than one clamp, and therefore more than one pair of clamping-bolts. The eccentric is adapted for medium and small sizes only. The screw arrangement is the most general. Upon the top of the movable stock is the finer screw adjustment for length. This consists of a spindle, cylindrical on small lathes and square upon some large ones, which has a long bearing (Fig. 87). This spindle may be moved in and out from the tail-stock by a screw which is turned by a hand-wheel or ball-handle from the extreme left end. This screw is usually cut with a left thread, so that the spindle may be protruded by an instinctive "screwing-in" motion. When the end of the center enters the drilled hole in the work, the spindle must be clamped to prevent the center from turning out. It is therefore necessary that the spindle shall move in the axis of the lathe independent of the tail-stock, and also the clamp must be such as not to throw the end of the center out of line. There are three types of clamps for the spindle. One form draws up a ring or forces a set-screw or other frictional device upon the center of the spindle from above (Fig. 88). The second clamps the outer end of the spindle by a screw which tightens a collar split upon one side. This collar is often a projecting part of the long bearing (Fig. 89). The third type (Figs. 90 and 87) uses a split sleeve tightened upon the spindle by a conical muff. The muff is drawn upon the sleeve by a screw when a partial turn is given to it. This latter system has the advantage that under abuse it will not be so likely to spring the spindle out of line, either up or down. The casing containing the long bearing for the spindle is cast solid. In the earlier forms, the cap which guides the screw had to be screwed on by a flange. The spindle is kept from turning by a spline.

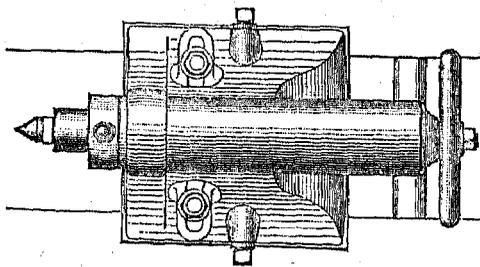
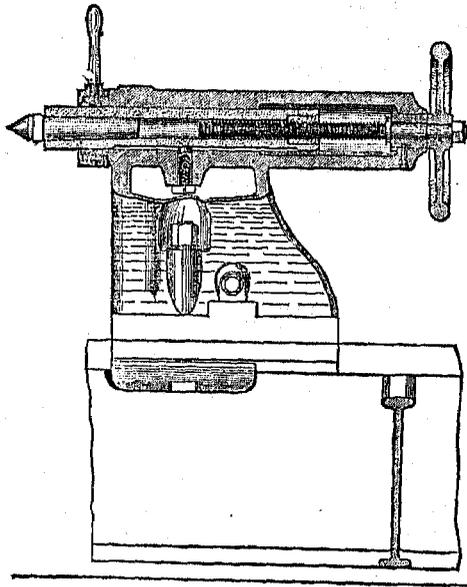


Fig. 87.

for the spindle in the first instance it is hard to get the lateral accuracy of the boring-bar relative to the shear-guides. The vertical adjustment is easy. Since it is desirable to have a little lateral adjustment for the dead-center when in place on the shears, this lateral motion can be easily made larger, and the lathe will then turn conical surfaces as well as cylindrical. Such tail-stocks are called "set-over tail-stocks", and have been hitherto almost universal. Advanced practice of today, however, prefers the use of an attachment for turning tapers which controls the motion of the tool. This system not only avoids the difficulty of readjusting the rear spindle after every taper, but also permits the boring of taper holes without a compound rest. When taper attachments are used, the tail-stock has only sufficient motion for adjustment. The older standard form of tail-stock is shown by Fig. 91; the newer shape is that of Fig. 81.

Very often a small oil-cup is cast in the spindle-casing, from which the lubricant can very easily be put upon the stationary center. The largest tail-stocks are too heavy to be moved directly by hand, so that a small pinion is made to engage in a rack at the side of the bed, and the squared end of its vertical axis will take the end of a long lever. The rotation of the pinion drags the heavy casting upon the shears. On some of the largest lathes also the tail-spindle has power-feed for boring. This type will be illustrated by Fig. 92 and further in advance.

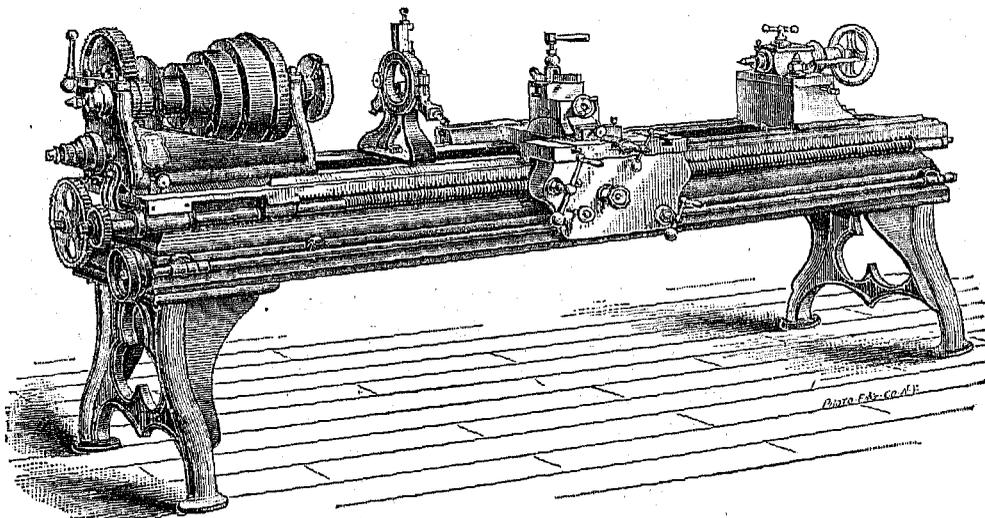


Fig. 88.

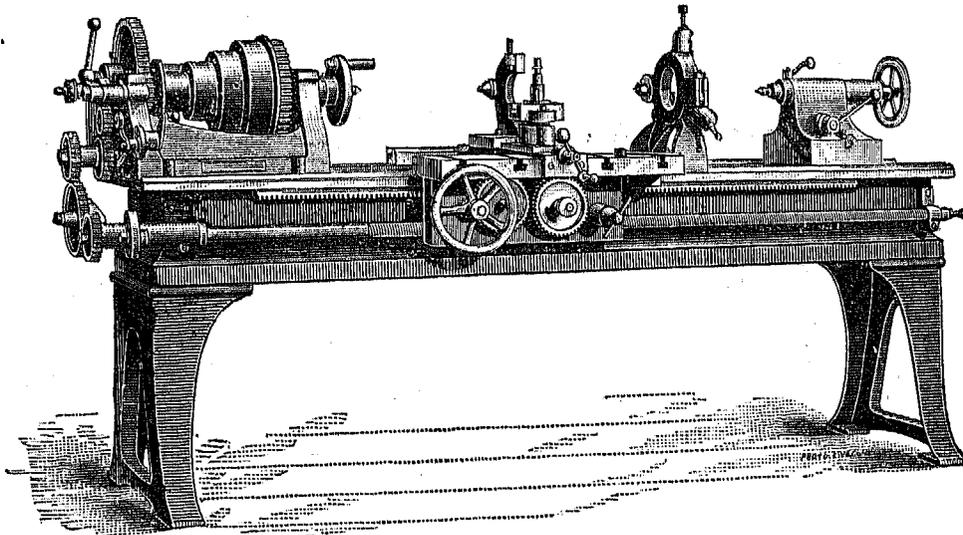


Fig. 89.

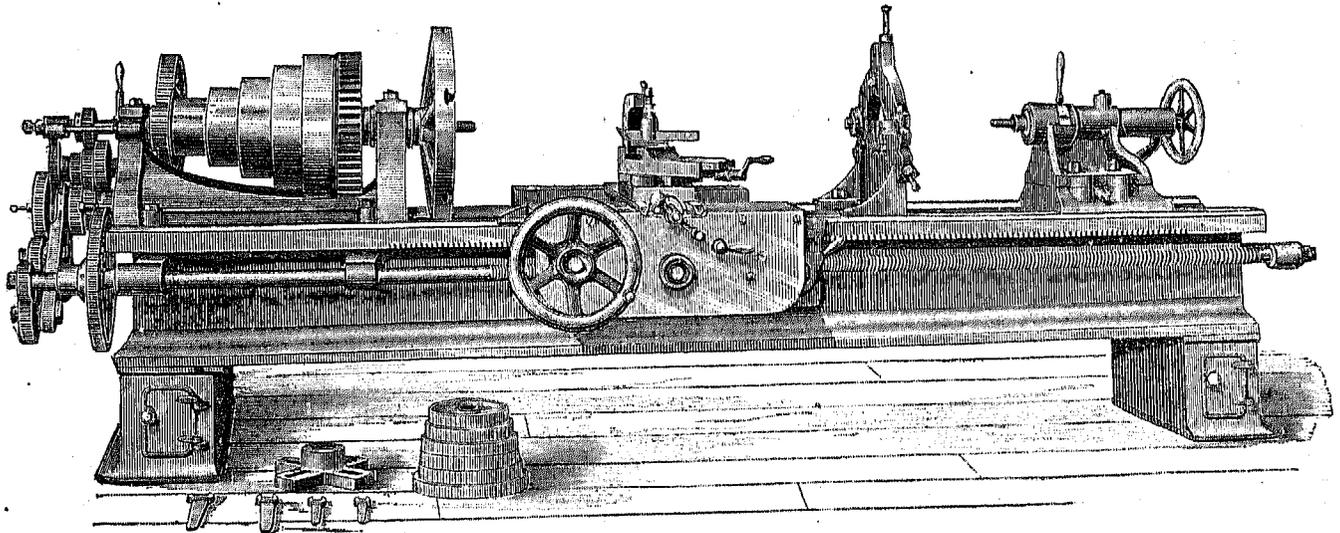


Fig. 90.

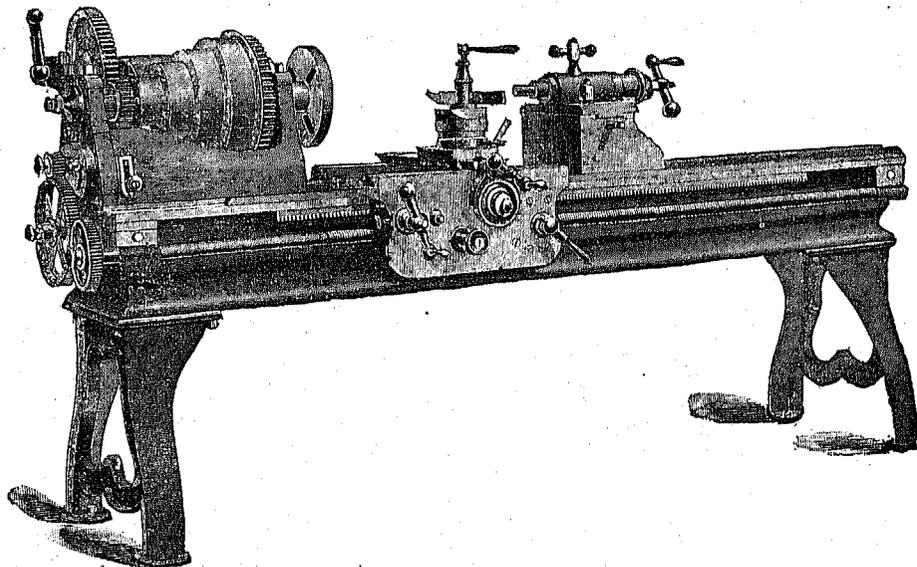


Fig. 91.

The line between the centers being thus made exactly true, it remains to give to the tool-point a motion which shall be truly parallel to that axis, and also one at true right angles to that axis. The motion of the tool parallel to the line of centers must also always be in the same plane with that line. The tool will therefore be rigidly held in a

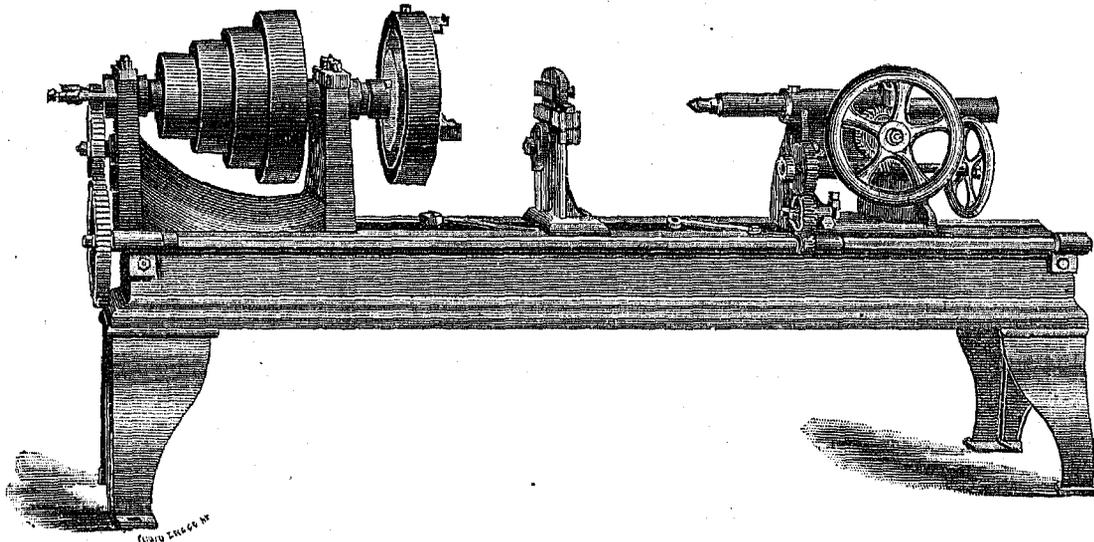


Fig. 92.

tool-post, supported upon a guided carriage. This carriage must receive the two motions at right angles to each other, each motion being independent of the other. The lower part of the carriage will span the opening between the two sides of the bed, so as to be guided by its extreme ends. In the flat shears the tendency to twist the carriage is resisted by the outer surfaces of the shears. These incline inward, and adjustable gibs are fitted against these inclines front and rear, which also keep the rear end of the carriage from lifting under the strain of the cut. In the V shear system the carriage rests upon the outer rail of each shear, and is thus kept from lateral motion. Flat gibs under the square edges of the shears resist what little tendency there may be to cause the saddle to lift. In both cases the bearing surfaces of the carriage are made much longer than is necessary, simply to support the cross-rail or saddle. The plan of the whole would be usually a square, in which the sides were broken away to enable the saddle to come close to the head- and tail-stock. The necessity for these long guiding wings to the carriage results from the method of driving the carriage from the extreme of one side, and also from the leverage exerted upon the tool-point in certain positions. It is an argument urged against the V-shear system that the long span of the saddle to clear the inner rail makes a greater thickness of metal necessary at that part for stiffness, and therefore reduces the swing of the lathe. The

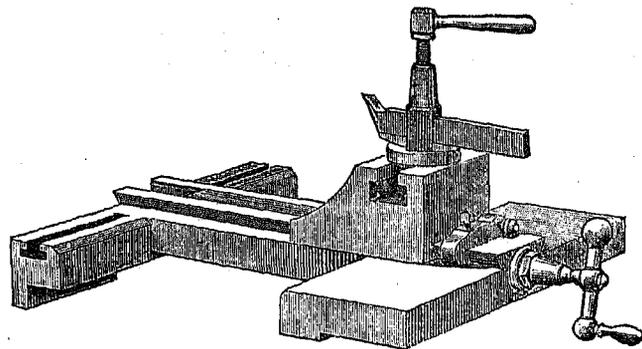


Fig. 93.

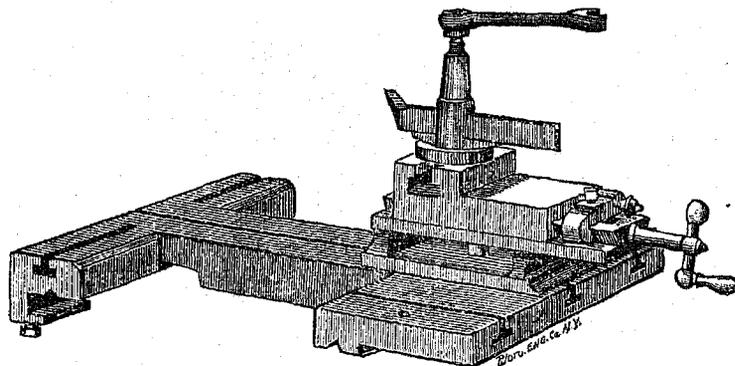


Fig. 94.

shortest radius from the center to the shear limits the face-plate work which the lathe will take in. In long work the limit is fixed by the shortest distance from the axis to the saddle, and the thinner this is the greater the swing of the lathe. This difficulty is met, by thickening the metal of the saddle downward between the shears. Nearer the abutments the depth may be reduced. The majority of the carriages are what are called half-gibbed. The gibs take hold below the outer back and the inner front of the shears. Flat-shear and many V-shear carriages are gibbed at the outside, back and front. There are comparatively few which are gibbed on all four surfaces.

Fig. 93 shows the ordinary plain gibbed rest for small and average lathes. The apron which holds the driving gear, to move the rest automatically, is secured to the flat surface at the under side of the front. The cut shows the ordinary tool-post, consisting of a block with a T-socket in its top. The post is slotted out so that the shank

of the tool may pass through it, and a set-screw in the axis of the post screws down upon the tool. The abutment is the round head which fits into the T-slot and binds tool and post to the block. For the adjustment of the point of the tool, that it may come opposite the horizontal diameter of the work, is the object of the washer below the tool. This is dished out into a segment of a hollow sphere, and a steel segment of a zone of the same sphere fits into the hollow. The tool rests upon the flat surface of the wedge, whose spherical lower side permits the tool to have a full bearing at any vertical angle within the necessary limits. The same object may be attained by a spiral washer under the tool.

It is the block below the tool-post which receives the cross motion at right angles to the axis of the lathe. Upon the saddle are planed flat, dovetail shears, truly at right angles to those of the carriage below. The post and block can be moved on its shears by the cross-feed screw which holds against the carriage between a shoulder and the ball-handle spacer-washers. The tool-block is made with long bearing surfaces, and any wear in its fit is taken up by screws which bear upon an adjustable gib. The T-slots on the rear wings are planed out to receive a back-rest or any other convenient attachment. On larger lathes, what is known as the "Philadelphia rest" is often used (Fig. 94). An open casting slides in a T-slot across the carriage, to which it can be bolted. The shears for the tool-block are on the top of this adjustable foot. The advantage of this form is that it can be bolted to any part of the rest by the T-slots wherever the exigencies of the work may demand, or the whole tool-holder can be removed, so that the flat carriage only may be left. The cross motion, however, cannot be automatic.

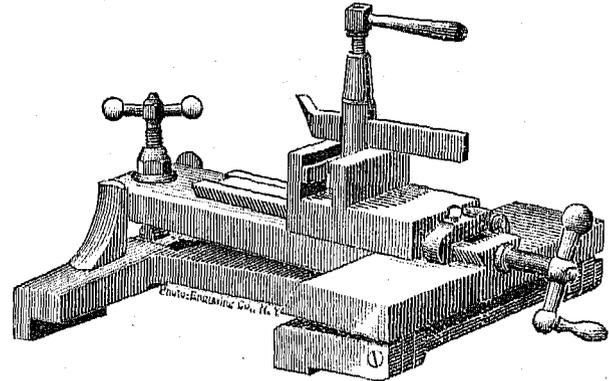


Fig. 95.

For many classes of light job-work the easy, rapid, and secure adjustment of the point of the tool is of considerable moment. To effect this is the object of the gibbed rest shown in Fig. 95. The saddle is made double, the top half revolving around a horizontal hinge at the front. The lifting-saddle is prevented from twisting strain

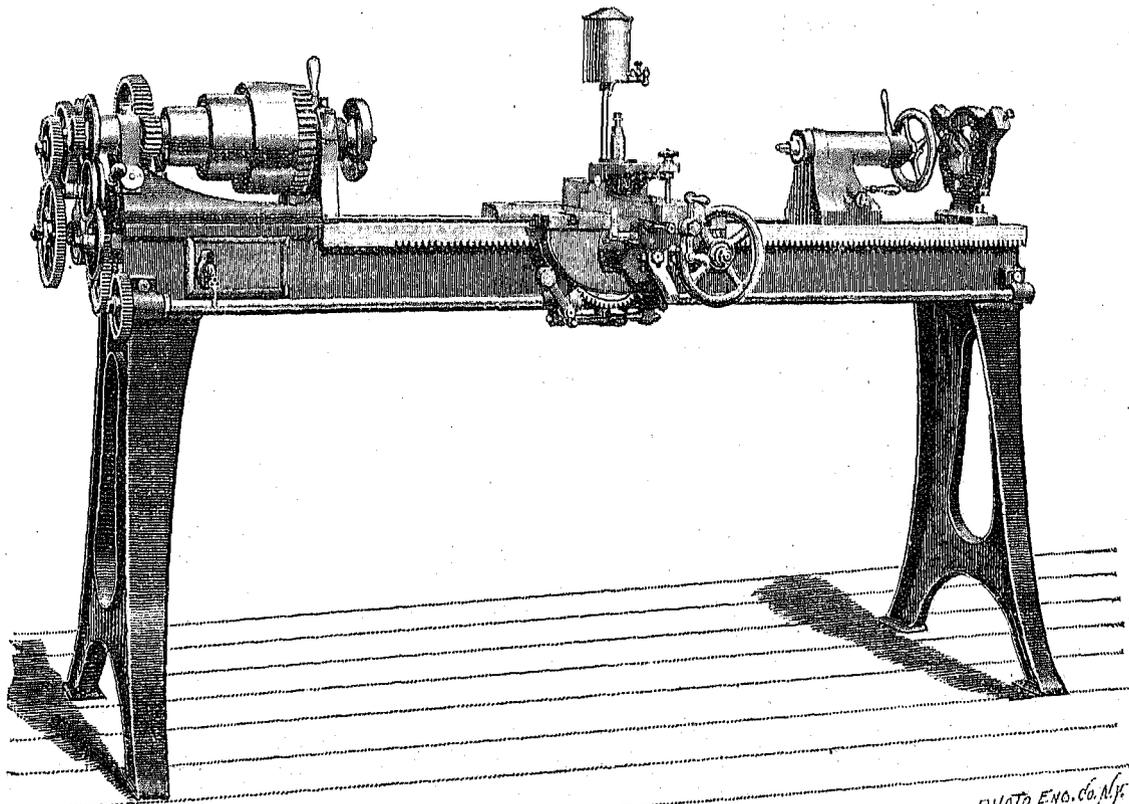


Fig. 96.

by the faced brackets at the back, and the degree of elevation of the rear end is controllable by a screw, which passes down into the lower saddle. The motion of the screw in the upper and lower saddle is circular around horizontal axes (Fig. 96). This is provided for, and lost motion is taken up by several devices. The most usual

is to make the lower end of the screw spherical, which fits between brass washers, curved to fit the ball. These washers are confined by a screw-sleeve in the top of the lower saddle, by which any play can be taken up. In the upper saddle the nut for the screw is also made externally spherical and confined by similar sleeves. Others pin the end of the lifting-screw into a slide on the lower saddle, so as to avoid the ball-and-socket fit. Wear is taken up in the nut by splitting it across the axis, and controlling the approach of the two parts either by the sleeve-nuts or by conical-pointed set-screws. In rests of this type the tool-block slot is so made as to give a stiff hold for the tool at a distance from the set-screw. Not infrequently the top of the block is serrated to increase the friction.

Other methods of raising and lowering the tool-point are shown by Figs. 88 and 91. In Fig. 88 the gibbed block slides over a shear on the surface of a horizontal cylinder. A rack on the end of a screw meshes into a sector on this cylinder, and the point of the tool rises in an arc. Another device has the cylindrical surface replaced by a spherical surface, the head of the slotted bolt coinciding with the center of the sphere. This works very well as long as there are no defects in the spherical contact. Still another uses inclined planes on the two halves of the post, controllable by a separate screw. The disadvantage of these methods is that horizontal adjustment of the block must be made after every vertical change. A joint where lost motion may occur is also introduced between the tool and the carriage. Another plan, which has the advantage of stiffness, makes the post with a screw-thread on its lower part. By raising and lowering this large pillar-screw the point rises and falls. One similar design raises the tool by a capstan-nut on the outside of the post, while internal to the post is another which acts to clamp the whole from moving. In still another the pillar of the post is lifted by an elbow-joint, clamped by the screw which controls the joint.

For small lathes an especial practice prevails in New England. The slide-rest carriage, moving on V-shears, is kept to its bearing on the track by a weight, and no gibs are employed. This system gives great steadiness of motion for light cuts, since all lost motion of adjustment and for free travel is absorbed in the weight. The hinged saddle is used, lifted by the end screw by contact joint only, and no "take-up" devices are required (Fig. 97). The

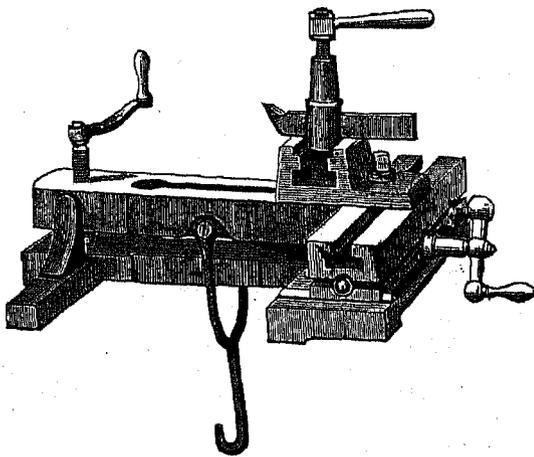


Fig. 97.

cross-feed can be only limited in length on this system. When wide surfaces are to be faced, the post-block must be reset in the slot. No tools of this design are approved at the South or West, but in New England they are preferred by many of the best workmen and builders. As the swing of the lathe increases the height of the tool-post must increase also. To increase the capacity of the tool-holder, the compound rest is approved. The lower block, which may travel across the bed at right angles to the axis of the lathe, carries a horizontal flat disk with a circular T-slot in it. Upon this disk may be bolted at any angle a secondary tool-post, which has a screw cross-feed motion upon its own shears (Fig. 98). So that, beside the two motions at right angles to each other, which are common to the smaller devices and are here retained, the tool may have an angular feed in any direction for turning tapers and conical shapes. On lathes of the largest size, where the pillar on which the tool-holder stands is quite high and the cuts will probably be heavy, the form shown in Figs. 99 or 100 is used. The tool is held by two clamping-crews, and while the large

post has the two original motions, the holder on the top has also two motions at right angles for convenient use by hand. In newer practice, even these feeds can be driven by power for smaller work.

To actuate these carriages automatically by the power of the tool itself two general systems are in use. One moves the carriage by a screw, whose nut is held in the apron of the carriage, and the other by a driven pinion in the apron, which meshes into a rack on the under side of the shear. Both systems may be combined in one lathe for different uses. The screw-feed will be used for the reproduction of screws; the feed by the pinion, usually known as the "friction-feed", will be used for the general turning in the lathe. The driving-screw is continuous for the whole length of the bed. It is often called the "lead-screw" or the "feed-screw". In very long lathes it has to be supported to prevent sagging between supports. This is accomplished by flat hooks, which catch hold of the shears and pass under the screw. They are perfectly movable and can be put where most needed. Usually they bear on the tops of the thread of the screw. The thread may be cut away for a length less than that of the nut in the apron if it is desired to give the supporting hooks a complete straight bearing. The lead-screw may be put in front of the bed, at the back of the bed or between the shears.

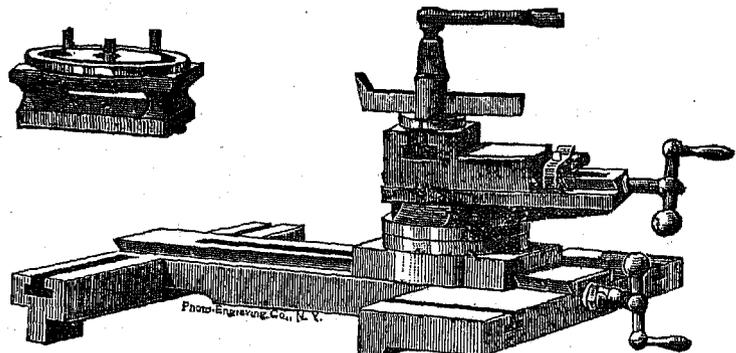


Fig. 98.

There is but one designer using this latter system. In this make, the screw is supported in a trough in the shear casting, and is protected from chips by the projection of the shear. A half-nut or chasing-nut is used on the carriage. The preponderance of practice has the screw in front of the bed. The friction-feed apparatus is always in front.

The screw is driven by a train of gear-wheels from the spindle of the lathe. These wheels come in sets, so

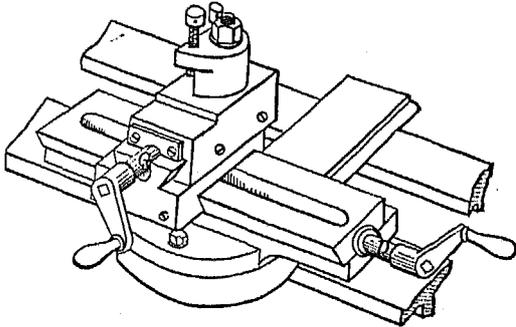


Fig. 99.

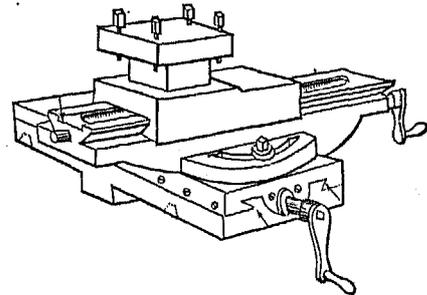


Fig. 100.

that almost any desired combination may be interposed between the spindle and the screw, to vary their relative velocities. If the spindle and the screw turn at the same rate, the tool-point will cut a duplicate of the lead-screw on the work, since each will have gone round the same number of times while the tool moved over one inch. To cut any other thread the revolutions or the number of teeth on the wheels of the first and last of the train must be as the thread to be cut is to the thread of the feed-screw. It is therefore convenient that the pitch of the feed-screw be a convenient divisor of the usual threads. Very often it has four threads to the inch. One designer uses two threads to the inch, for convenience of calculation and to make it more easy to strike into the thread under the cut. To connect these fixed studs at the two ends of the train the studs upon which the intermediate idle wheels are placed are borne upon a slotted swinging casting, which revolves around the screw or its journal as a center. The studs for the wheels take into these slots, and the casting is clamped by a set-screw to the head of the lathe (Fig. 101).

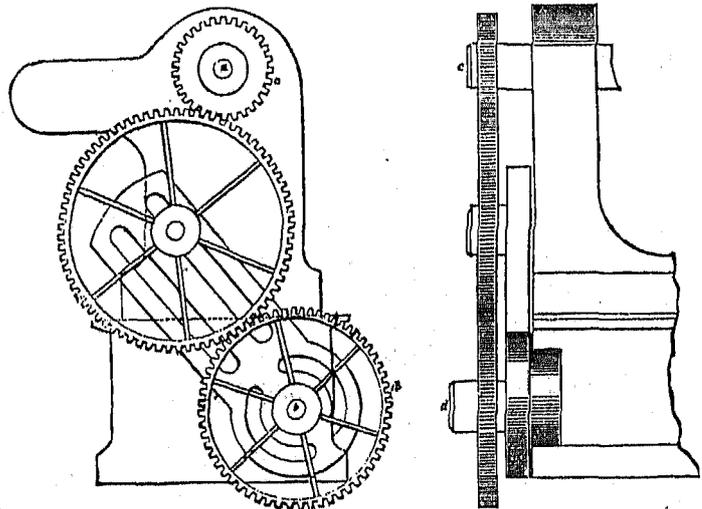


Fig. 101.

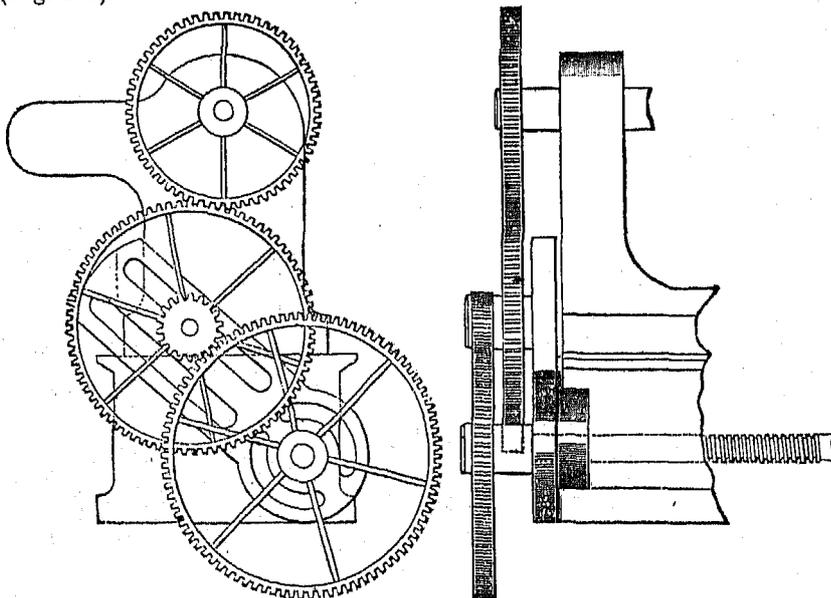


Fig. 102.

Many lathes of large swing having a large feed-screw with small number of threads to the inch will be double-gear or compound-gear. By this is meant that upon one idle shaft are two gears of different diameters turning together. A larger range of speed between the spindle and screw is obtainable with few gears. To avoid confusing the operator with different motions for reversing it is best always to have the same number of spindles in the train. Also, the use of a large gear on the screw may be avoided, necessitating a cut in the floor, and heavy gears are dispensed with. There may be also the gain due to the greater smoothness of working when the driver and follower-gears are more nearly of the same size than would be possible with the single gear. The arrangement is shown by Fig. 102.

The tendency is toward smaller diametral pitch in the change-wheels. While it used to be 12 per inch, it is now 6, and some prefer 4 per inch.

For reversing the motion of the screw in general practice one method is preferred. It depends on the principle that in any train of external gears the even numbers in the series will be turning in one direction and the odd numbers turn in the other. By a simple motion of a lever the train of gears driving the screw may be made to contain an odd or an even number of wheels.

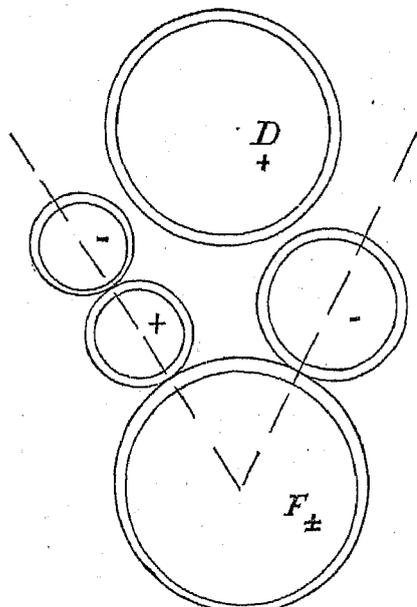


Fig. 103.

In Fig. 103 a V-shaped lever turns at its apex on the stud of one wheel as a center. On one arm of the V is one wheel and on the other are two. If the V is rotated so as to bring the driving-pinion D into gear with one arm, the follower at the apex will turn one way; if with the other arm, the follower will turn the other way. There is, of course, a neutral position, in which the driving-pinion will drive neither. The lever which moves the V projects conveniently for the hand of the operator, and is prevented from disengaging itself either by a latch-pin into holes, or by a clamp-screw, or by a little cam. The clamp-screw requires the use of both hands.

Another type of reversing mechanism uses the principle of the two loose bevel-gears driven by the third between them. The combination is put under the cone-pulleys, and a clutch is engaged by a rod from the apron with one or the other of the loose gears. The advantage of engaging and reversing at the head also rather than at the carriage only is that, when speeding the lathe for polishing, the gears need not be clattering and wearing each other out. For engaging and disengaging at the carriage, the universal device is a split nut. This is divided along a plane through the axis into two parts, which approach to clasp the screw or recede to release it at the will of the operator. This clasp-nut has the halves moving in guides so as truly to come together and make a nut, the motion to open and close being given to both parts. Usually this motion is given by a disk in which are two spiral slots. In these slots fit two pins, of which one belongs to each half of the nut. The slots are so laid out that when a partial rotation is given to the disk the pins come equally toward its center

or recede from it, carrying the sliding halves of the nut. Another device draws the halves together by fitting them to a bolt with a right thread on one half and a left thread on the other.

This clasp-nut device is practically universal in lathes driven from the screw in the apron. A New England design, with the screw at the back, uses a solid nut, which bolts through a bracket to the saddle by easy working tap-screws, when required. This system of solid nut renders obligatory the use of reversing counter-shafts—a system expedient in all cases for the economy of time and exactness of screw profile. Left threads are cut in this single-connection system by putting an extra idle-wheel in the gear-train.

The use of the screw and nut for ordinary turning-feeds has two objections. The principal one is the wear of the screw, which will be greatest near the head-stock where the greatest amount of work will be done. Therefore a long screw cut on such a lathe will not be uniform or regular. The nut will also wear and permit lost motion. A second minor objection is that the ordinary feeds are so much slower than a screw-cutting feed that considerable rearrangement of the train is necessary to get the proper speeds when the work varies. To avoid these difficulties, nearly all the smaller and medium lathes of to-day are provided with a second feed system, known usually as the "friction-feed". Motion is imparted to a train of gears in the apron of the rest, by which a small pinion is made to turn in gear with a stationary rack upon the shear. This train of gears is engaged and disengaged by a friction-clutch in the apron.

Figs. 104 and 105 show a plan and elevation of a very usual form of the gears in the apron. The rod *f* is driven by a narrow belt from a cone-pulley on the first spindle of the change-wheel train. There are usually three changes

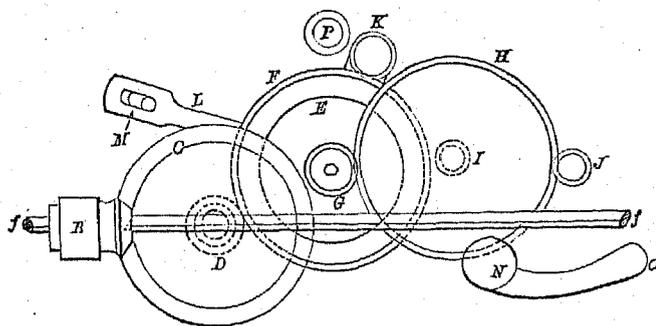


Fig. 104.

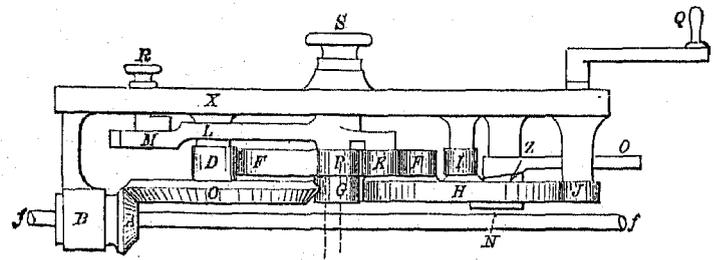


Fig. 105.

on the cone, and the reversing is done either by the lever with the one and two gears, or by crossing the little belt, or it may be done in the apron. This rod is splined, and carries a bevel-wheel, A, mounted on a bracket, B, from the apron. The rotation of *f* will therefore turn A wherever the latter may be upon the rod. When A revolves,

it turns the wheel F, which is the female part of a friction-cone. The rest of the train, up to the rack, is connected with the male part of the cone (Fig. 105) through the pinion G. The cone is engaged by the screw Y, controlled from outside by the hand-nut S. The wheel H catches in the rack under the shear, and on the axis of the pinion J is put the ball-crank or hand-wheel for traversing the carriage by hand. It will be seen that if a second bevel-pinion be put opposite to A, so that either may be at will engaged with C, a very simple reversing and disengaging gear is designed, which is worked from the carriage entirely, without stepping to the head. In many designs the bevel-gear A is replaced by a worm. This permits the reduction of speed to be made with few wheels in the train. For reversing in the apron, one designer has one right and one left worm on the rod, either of which can be brought under the worm-wheel by a lever in front.

The worm-system is objected to by many builders on account of the danger to it if allowed to get dry by neglect. The wear of the surfaces becomes very rapid. The wheel is made of cast iron, the worm of wrought iron, steel, or cast iron. In some cases it turns in an oil-pan to keep it lubricated. Very often, instead of driving the wheels in the apron from a separate splined rod, the feed-screw is splined to carry the worm on the bevel-gear. This is objected to by some on the ground of the wear on the top of the thread and at the points of the threads where they are cut by the spline. One designer gears the rod to the screw and drives both at once (Fig. 89). The end play of the screw is prevented by a steel step-screw or by a washer of some material like rawhide. When a lathe has both feeds in the apron there have been devices to prevent the operator from throwing in both at once. For reasons of simplicity of mechanism this attachment is not often applied. The gears are usually carried on studs bolted into the apron. To avoid the strains on the overhanging bearings one designer makes the apron with two walls (Fig. 81). Another plan has all the gearing on the outside in front (Fig. 89); this is a gain in cleanliness, but there is more danger of accident to a careless operator. The rod-feed of the lathe shown in Fig. 80 is driven by a friction device by means of which the speed of feed may be varied. A smooth disk of cast iron is the driver, which is clasped by two disks of brass upon its sides. These disks of brass are kept against the iron by a stiff steel spiral spring. A second disk of cast iron upon the splined rod is driven by the contact of the brass plates on the side of their axis opposite to that of the driver. The axis of the connecting plates is movable along the line of centers of the driver and follower disks, so that any ratio of radii within the limits of the design can be secured. In this lathe also the screw is not clamped between the two halves of a nut, but a half-nut presses against the screw laterally, and flexure is prevented by the shape of the shear casting. In the Sellers small lathe the rod-feed is often driven by their frequent device of a concealed worm or spiral pinion. In the Miles lathe the feed is driven by an original device to avoid the loss of time in changing the gear-train (Fig. 106). The live-spindle is

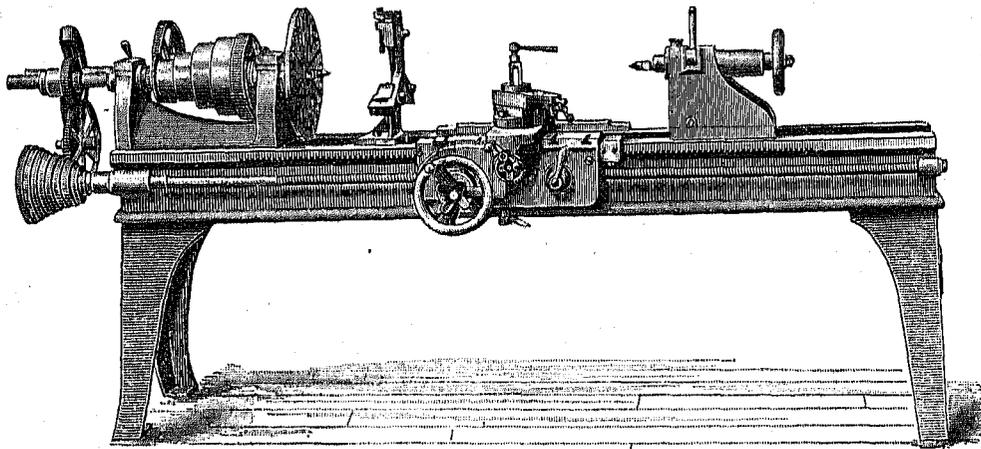


Fig. 106.

prolonged for some distance at the head of the lathe, and is splined to carry a spur-wheel and pinion. At the rear of this spindle is a round horizontal pillar, upon which slides an arm, carrying an idle wheel on a horizontal stud which can connect either spur-wheel or pinion to a nest of gear-wheels of different diameters fast on the screw. The pillar is graduated so that the edge of the arm may be rightly clamped to cause the proper thread to be cut. Changes of feed speed by this arrangement are very simple and rapid and the gear is durable. The racks under the shears are usually in segments, screwed in place. They are of wrought iron, steel, or cast iron. Steel is preferred by some because of the weakness of the teeth of fine racks under strain of the feed.

The screw for the cross-feed of the tool-post is most frequently engaged by a second friction-clutch operated like the other by a screw (Fig. 78). This takes hold of the gear before the other, so that both may be used at once or only the one which is required.

The arrangement shown in Fig. 104 is a type of another system where the connection is made by moving an idle pinion into the train. The pinion K is on a stud upon an arm which turns around the axis of the driving cone-

wheel F. A slight motion of the arm around its center will put the idle pinion into gear with the pinion on the cross-screw P. This can only be reversed by reversing the motion of the rod. For large wheel-turning lathes and the like, the cross-feed has often been driven by a click and ratchet motion by a weighted lever (Fig. 107). A

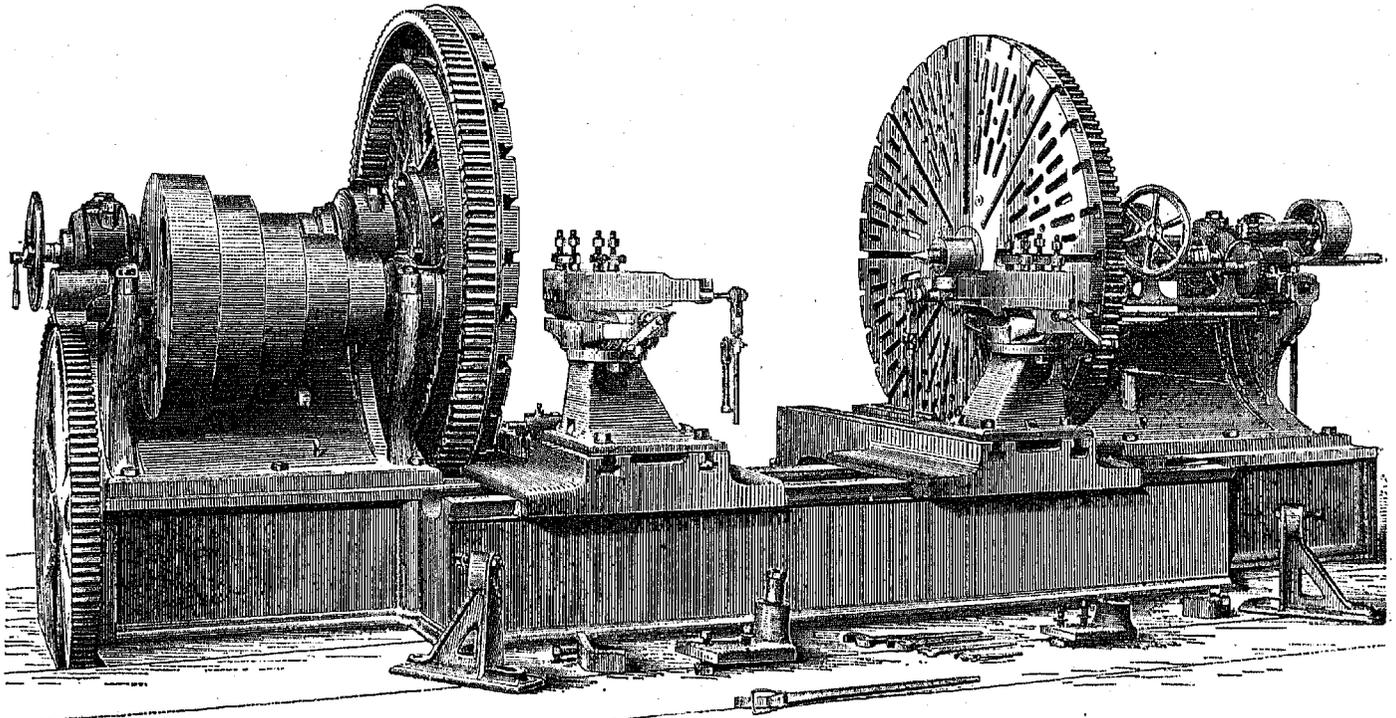


Fig. 107.

rope passes from an adjustable crank at the head-stock to a pivoted lever overhead, and from thence a second rope comes down to the ratchet lever on the screw. The intermittence of the motion is compensated for in the spring of the tool. A longitudinal ratchet-feed is not now used to any extent (Fig. 86). The saddle may be clamped against longitudinal motion when cross-feeding by a movable gib, or by any convenient device.

To avoid the inconvenience that the friction-cones in the apron will sometimes set themselves, a designer in Philadelphia makes the clutch cylindrical, of a split steel ring, kept open by a little cam. When the cam is turned the ring closes and engages the gear. There are several devices in use to prevent the unintentional seizure of the conical forms.

Every lathe has certain accessory appliances as part of its furniture. One of these is called the "steady-rest". It is intended to support long cylindrical work which might sag by its own weight between centers. It consists of a frame to support three radial sliding jaws which can be moved toward the axis of the tool by screws. The rest

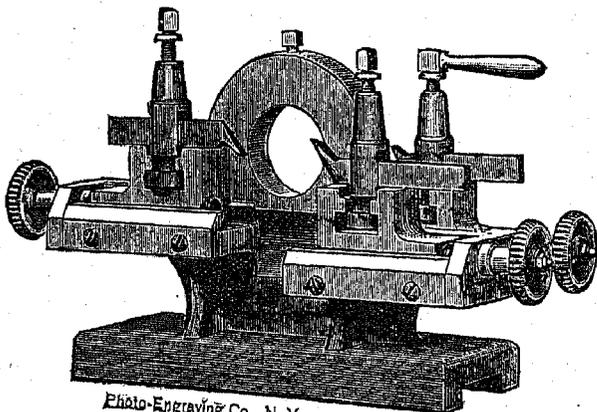


Photo-Engraving Co., N. Y.

Fig. 108.

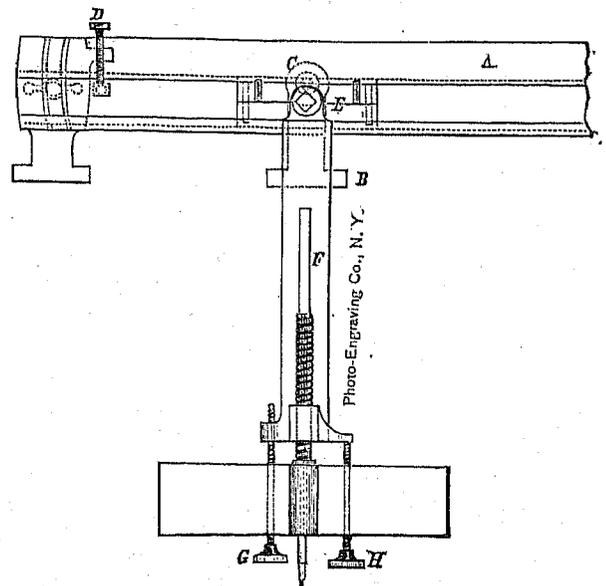


Fig. 109.

stands on the shears and is clamped by a cross-piece below. The cylindrical frame which holds the jaws is split at the horizontal diameter for convenience of inserting and removing work, two of the jaws lying at angles of 30° below the horizontal line. When the work is not cylindrical, a shell "doctor" with radial set-screws in pairs can be secured to the work so as to turn centrally upon the jaws of the rest. To resist the horizontal spring of light work away from the tool-point, a "back-rest" is used. A curved upright bolts in T-slots in the carriage, and adjustable jaws oppose the pressure of the tool. These difficulties are overcome in lathes for turning shafting by making the rest on the duplex system (Fig. 108). There are two tools opposite each other, one turned up and one turned down. A third tool may produce the finishing cut, and the shaft may be sized perfectly by a hollow reamer.

A type of the attachments for turning tapers on a lathe is shown in plan in Fig. 109, and in place on the lathe in Fig. 110. At the back of the bed are three brackets which carry a grooved bar. This bar can be adjusted

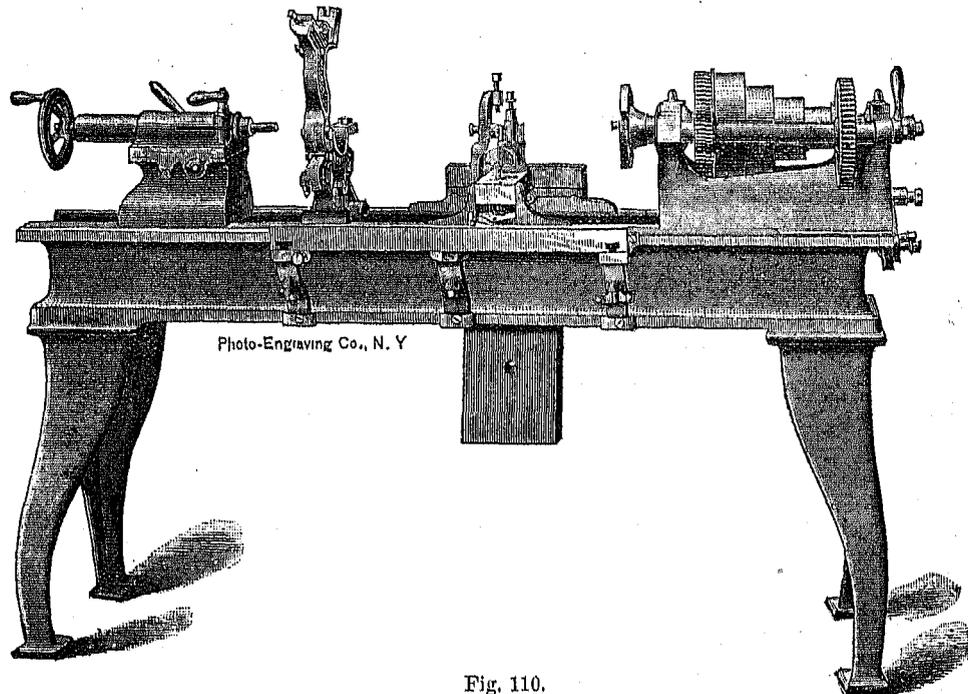


Fig. 110.

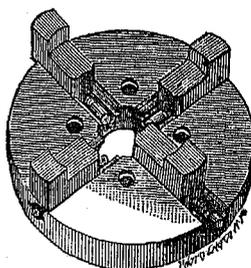
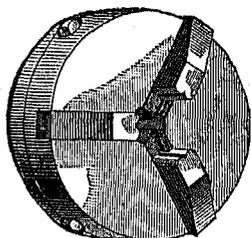
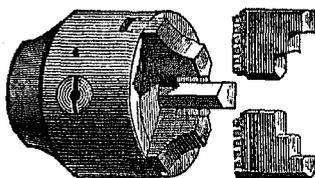


Fig. 111 a.

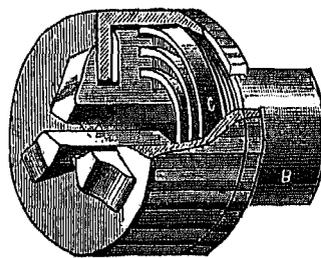


Fig. 111 b.

parallel to the axis of the tool or at any angle with its horizontal projection. In this groove slides a block, E, which is pinned to the nut-bar F, which slides in a groove in the lower part of the tool-carriage. G and H are stop-screws to be used in outside and inside work respectively. When the bar A is swung around its center pin, C, and clamped into the required position as determined by the tangent-screw D, a gradual transverse motion is imparted to the upper part of the tool-carriage in and out from the centers. This type of attachment is unaffected by the length of the piece, requires no preliminary cuts for trial of the taper, works as well for inside work as for outside, and avoids setting the centers out of line. A similar type which avoids any lost motion of the slide in the groove holds the guiding surfaces in contact by a weight over a pulley.

A universal or self-centering chuck is a usual accessory. These are made for small and medium lathes upon two principles. The jaws are usually three or four in number, sliding in radial grooves. The scroll-chucks have a plate

with a continuous flat spiral groove cut in it. The jaws have projecting lips, which enter the groove, and when the scroll-plate is turned the jaws all move equally toward the center (Fig. 111 b).

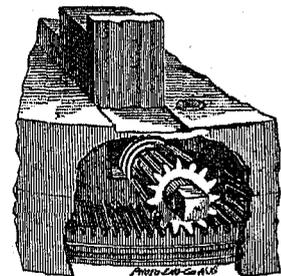
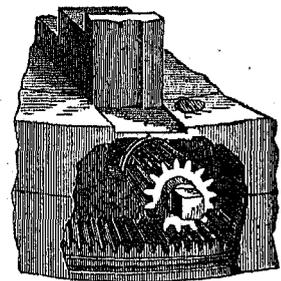
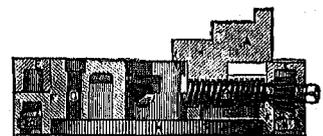


Fig. 112.

The second type has the jaws mounted and moved inward by screws. These screws have each a small pinion near the outer end meshing into a large gear concentric with the chuck. When one of the screws is turned the others must all turn equally and the jaws will move to the center. Fig. 111 *b* shows a type of scroll-chuck. Fig. 112 is a screw-chuck of the second type. The screw type enables the lost motion due to wear to be taken up. Each screw can be separately tightened by the wrench in this form, since the two gears may be disengaged. The special chucks, the drill-chucks, and the eccentric-chuck, the mandrels, and the dogs and drivers, are articles of especial purchase or manufacture.

§ 17.

SPECIAL FORMS OF LATHE.

Special constructions of lathes are adapted for special uses. Where a large chucking capacity may be called for, but only average swing over the rest of the bed, a gap-lathe (Fig. 113) may be used. This gap may be

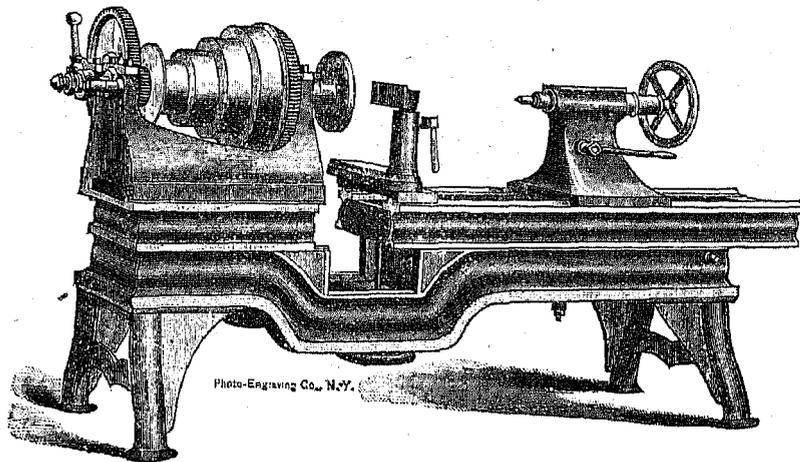


Fig. 113.

permanent, or the shears may be in two tiers, the upper or working bed sliding over the gap when it is not needed. Where work is always to be of large diameter and flat, of such a shape as to be worked best on the face-plate, the bed may be made short and the tail-stock may be omitted. This form of lathe will be called a chucking-lathe (Fig. 114). For very large fly-wheels and work of that class a chucking-lathe only is required, and very often the face-plate and tool-carriage rest upon separate foundations, and are really separate machines.

A lathe especially adapted for locomotive driving-wheels is shown by Fig. 115. There are two large face-plates driven from pinions on splined shafts. This avoids the twisting strain on the axle when the resistance comes at the end of a long lever. The frames of the heads are of the box pattern, giving great stiffness. There are two tool-

carriages, and the tool-carriage is driven by a separate mechanism. The tool-carriage is mounted on a separate foundation, and is driven by a separate mechanism. The tool-carriage is mounted on a separate foundation, and is driven by a separate mechanism.

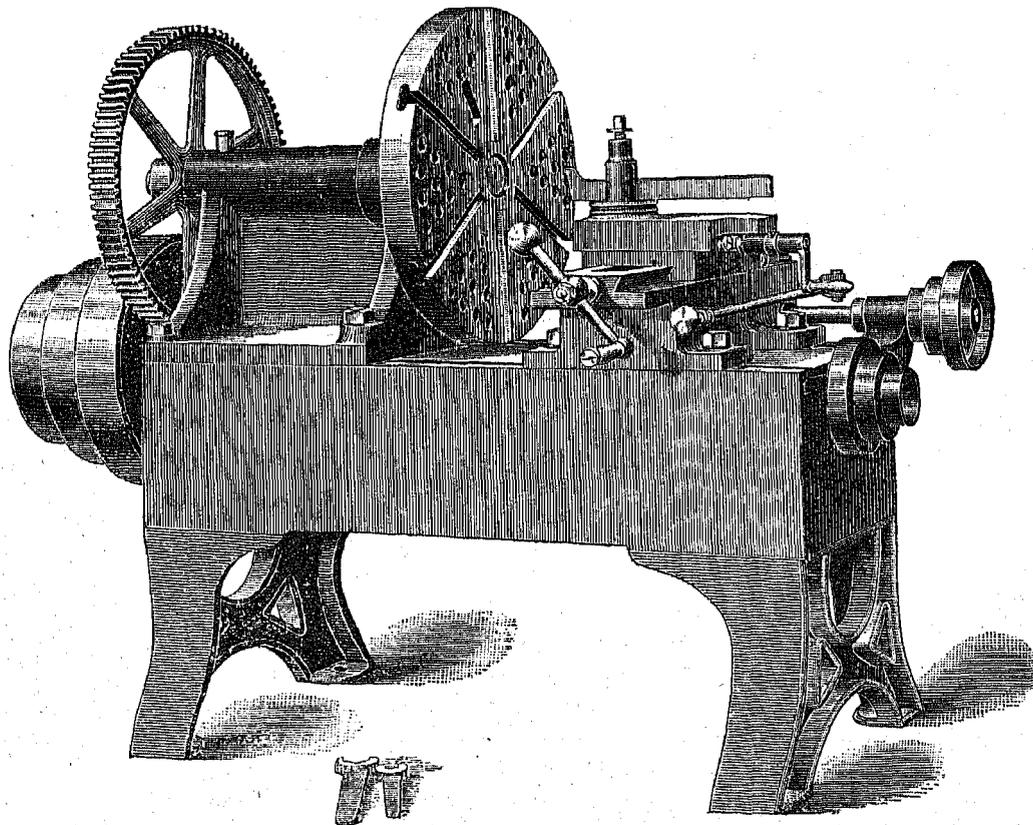


Fig. 114.

posts, and a facing-rest may be secured to the face-plates. Upon the tool-posts may be secured a quartering device for boring the holes for crank-pins at exactly 90° with each other. In other forms of this same tool the quartering attachments are secured to the frames, so that the spindle passes through the face-plates. The tool-posts clamp in place and are fed from overhead.

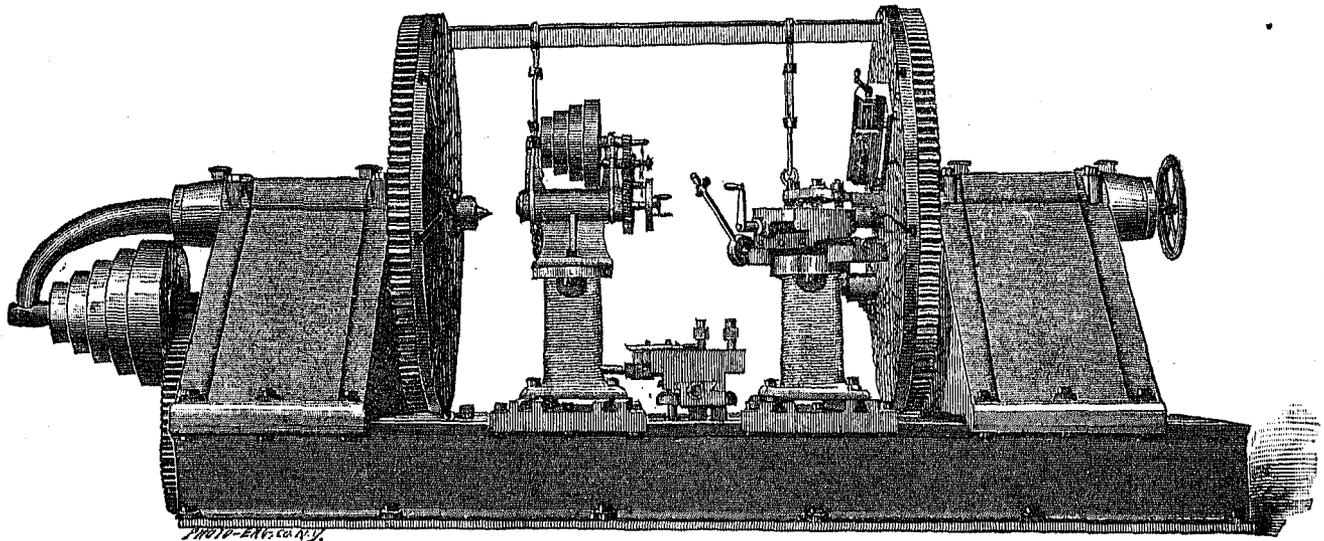


Fig. 115.

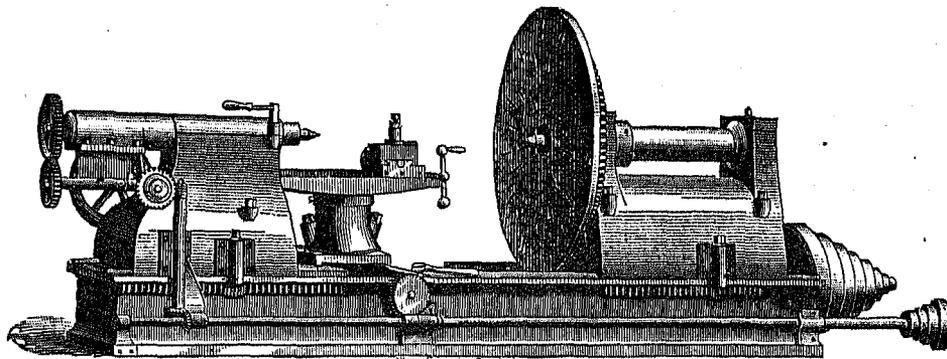


Fig. 116.

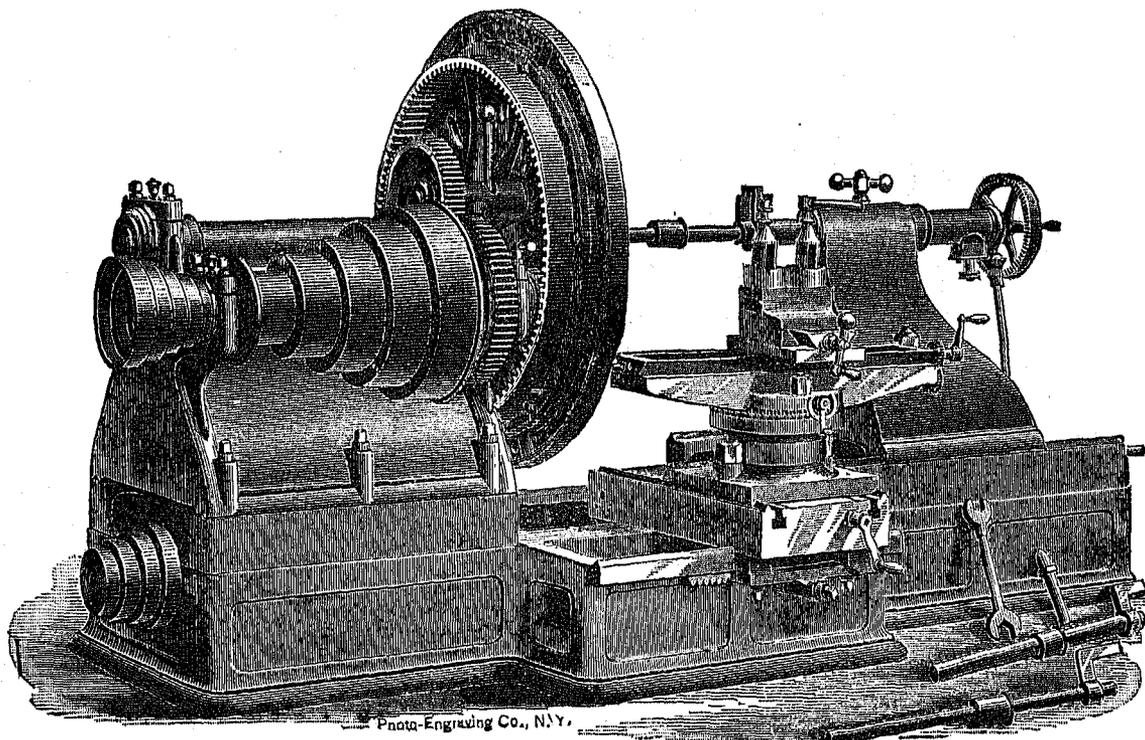


Fig. 117.

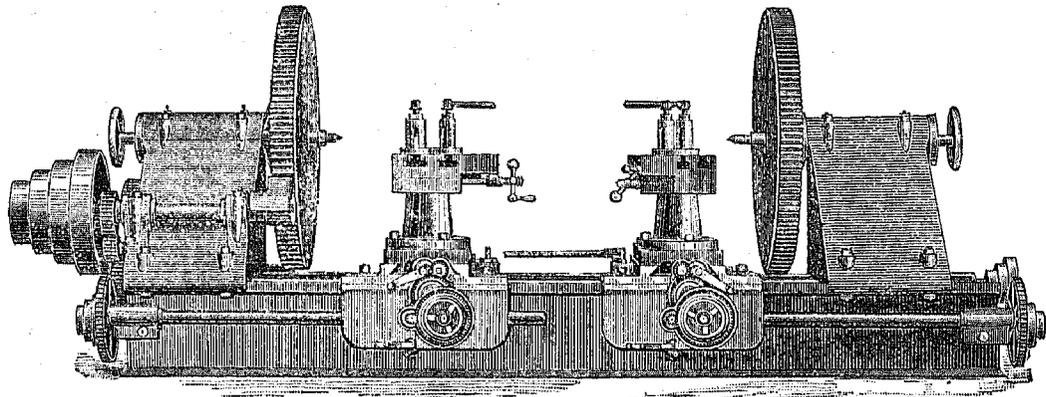


Fig. 118.

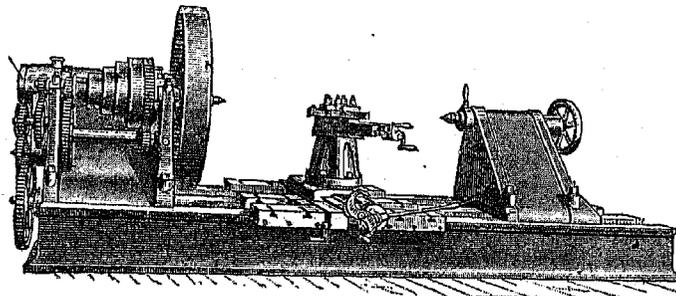


Fig. 119.

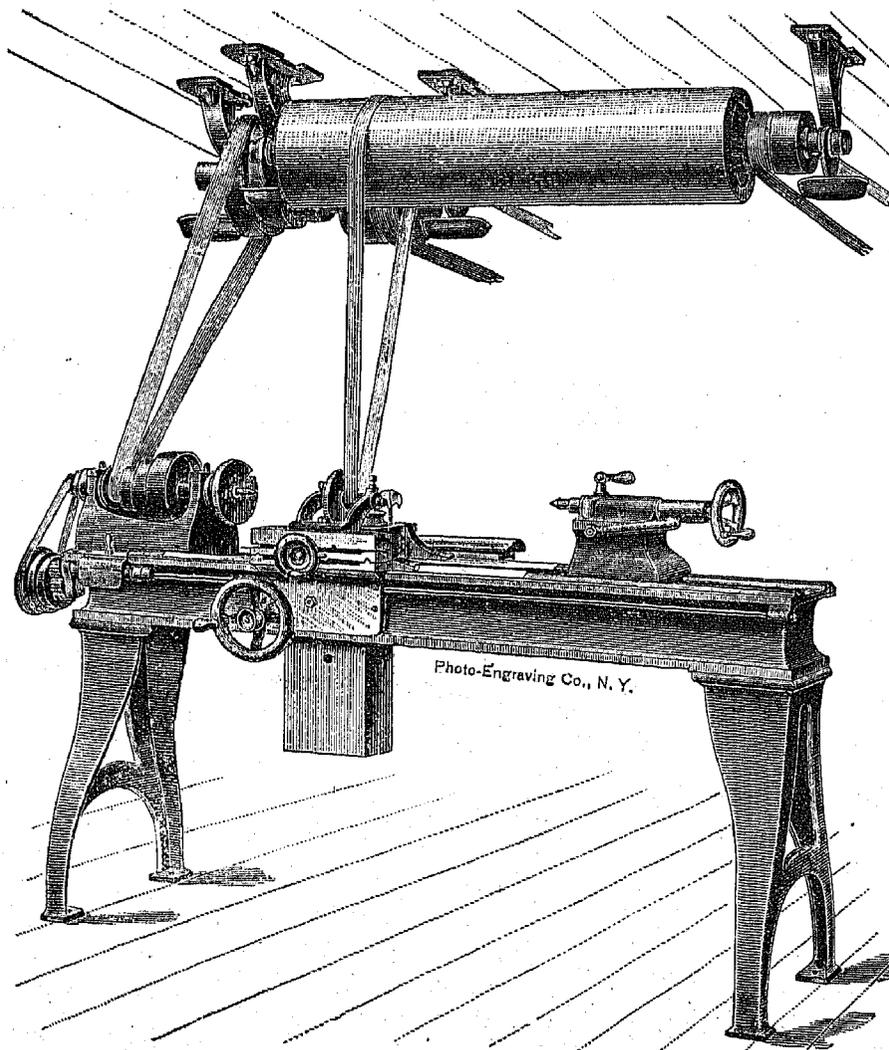


Fig. 120.

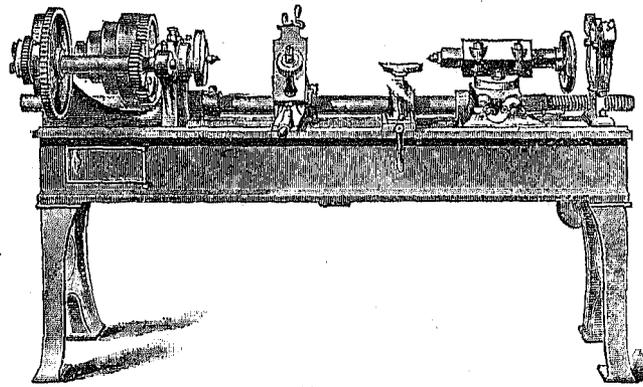


Fig. 121.

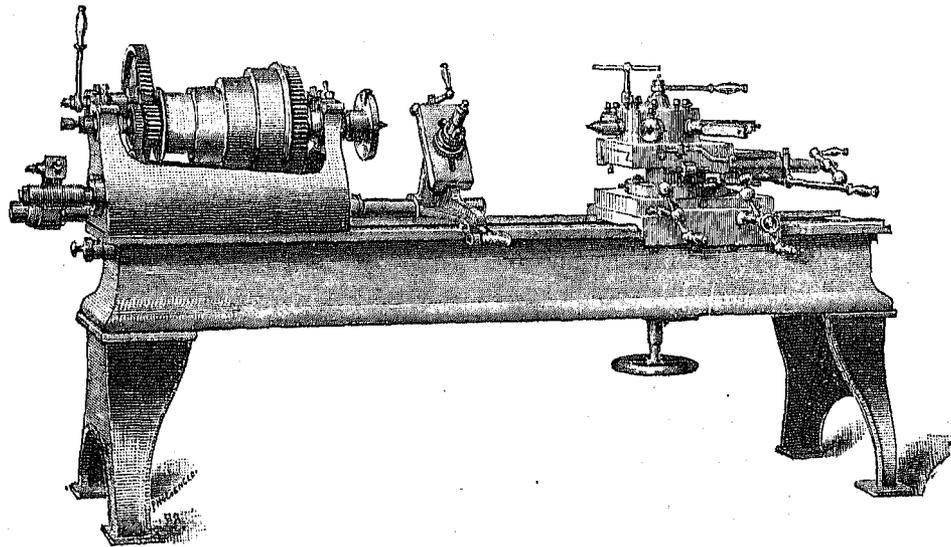


Fig. 122.

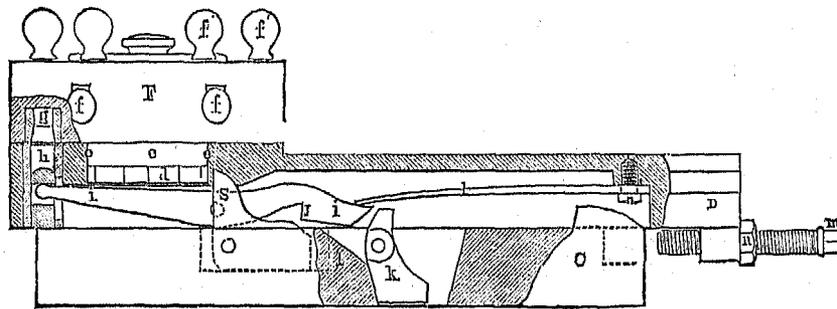


Fig. 123.

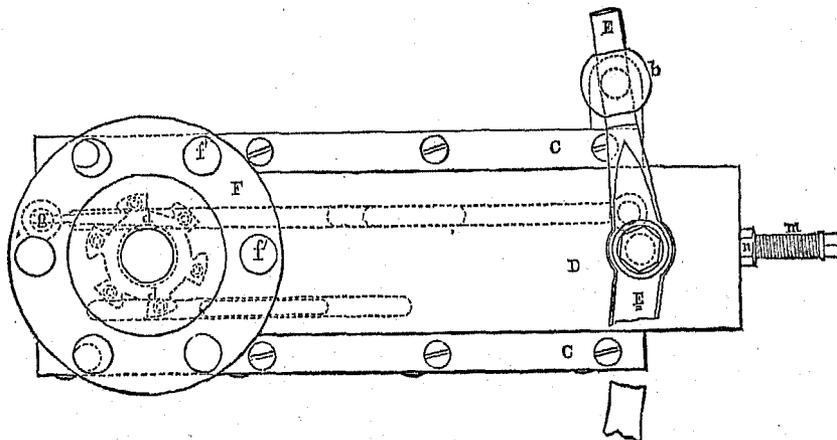


Fig. 124.

The lathe of Fig. 116 has one or two stationary tool-posts. The head- and tail-stock are both made movable by rack and pinion along the bed. The face-plate is driven from a splined shaft below the shears. The tail-spindle has power-feed for boring from the feed-shaft at the back. The feed for the tool is carried up vertically by bevel-gear through the center of the post, and at the top is carried to the feed-screws by double bevel-gear, giving motion forward or backward at will. The driving-axis, being central to the post, permits feed at any angle. The movable heads with stationary post gives great steadiness and stiffness. A slightly different tool with similar facilities is shown by Fig. 117. Figs. 118 and 119 show types of lathes of very large swing.

For the exact sizing of hardened steel spindles and the like the cutting has to be done by an emery-wheel. Fig. 120 shows the arrangement for such lathes, the grinding-spindle being driven by a separate counter-shaft, with a long drum. The shear-tracks are protected from the emery-dust by guards. The slide-rest has an automatic longitudinal traverse in both directions, the reversing being done by double bevel-gears and a clutch connected with the feed-rod. It can grind tapers as well as cylindrical surfaces.

For reduplicating small chucked work in the soft metals what is called a chasing-lathe (Fig. 121) is in very general use. It is not intended for turning work between centers, but it can be so used if desired. The head-stock receives motion in the usual way by cone-pulleys and back-gear. The tail-stock has also two motions, so that a tool can be inserted in the squared spindle, and by working the cross-feed to a stop any standard diameter can be reproduced without the loss of time for calibrating. It can also be set to cut tapers. The slide-rest is clamped upon a guided bar at the back, and is brought to its work by a handle, which is pressed down upon the front shear. The tool-post is fed upon an inclined shear by a screw. An arm on the guided bar carries a half-nut, which is brought into gear with a chasing-hob, driven from the live-spindle by the movement of the handle which brings the tool to its cut. The spindle carrying the hobs can carry two of different pitches, and a single-pointed tool can cut single, double, or quadruple threads. The slide-rest is counter-weighted so as to be brought up against a collar on either side at will when released from the chasing-hob. This collar can also serve as stop to prevent any given operation from being carried further than a certain length on the work. A hand-rest enables small finishing and chamfering cuts to be made by hand. A tool of this kind is adapted for miscellaneous work in brass, such as globe-valve and lubricator work, which it does very rapidly, exactly, and at one chucking.

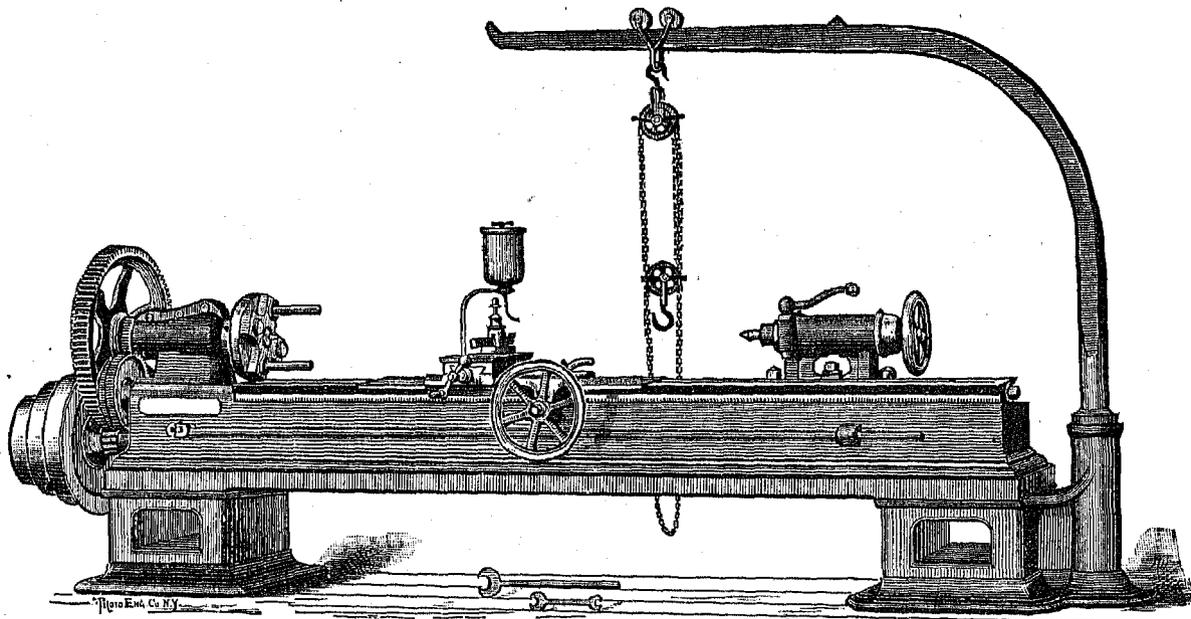


Fig. 125.

A similar tool, differing only in the construction of the tail-stock, is shown by Fig. 122. This tool is fitted with what is called a turret-head. A vertical cylinder, like a monitor turret, has six radial openings in the vertical surface, each of which carries a tool adapted for a different operation on the work. After the lower block has been clamped, the turret may receive its various motions by levers or by screws acting against adjustable stops. The interior construction of the turret-head and slide of one of the best forms is shown by Figs. 123 and 124. The lever *E* moves the slide *D* to the right and to the left. As the slide *D* carries the turret *F* to the right, the lug *S* strikes projections *d* on the bottom of the turret and gives it a partial rotation around its axis. That the proper amount of rotation may be given and the turret locked in the right place is the object of the pin *h*. This pin is thrown up into spaced holes in the bottom of the turret by the lever *i*, when it is released from the catch *k*. When *D* is moved to the right the pin is withdrawn from the hole *g*, and the end of *i* passes over the catch *k*. The movement of *D* in the other direction causes *i* to be released from *k*, and when the hole comes opposite the pin the

spring *r* forces the former upward and locks the turret. The pin and the bushing *s* of the holes are made conical, so as to come to an exact fit, and are hardened to prevent wear. In the lathe illustrated the disagreement of the centers, which is such an annoyance in turret-lathe work, is avoided by an especial device. The head-stock swivels, and at its juncture with the bed is a tongue which permits the head to be raised by the elevating-screw under the head while preventing lateral displacement. If the centers do not agree, standard tools in the turret will turn work out of size.

For turning locomotive- and car-axes an especial design of lathe is preferred. These are of two kinds, the single head and the double head. The single-head machine acts on one end at a time only. Such an one would

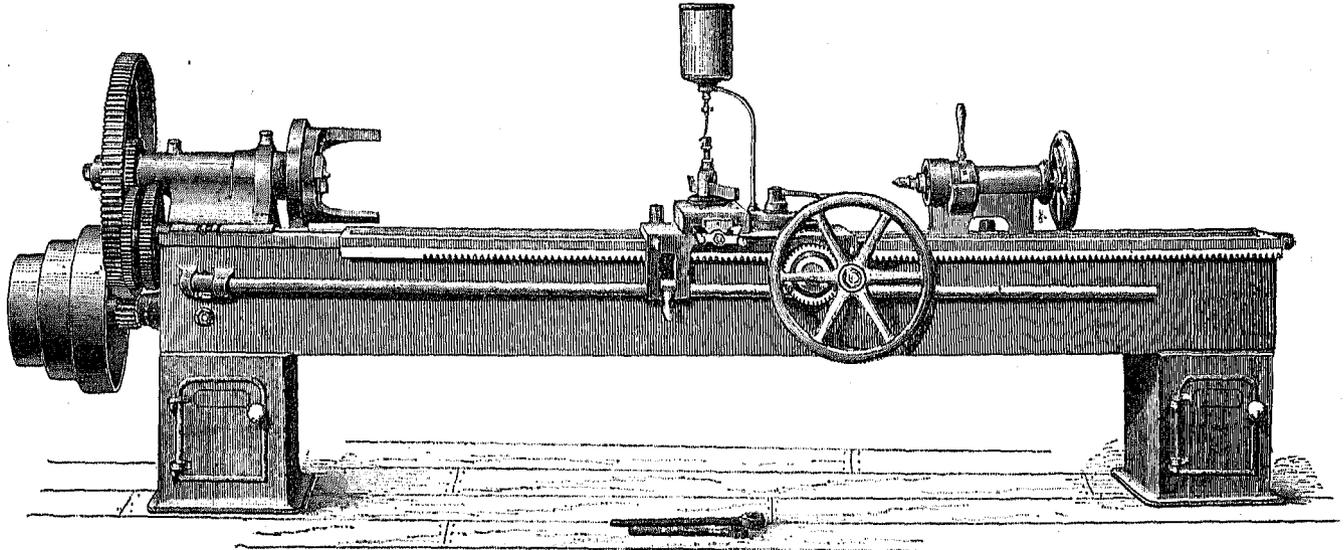


Fig. 126.

be illustrated by Fig. 125. The shears are flat, since the strain can come inside of them, the tail-head moving on a lower plane than the carriage. The head-stock is made adjustable for wear by the split in the casing, which is

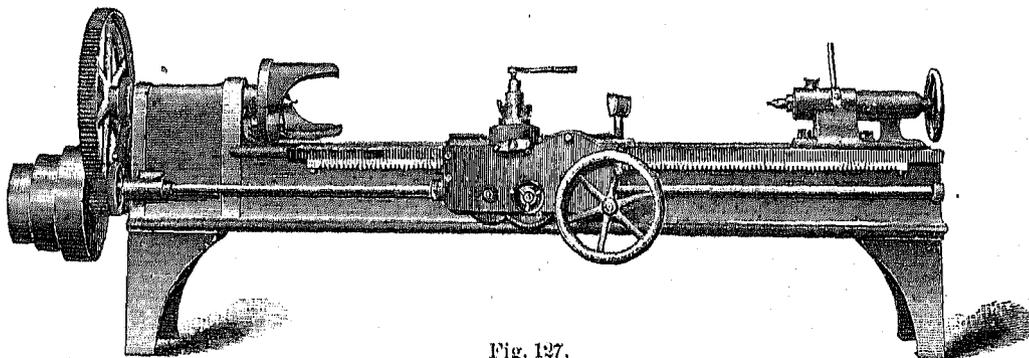


Fig. 127.

kept together by bolts. To equalize the turning strain on the axle when under the cut it is driven by two pins on the face-plate. There are two speeds of the tool for roughing and finishing which are caused by the two sets of pulleys on the counter-shaft. The two sets of feeds are produced at the head by the rod in front of the bed. The crane with differential pulley-gear enables the work to be handled easily.

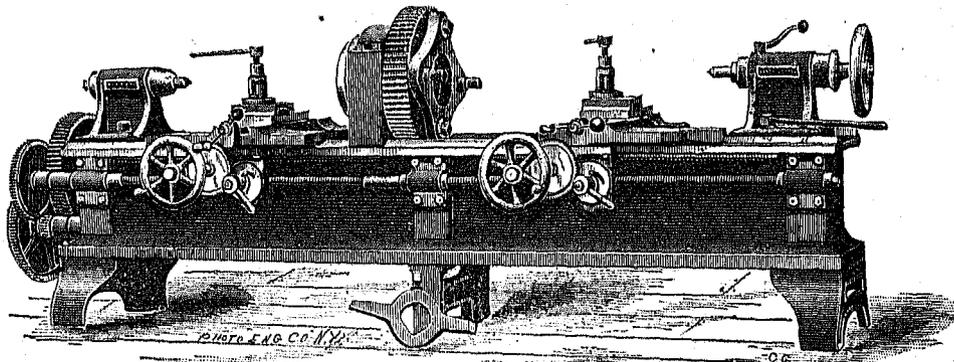


Fig. 128.

Differing only in some of the details are the car-axle lathes shown in Figs. 126 and 127. The lathe of Fig. 128 is one of the double-headed type. The axle is driven by a driver from the middle, and there is a tool-post for each

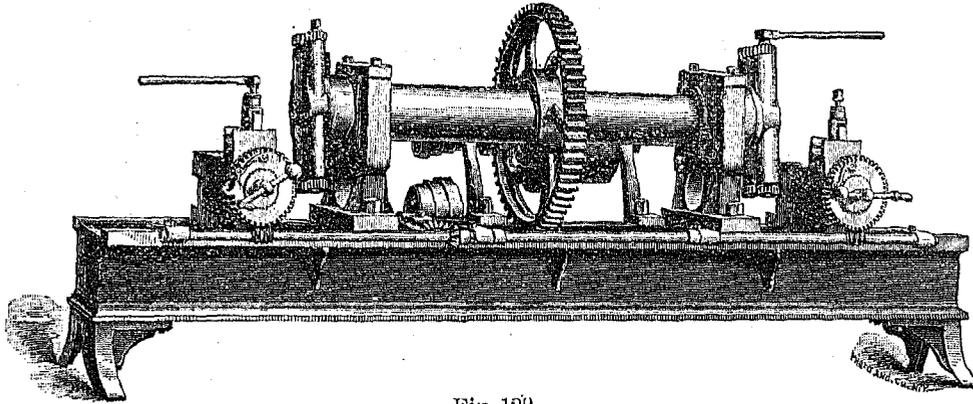


Fig. 129.

end, so that the two ends may be worked at once. The driving-pin plate is not rigidly bolted to the gear-wheel head, but has a certain diametral adjustment in slots. This enables the driver to be acted on equally by both pins,

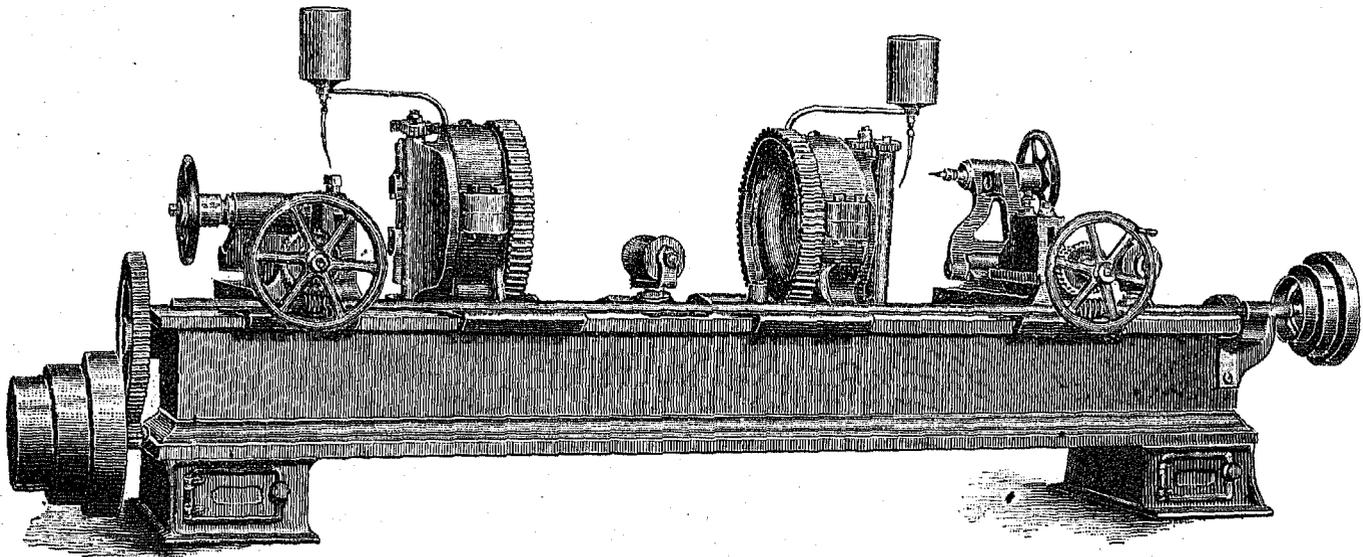


Fig. 130.

and avoids the tendency to spring sidewise which is not infrequently manifested when the axle is driven from a jaw-chuck. When this happens the work is out of round when released.

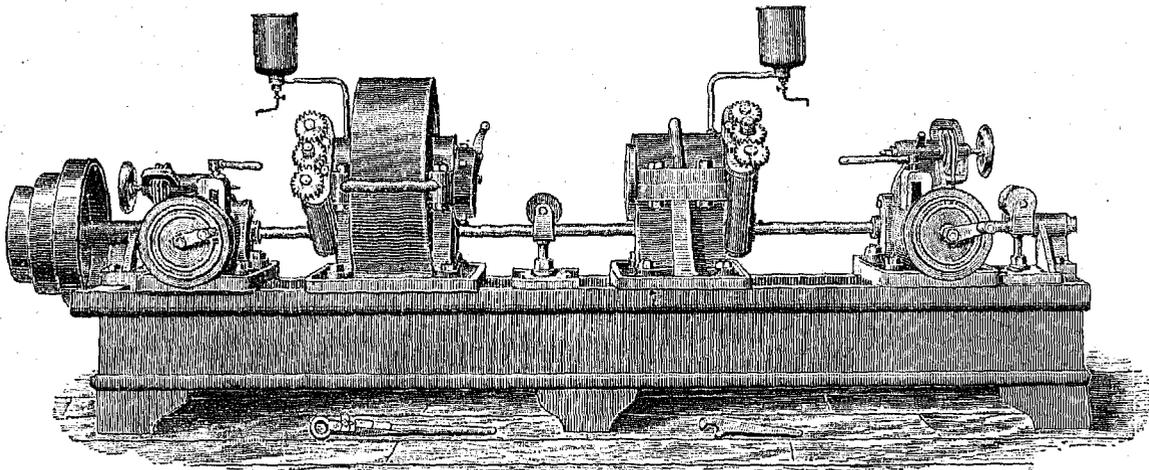


Fig. 131.

Another type of double-headed lathe is shown by Fig. 129. The axle is driven by jaws close to the cut, and the slide-rests have lateral and longitudinal power feed. By this system it is unnecessary to center the axles after being cut.

For cutting off and centering axles as they come from the hammer the tool shown by Fig. 130 is in use. The axle is driven at each end from the splined shaft within the bed, and cutting-off tools are fed against them at the proper length. When the crop-ends are removed the centering-heads may be fed into the end to drill and countersink for the center of the lathe which is to follow. The centering-heads can be swung out of the way when not in use. Fig. 131 illustrates another form of the same tool. A machine for centering only, after the crop ends have been removed, is shown by Fig. 132. The jaws are moved by right-and-left screw, and the center drill is fed rapidly by a rack and hand-wheel. An axle can be centered in three minutes by this machine.

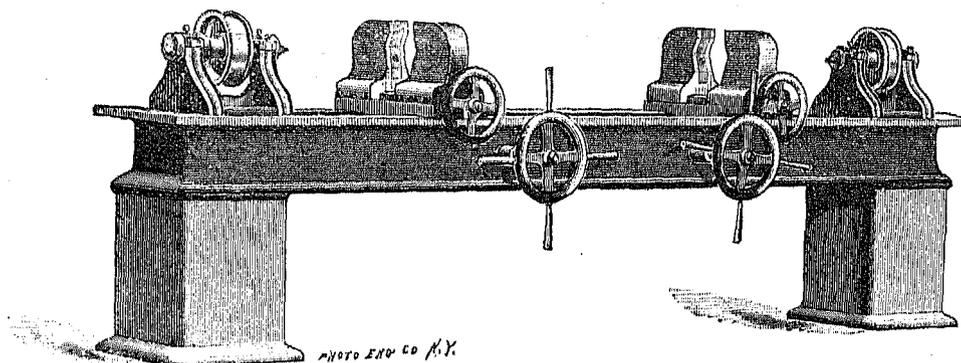


Fig. 132.

The lathe shown in Fig. 133 differs from the preceding in using a bed of a cylindrical section, with flats raised for the poppet-head and slide-rest. The feed is by a worm of four threads meshing into a rack on the front of the bed. The axle is driven by what is known as Clements' driver on the face-plate. The gearing is strong enough to rough out the journal in one cut of a depth of $\frac{3}{8}$ or $\frac{7}{8}$ of an inch. For centering the rough axle and sizing the wheel-fit the machine shown in Fig. 134 is used. The axle is driven from a powerful chuck lined with brass. This

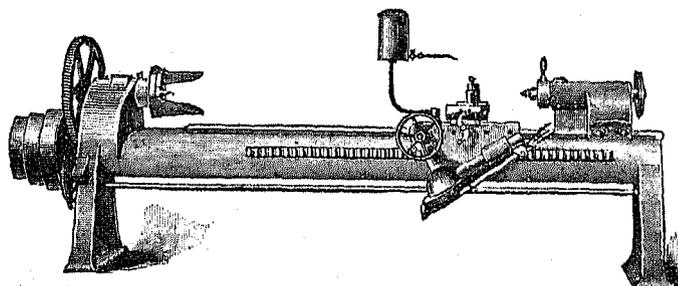


Fig. 133.

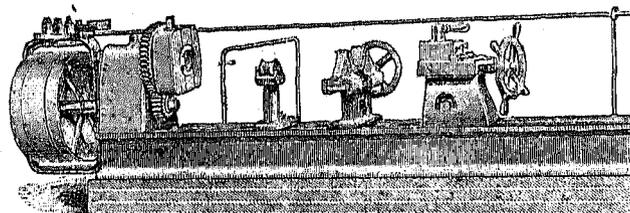


Fig. 134.

may clasp the axle by its collar when it is finished. The free end is held in an adjustable V-guide, and the end of the axle is squared and centered by a tool fed to it. The wheel-fit is sized exactly by a hollow reamer with adjustable blades. With these conveniences it is claimed that this tool and the lathe make it possible to produce from eighteen to twenty axles per man per ten hours.

With the lathes for axles should be discussed those lathes designed specially for finishing pulleys. Fig. 135

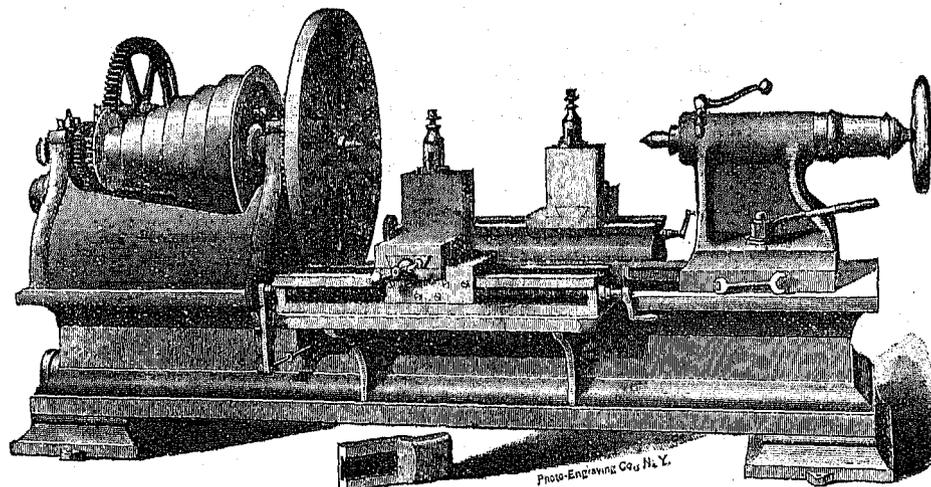


Fig. 135.

shows an ordinary lathe design of large swing, specially altered for pulley-work. The chief differences are in the use of two tool-rests of variable ratchet-feed, and in the arrangements to permit the face to be turned crowning.

Fig. 136 shows a special pulley-machine for taking bored pulleys on a mandrel. This system has the advantage

over the chucking system of turning the pulley more under the same conditions in which it is afterward to be run on a shaft. The pulley is secured on the mandrel by its own set-screws or keys, although it is driven by driver-pins on the gear-wheel, resting against its arms. A former attachment will turn the face crowning. For filing or polishing the mandrel may be driven directly by the belt-wheel on the spindle.

A similar tool is shown by Fig. 137, except that worm-gear is used to drive the mandrel, and the driver-pins are adjustable upon the face-plate to equalize the strain on the pulley-arms. The crowning is effected by setting over one end of the tool-post rail, according to the graduations. The worm-wheel on the feed-screw is relieved to permit this adjustment. The turned pulley is polished by securing it to the end of the worm-shaft, and the two operations of turning and polishing may go on at once.

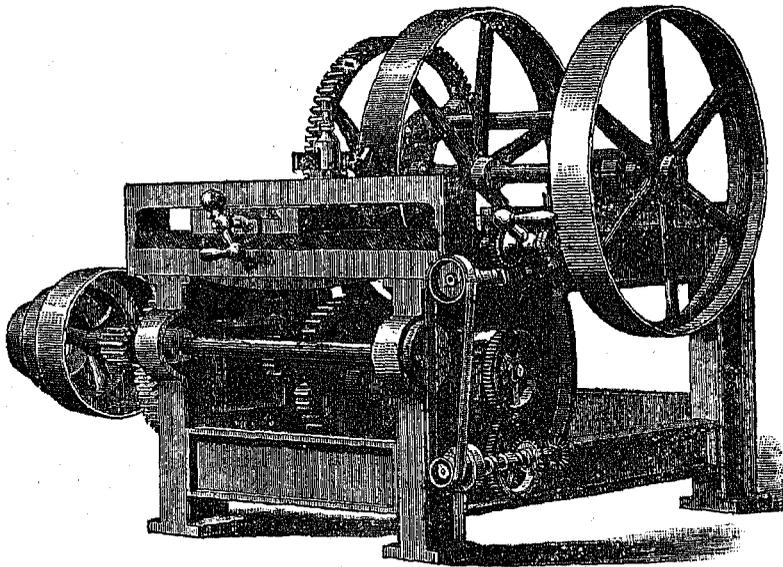


Fig. 136.

Fig. 138 shows a double pulley-lathe on the mandrel system. The mandrel may be supported on a head with adjustable center, and the faces may be turned flat or crowning. Each slide has an independent self-acting feed, with automatic disengaging gear.

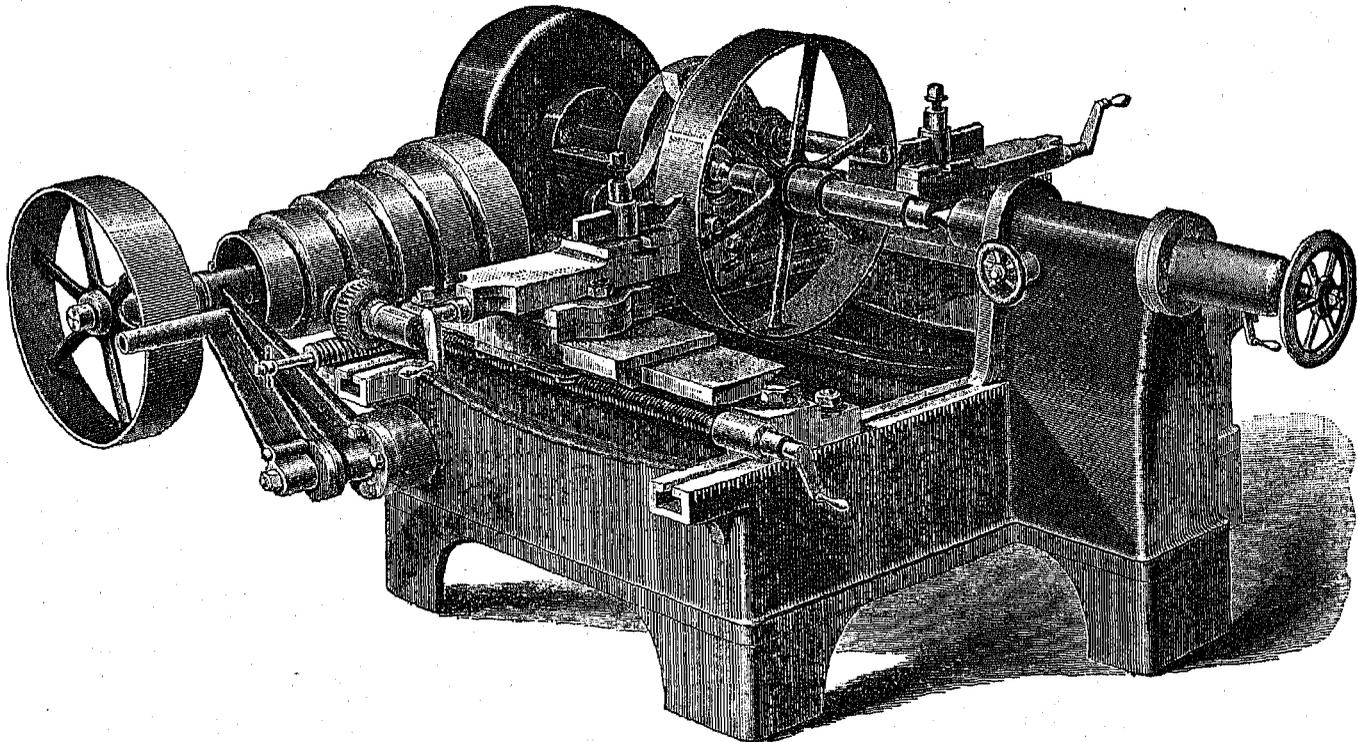


Fig. 137.

An objection to the mandrel system in these forms is that the pulley must first be chucked and the hole in the hub must be bored before the wheel can be put on the special lathe. This requires two tools, and some of the forms of boring-machine must precede the pulley-lathe.

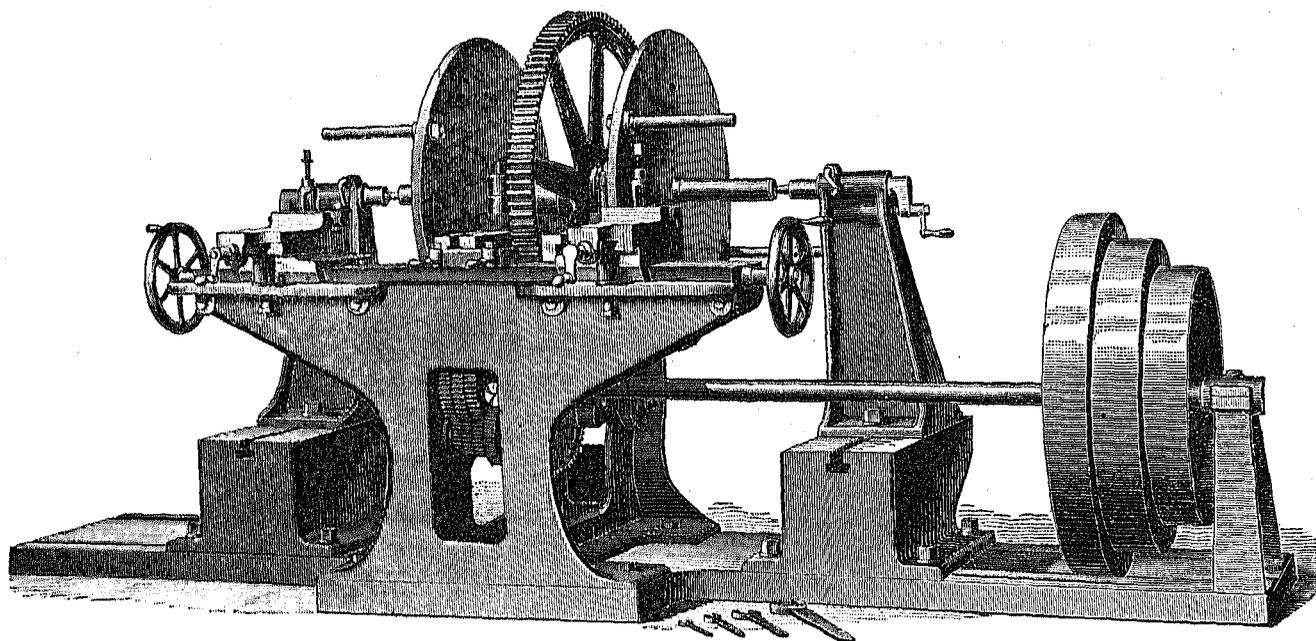


Fig. 138.

§ 18.

VERTICAL LATHES AND BORING-MACHINES.

The distinction between a lathe and a boring-machine is somewhat one of convention. Any lathe can be used as a boring-machine, either by securing the work to the chuck or by securing the work to the carriage and supporting a boring-bar between the centers. Especially is the distinction elusive when applied to the vertical machines. To carry out a possible analogy from the horizontal machines, a lathe would be a tool where the work revolved while the tool has only linear motions, while a boring-machine would be one in which the work was stationary and a cutting-tool described the surface of revolution. Many vertical lathes, however, on this classification are currently known as boring-machines, because they are designed for one class of work only, such as pulley or car-wheel boring-machines. There are certain of them which come unmistakably under the class of lathes, since they can turn as well as bore.

Fig. 139 shows one form of turning- and boring-mill. The work is secured to the horizontal face-plate and the tool is carried by the holder upon the cross-head. The feed of the tool is self-acting in all directions by the twisted belt at the right. The idle shaft, connected to the driving-shaft by a link, keeps the belt tight by its weight and permits the cross-head to rise and fall. The cross-head is only finished to guide the tool-post for a little over one-half the swing of the tool, since the cut is intended to be resisted by the compression against the cross-head. The slide on the cross-head is fed horizontally by the screw and vertically or at any angle from the splined shaft above the latter. The shaft carries a bevel-gear, which turns the rod parallel to the axis of the holder through an idle pair of bevel-wheels. As these mills have large capacity, swinging from 84 to 120 inches in the different sizes, the large face-plate must be steadied. This is accomplished by making a V-ring on the lower side of the plate which projects into and fits a corresponding V-groove in the bed. This makes the motion as steady as that of a planer bed. An adjustable step at the center can be made to take up any desired amount of vertical strain in the preliminary work of chucking and centering.

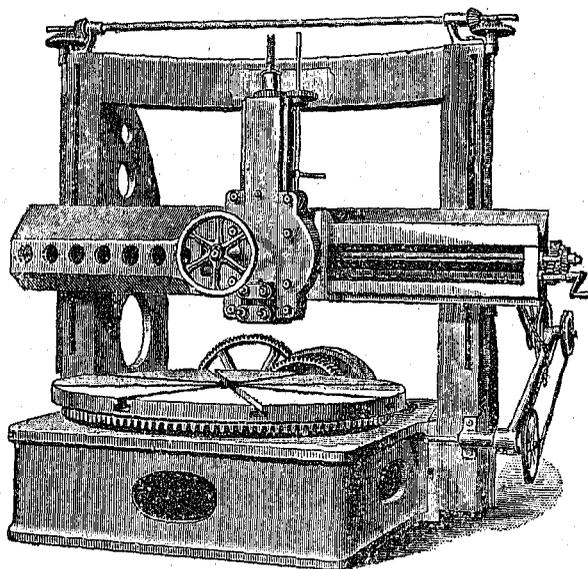


Fig. 139.

Fig. 140 shows a similar design, with two tool-holders. The holders are each counter-weighted by a weight on a wire-rope over pulleys. The rope winds on a pulley with a spiral groove at the back of the holder, the circumference of the pulley being in the axis of the holder. This prevents the action of the weight from departing very much

from the line of the action of gravity. The axis of the grooved pulley turns a pinion meshing into a rack on the side of the holder. The feeds for the tools are automatic in every direction and independent. The facing traverse is by screws which can feed in either direction. Their motion is received from the vertical shaft at the right, which

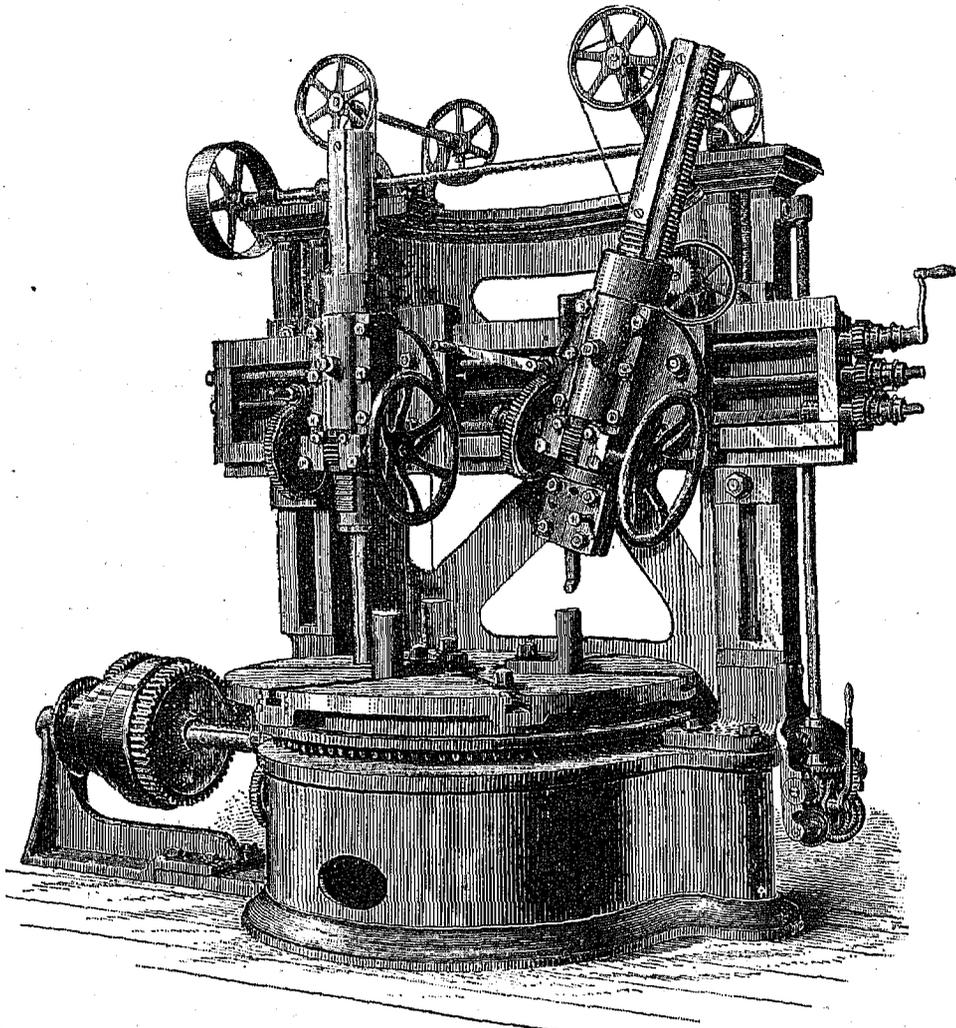


Fig. 140.

can be driven in either direction by the combination of three bevel-gears and a clutch from the cone-pulley shaft. Either cross-feed may be disengaged by a slip-jaw clutch on the end of the screw. For the downward and angular feeds the central splined shaft is used. A pair of bevel-gears, with clutch, is carried on the cross-slide. Between them is a third wheel, on whose shaft is a worm which turns a pinion-shaft and lifts and lowers the holder by a rack. The clutch to the worm-shaft is worked from behind the cross-head for change of direction, and the pinion-shaft is

disengaged for convenient hand-feed and quick return by a slip-jaw clutch. The face-plate on the large sizes is driven by internal spur-gearing (Fig. 141) to avoid the lifting or bending action produced by bevel-gearing. The entire revolving weight is borne upon a central step. This consists of a loose steel disk, hardened and ground, which is placed between two others of a hard alloy of copper and tin. One is fast to the foot-step, and the other is on the revolving spindle. These disks are grooved for the distribution of oil, delivered through a tube under the center. Chips are kept from the lower bearing by guards. By the use of two holders a piece of work may be exposed to

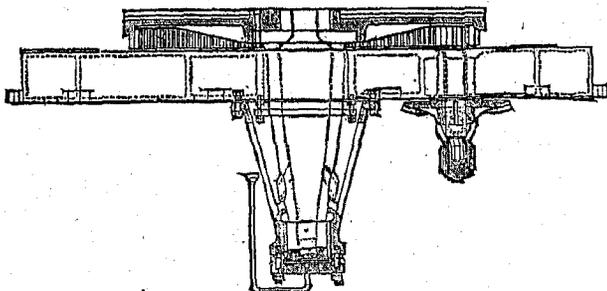


Fig. 141.

two operations at once. A pulley may be faced and bored at the same time, or a ring may be turned and faced at one operation. In another design the down-feed is given by a worm and wheel in front of the holder. The worm is driven by extensible shaft and universal joints for turning tapers. These tools are also made up to 12 feet swing. Some of the smaller sizes have the face-plate carried on a Schiele anti-friction curve, and a slotting attachment may be added for pulley-work.

A similar tool to the latter is shown by Fig. 142. It has the adjustable step for the spindle, controllable by the screw in front of the bed. The feeds are made variable in speed and direction by the brush-wheel combination at the right of the bed. The movable wheel is faced with leather, and adjusted by the hand-wheel. The tool-bars are counter-weighted, so as to have the pull of the weight always in the line of the axis without oblique stress on the guides. For pulley-work the adjustable driver-plate and carrier-pins are employed, and an adjustable dead-center is made use of. By setting the bars slightly oblique and feeding in opposite directions the pulleys will be

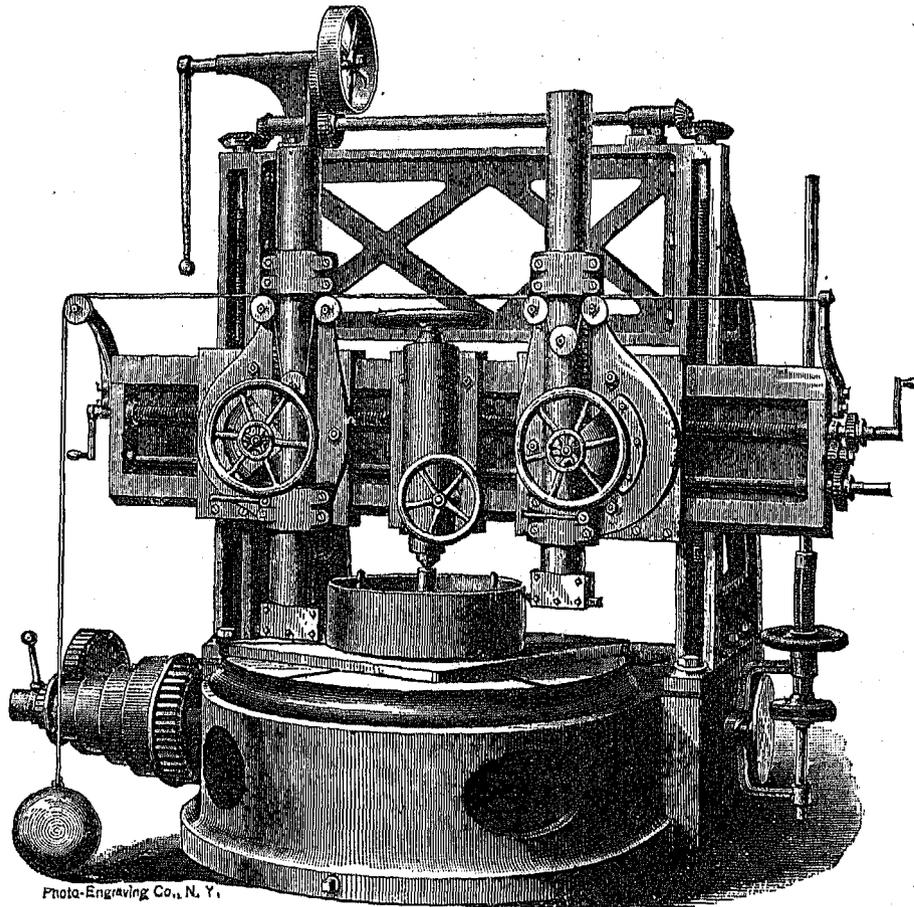


Photo-Engraving Co., N. Y.

Fig. 142.

faced off with a crown. These tools are built of sizes to swing from 5 feet to 16 feet in diameter. In common with the other vertical lathes these tools have the advantage of simplifying the labor of chucking large and heavy work. All the time required to secure the work for the tests of its position on the face-plate is saved. The work will lie by its weight on the horizontal bed until located, while, when gravity has to be overcome on a vertical plate, the piece must be bolted fast. This property, with the conveniences of the double tool-bar, makes these tools of very wide and general usefulness. By removing the uprights of a very large mill of this class it may be used as a fly-wheel lathe for the largest diameters. The tool is held on a special upright on a floor-plate, and is fed by hand. Many drawbacks of the old chucking-lathe are thus avoided.

A very large number of vertical lathes of small swing are made for boring only and for special work. A type of these is shown by Fig. 143, adapted for boring-pulleys and car-wheels. The stiff boring-bar, counterpoised overhead, is held in the long adjustable bearing. It is fed downward by rack and pinion, driven by worm and wheel. The hand-feed quick-return is released by a friction-clutch. Specially for car-wheels the same builders have the tool shown by Fig. 144. The crane attachment is very convenient for chucking rapidly. Such tools are made with chucks of the self-centering and independent-jaw variety. They have capacity for wheels of 42 inches diameter.

Another form of car-wheel boring-machine is illustrated by Fig. 145. The adjustment for the bearing of the bar is effected by tightening the bolts upon the split casting. The counterpoising of the bar is by means of the weighted lever, which has a floating fulcrum to avoid side strain. The face-plate is adaptable for boring tapers, for the few conical fits which are used by some. It is made of two disks, the faces of both being beveled as they lie together. By changing the relation to each other of these two disks the horizontal adjustment is destroyed and a conical hole is bored. There is also a hub-facing attachment. The boring-mill of Fig. 146 feeds the tool down by a different mechanism. The hub-facing attachment has a slide independent of the boring-machinery, so that a

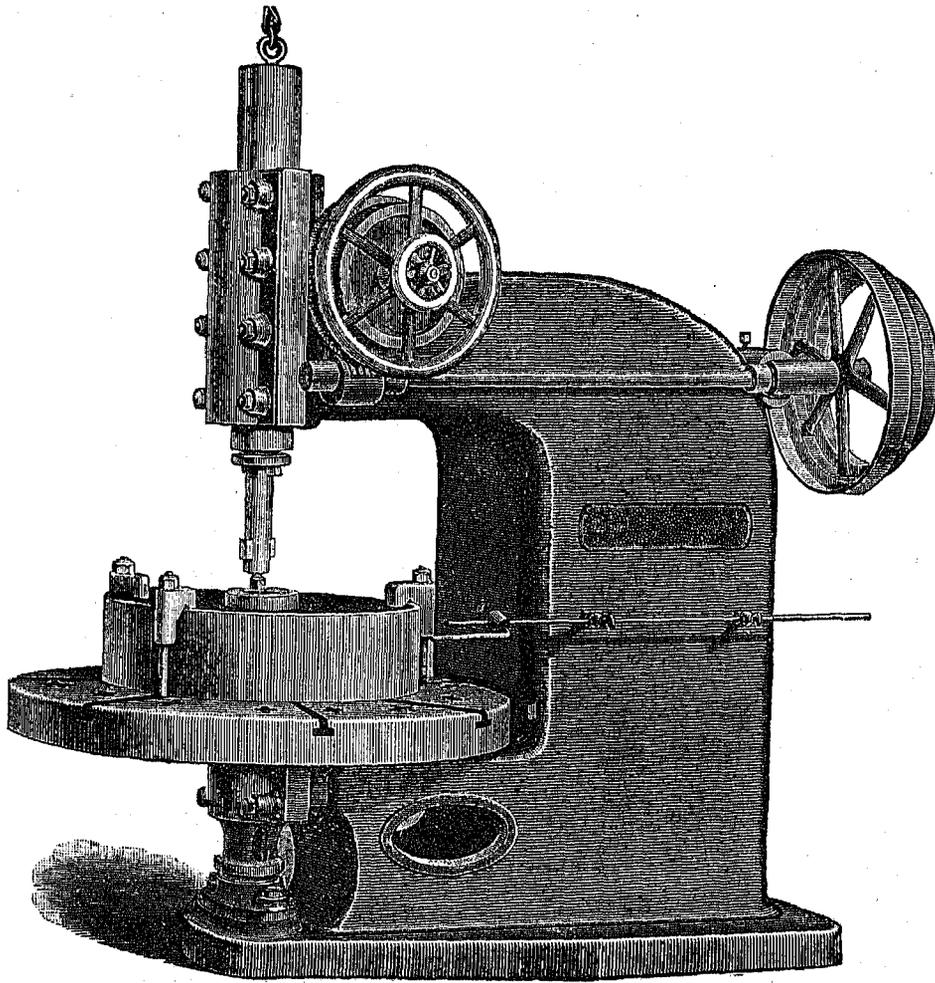


Fig. 143.

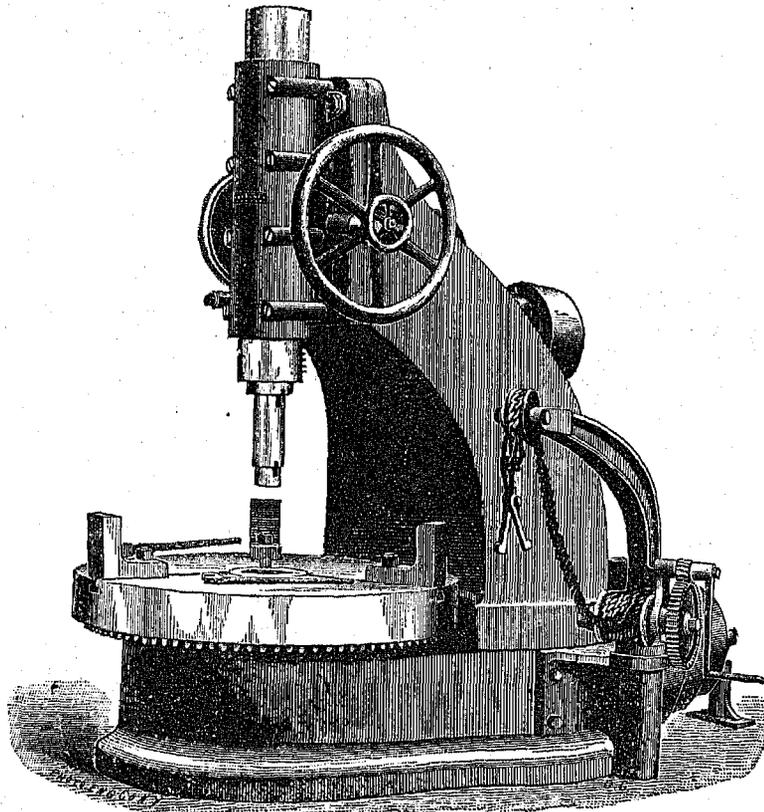


Fig. 144.

Hub may be bored and faced at the same time. The crane attachment for lifting the wheels is hung from a davit overhead. It is a geared hoist. This machine has a claimed capacity for fifty wheels per ten hours.

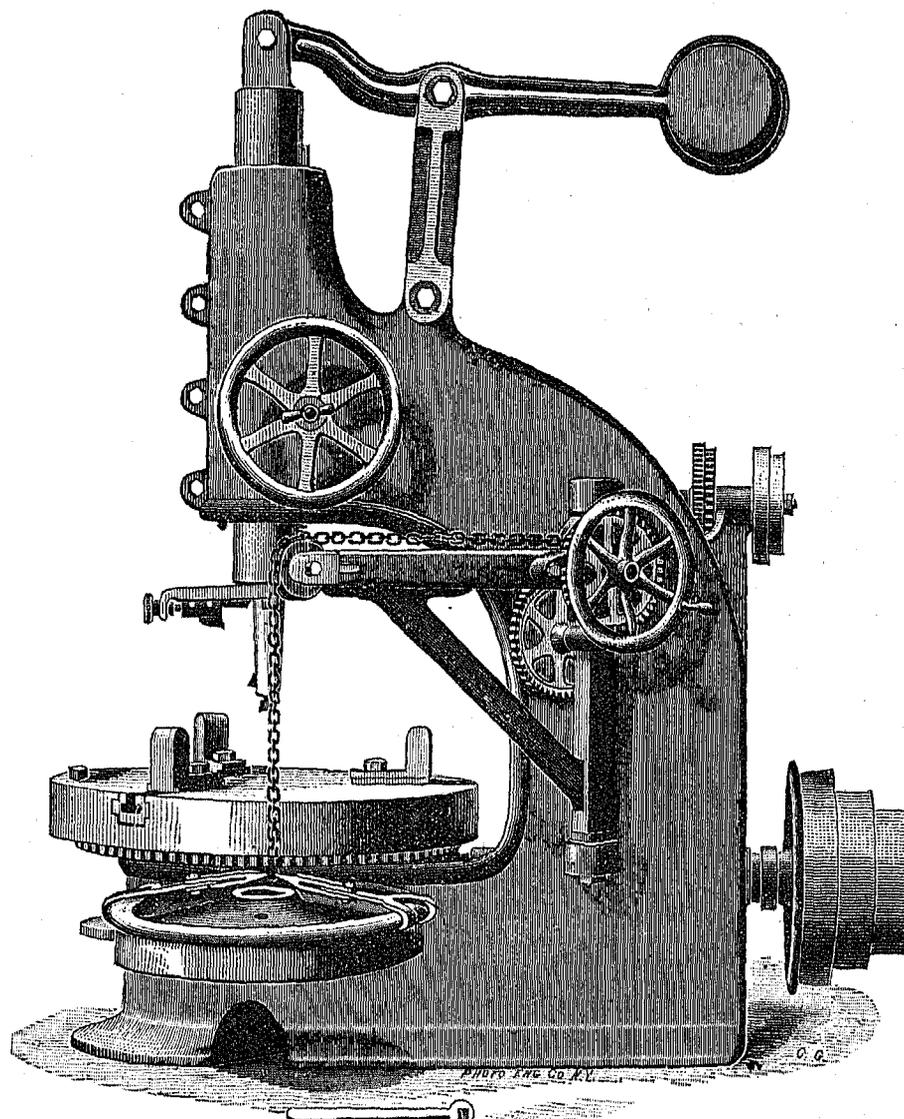


Fig. 145.

The borer of Fig. 147 takes up any lost motion around the bar by the glands at the top and bottom of the long bearing. These compress centrally a conical split sleeve when tightened down. The face-plate is carried upon a Schiele curve bearing, with a shoulder and ring at the top to prevent lateral jarring. The feed is by rack and pinion through worm-gear, engaged by friction. The gears are all external but boxed from dirt and accident. The roughing cut which should size to within $\frac{1}{16}$ of an inch is made with a feed of $\frac{1}{8}$ of an inch. The finishing cut is made with a feed of $\frac{1}{16}$ of an inch. By this machine a wheel can be chucked and bored in four minutes, as against seven minutes in the previous forms. The lifting-crane is also driven by power at the back.

For smaller work than this the table-borer (Fig. 148) is in use. The boring-bar is steadied and held by a counterpoised cross-head below the table. The feed is varied in either direction by the friction-disks between the desired limits, exactly as in the lathes of the same builders. The objection to these disks is their tendency to wear into rings, because of the sliding action where they overlap. All the borers of this type use the double cutters wedged into a slot in the bar (Fig. 149 *a* and *b*). The roughing-cutters wear more rapidly of course than those used for finishing. The first will probably lose its edge after boring four or five wheels; the other will last for more than ten times that number.

In all these forms of tool the horizontal chuck-plate permits very rapid adjustment of the wheels in place. Light hydraulic cranes are sometimes arranged to accommodate a number of tools, without requiring a special one for each.

For the boring of large vertical cylinders large shops usually have an especial apparatus, put up most frequently in a corner. A heavy boring-bar carries a spider or tool-carrier, which is moved up and down by a

screw in the deep spline which compels the rotation of the carrier (Fig. 150). A large gear drives the bar and the carrier-head, and reducing gearing feeds down the screw. Sometimes the feed-gear is driven by an epicyclic

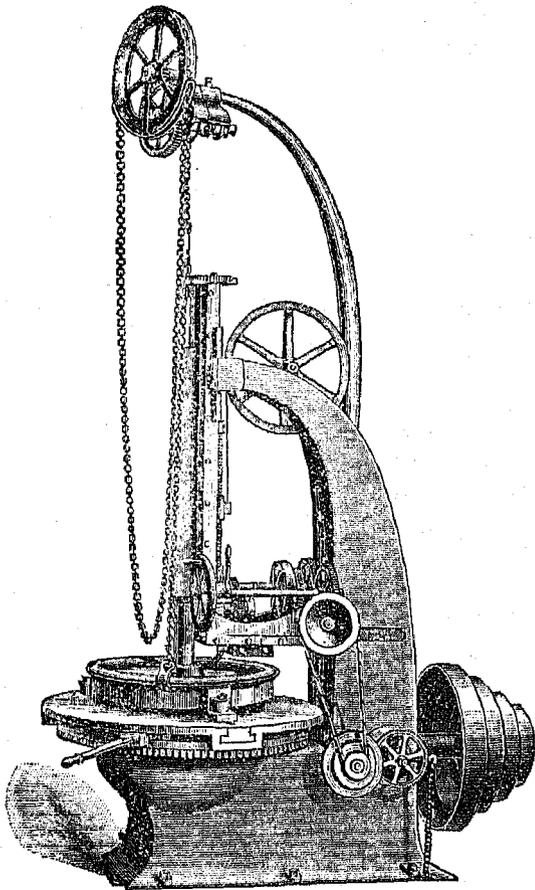


Fig. 146.

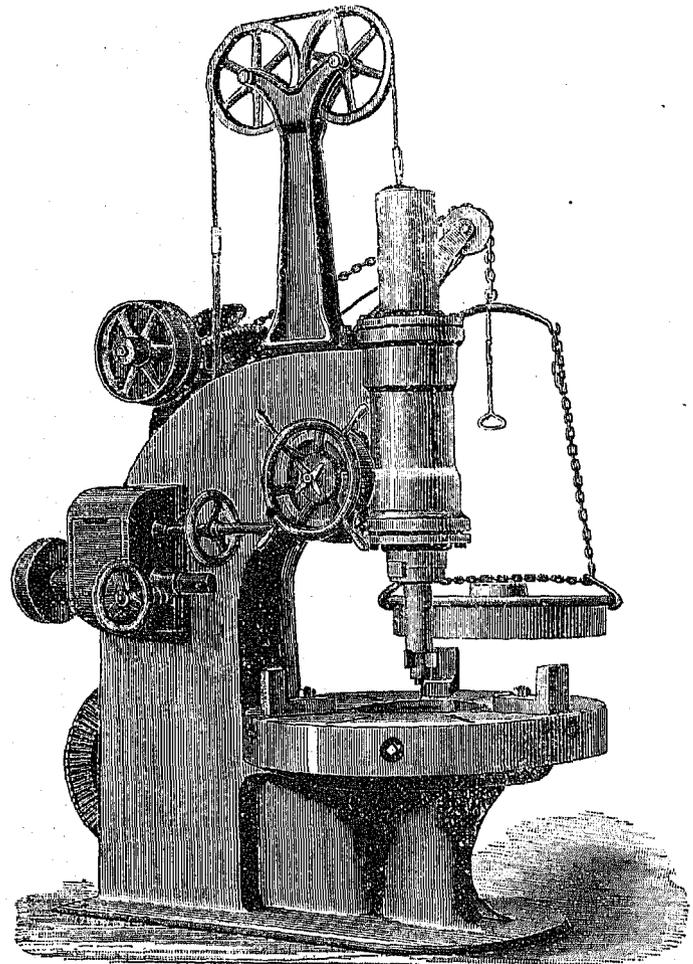


Fig. 147.

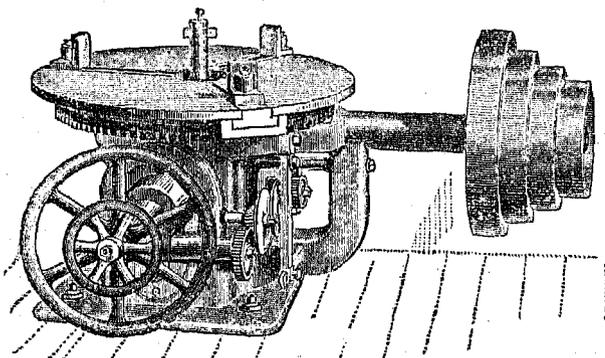


Fig. 148.



Fig. 149 a.



Fig. 149 b.

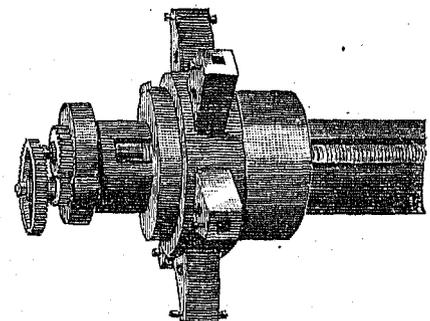


Fig. 150.

train. The cylinder is dogged and braced to a floor-plate at truly right angles to the bar. These machines have capacity for the largest cylinders.

§19.

HORIZONTAL BORING-MILLS.

The horizontal mills are especially adapted for bar-boring, either between centers or in bearings. The work is dogged to a table or carriage, which may be automatically fed or not, the feed in most cases being on the cutter-bar only. This type of tool is especially adapted for work in which the axis of the hole to be bored is parallel or not perpendicular to the chucking surface. It therefore lends itself easily to the boring of journal-boxes and hangers, of horizontal cylinders for engines and pumps, of elastic cylinders, and of cylinders without flanges, and work of that class.

For bar-boring between centers the machine of Fig. 151 is a type. The live-spindle is strongly back-gearred,

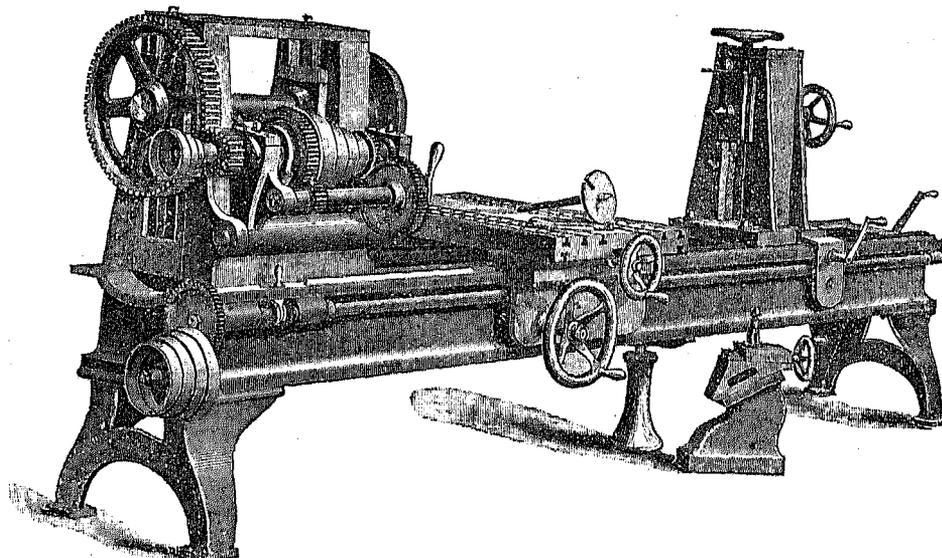


Fig. 151.

turning in long bearings at each end. The bearings of both head- and tail-stock are lifted by screws geared together by bevel-gears to a longitudinal shaft under the shears.

This arrangement insures that the two centers shall always remain in line. The hand-wheel at the dead-center permits accurate adjustment. The carriage is compound, having a longitudinal motion in either direction by power, and a cross-feed by hand. The power feed is reversed by a clutch between two bevel-gears. In some forms of this tool, when using a compound boring-bar, the carriage and work are stationary and the feed of the carrier is moved by a star-wheel on an arm from the head of the bar. Like any boring-mill with centers, this tool can be used as a lathe by simply bolting a tool-post to the slotted carriage; and conversely, of course, any lathe can be used as a similar bar-boring mill. This tool has the advantage over the lathe, in that the work does not have to be blocked up into the axis of the centers. The work can be bolted to the carriage, and then the centers can be rapidly adjusted into place.

For bar-boring in journals, and for horizontal drilling, the type of machine shown in Fig. 152 is used. A column supports a head like a lathe poppet-head. The spindle is long and has a longitudinal traverse. It is heavily back-gearred, and is fed forward by a screw driven by friction-disks. This permits wide variation of feed for holes of different diameters. There is also a hand-feed over the spindle. The front end of the spindle is bored tapering, and can receive either a drill or the end of a boring-bar. The table in front is carried upon screws which are moved together by a hand-wheel convenient to the operator. The carriage has a longitudinal traverse, by a screw moved by the second hand-wheel, and also an adjusting cross-traverse. For the use of a boring-bar, an adjustable bearing to steady its outer end may be clamped on the carriage. More frequently, however, when bar-boring is to be done, the yoke-system is preferred (Fig. 153). The hole in the top is in the center line of the spindle, and can be bushed for different diameters of bar. It can be bolted to any part of the bed-plate for different lengths of bar, and also serves to steady the free end of the table. The front of the column carries the long gibbed knee of the table, giving great stiffness when at work. The thrust of the spindle is taken up at the collars which embrace the bracket at the back. This bracket is guided at its foot, below V-guides, and is fed forward by a rack. This rack is driven by a worm and wheel, which is engaged with the hand-feed and quick-return by a friction-clutch. There are six changes of feed, three of which are for drilling and three for boring. The slowest feed will permit small holes to be drilled in steel; the fastest gives $\frac{1}{4}$ of an inch feed for finishing cuts in boring. The cut shows

the raising and lowering gear driven by power. The tool may be run forward and backward at the same speed, so as to cut in either direction with the same cutters. The back-gear is compressed for ease of handling and compactness.

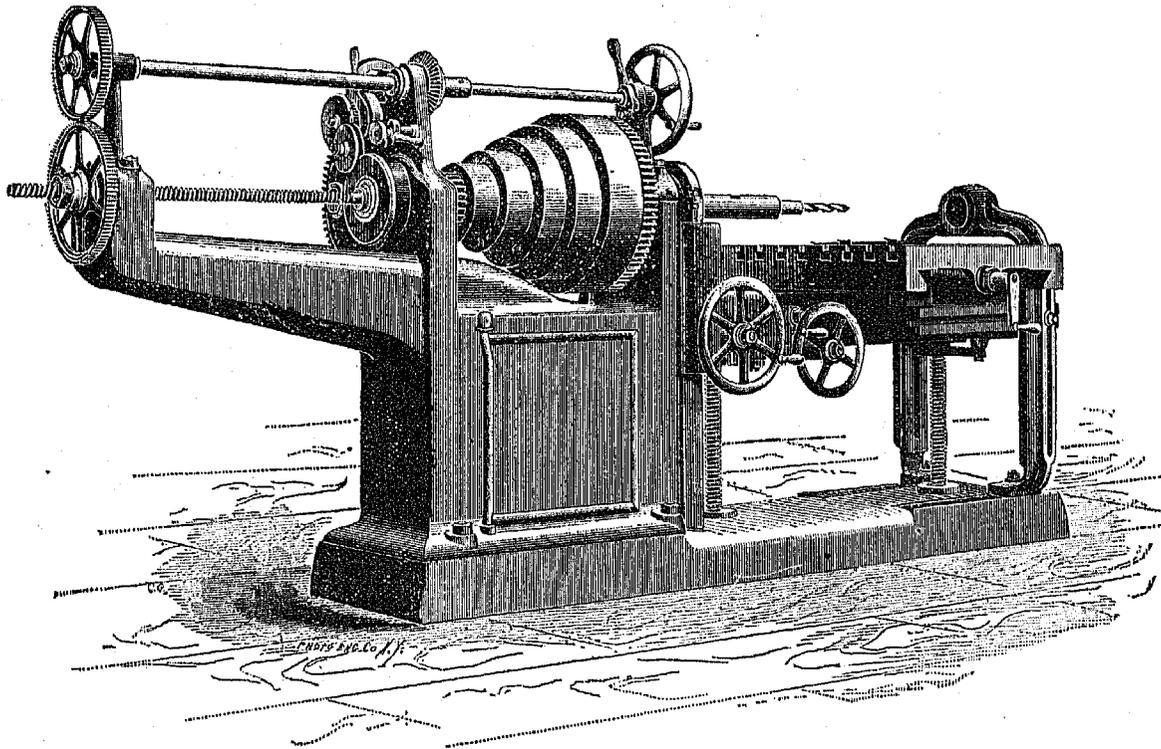


Fig. 152.

Fig. 154 differs only in the arrangement of the feed-gear. On one of the shafts are three loose gears. Each has a keyway cut in it. On the shaft is cut a spline till it meets a hole in the axis, in which slides a rod from the end. A key, fixed to the end of this rod, may be moved along the cut spline so as to come opposite the key-way in any of the gears, when it will slide into it, and make that gear fast to the shaft for the time. There is also a

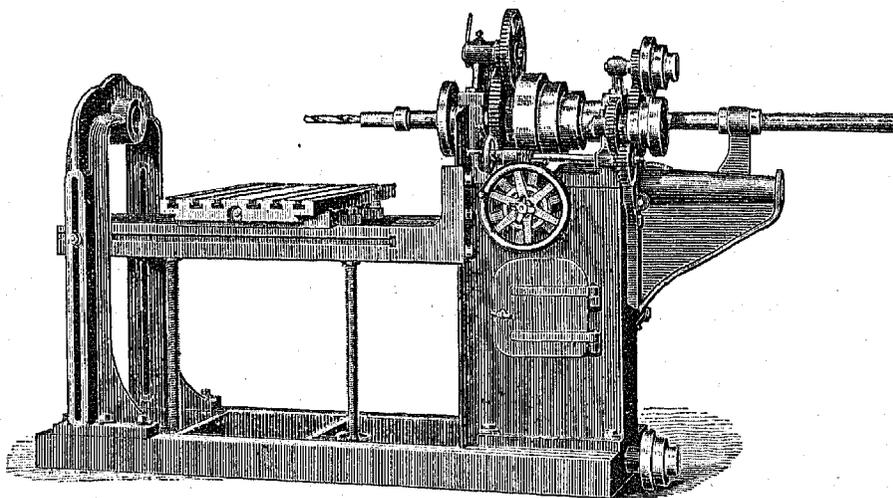


Fig. 153.

slow hand-feed and quick return. A facing-rest may be bolted to the face-plate, and will be fed by the star-wheel. The driving-pins are lightly bolted to the top of the head-casting. The thrust is taken up as before by collars against an arm from the guided slide, but in this design the arm is quite short. Sometimes a tail-screw is arranged on the slide to take up lost motion and to receive the thrust.

Where the work to be bored or drilled is very large or heavy, it is convenient to bolt it to the floor and to move the live-spindle into the proper position. Such a design is illustrated by Fig. 155. A large floor area is covered by a sole-plate with intersecting T-slots planed in it. In any position on this plate may bolt the lower

block of the spindle upright. The upright has an adjustment laterally on guides upon this block for distances less than the intervals between the slots. The spindle may be clamped at any elevation above the plate within

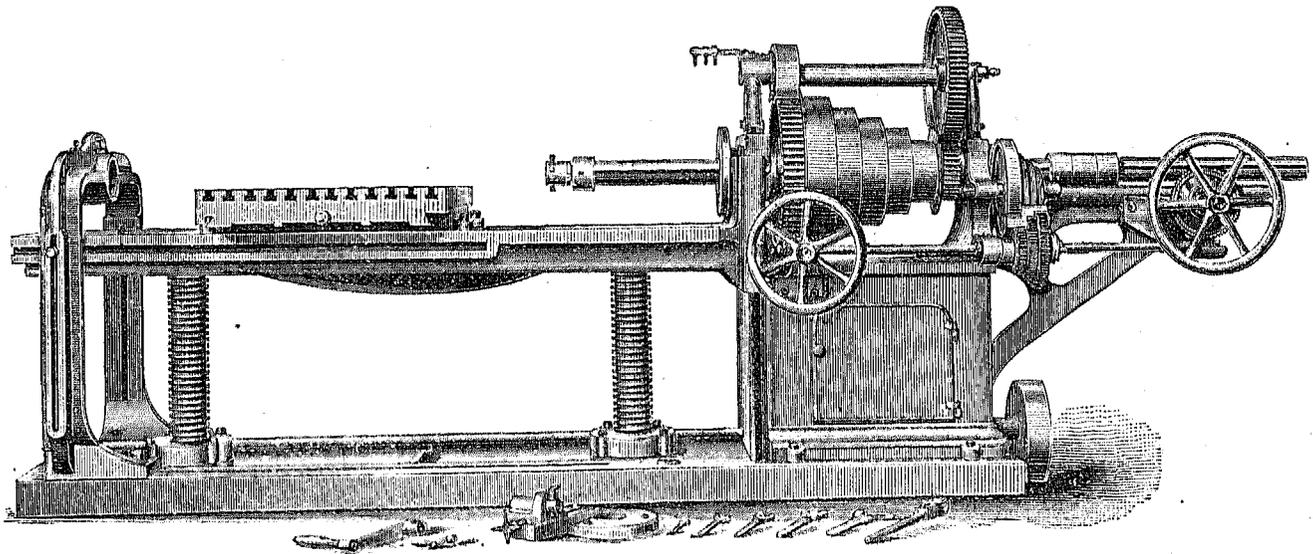


Fig. 154.

the limits of 6 feet 4 inches, and 14 inches. The casting is raised and lowered by screws driven by power. The power is transmitted to the tool by belts from swinging frames to take up the slack of adjustment. The bar is fed by a screw driven by friction-disks. To support the outer end of the bar a similar, but smaller, upright may be used, bolted to the slotted table where needed.

Another tool, with greater vertical capacity but less convenient horizontal adjustment, is made at Providence, Rhode Island. A tall upright, 15 feet high and braced from the roof, carries the gibbed slide with the horizontal

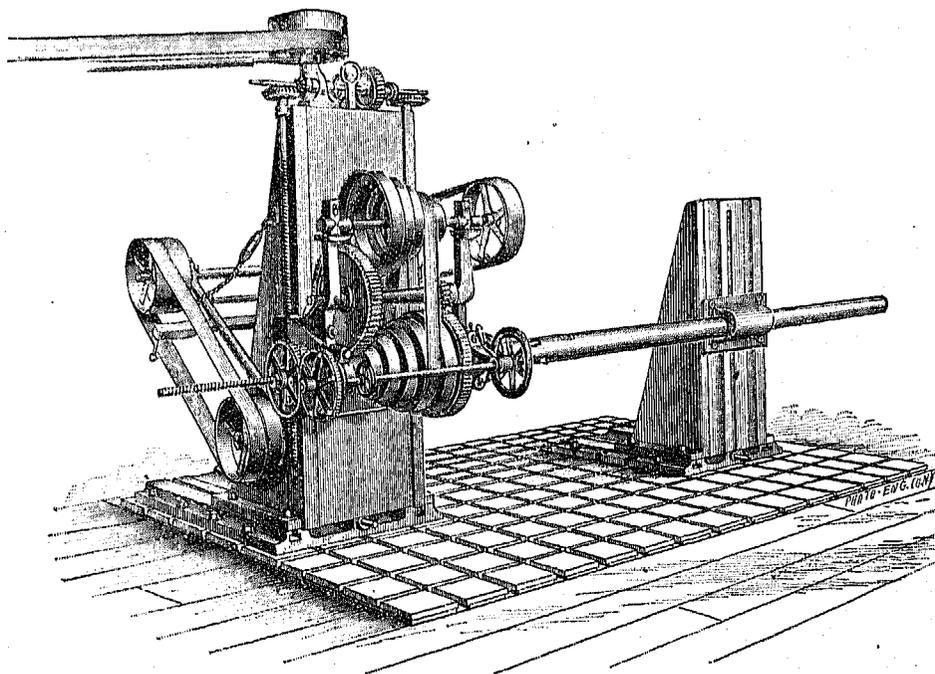


Fig. 155.

driving-spindle. Motion is imparted to the spindle by a pair of brass bevel-gears, the vertical shaft being splined and moving upward with the slide. The spindle is made long, and the thrust and feed are provided for by an arm from a guided slide. The feed is by hand and power, the adjustment of the slide being only by hand. Its weight is counterpoised. To secure the work a heavy table moves transversely on rails, the adjustment being effected by a pinion in the table taking into a fixed rack on the floor. There is no outer support for a long bar at high levels. The machine is more used for drilling, or for boring with short tools held in the end of the spindle.

A special tool for boring and facing flanged cylinders for locomotives and other engines is shown in Fig. 156. A 6-inch steel boring-bar is driven at both ends by the face-plates from a splined shaft in the bed. The bar can

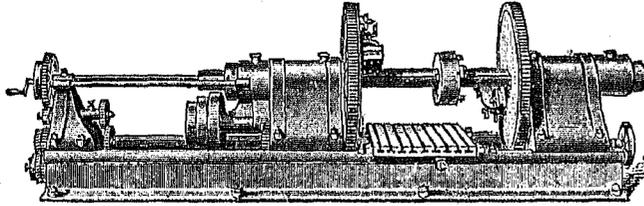


Fig. 156.

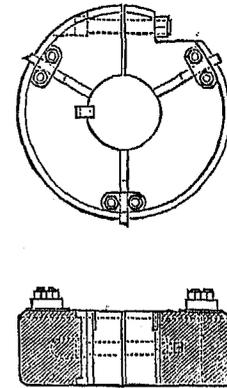


Fig. 157.

be withdrawn from the work by hand or power, and the cutter-head may be similarly fed in at the proper speeds for the heavy rough cut and the finer finishing cut. Facing-rests bolt to the two face-plates so that the sinking head may be cut off and the flanges faced up while the roughing cut is in progress. This arrangement gives truer

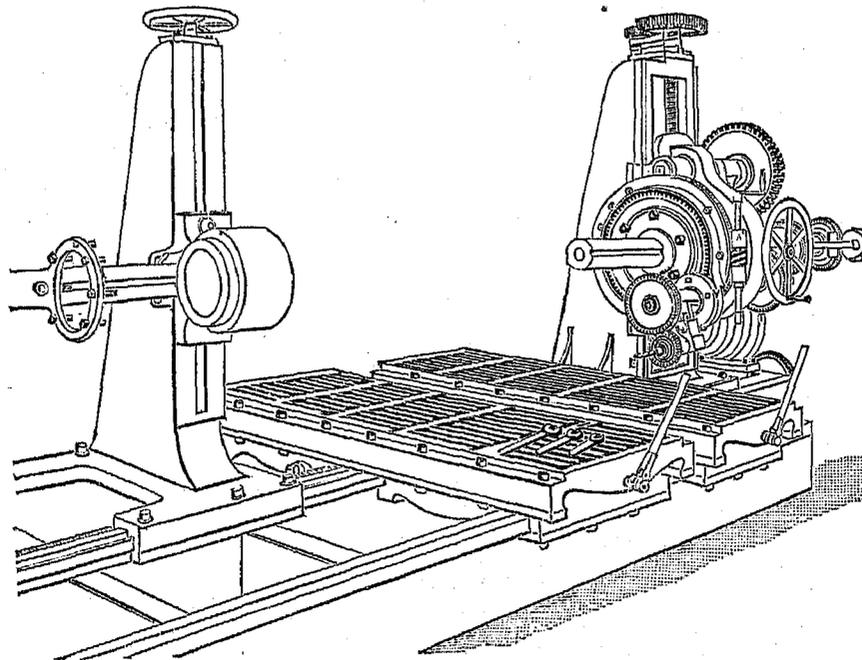


Fig. 158.

work than when the facing-tool is driven from the bar, since the variation in resistance will cause a springing of the joints in the latter case. By this machine the time for boring and facing a locomotive cylinder of usual dimensions has been reduced to a little over one-third of that required with less perfect machines. The boring-head for these bars is made to clip the latter (Fig. 157). The head is cut at one element, and is held by a bolt, which clamps firmly and yet can be instantly released.

A similar tool, designed for large horizontal work, is shown by Fig. 158. Beside boring and facing cylinders of large size, by this machine the holes in the flanges for the cover-studs can be drilled. The whole live-spindle head can be raised and lowered by power, and the post is arranged with a bracket bearing which will support the outer end of bars of different diameters by means of inserted bushings. Its longitudinal and vertical adjustment are effected by screws. The flange-drill E is revolved around the center of the spindle by the worm A' and held in place by it. By this system the holes can be adjusted to be on the circumference of any circle around the axis of the cylinder and can all be spaced equally.

Fig. 159 shows a third upright with a longitudinal and transverse motion beside the vertical adjustment. This head is used for surfacing work. The tables have compound motion. The bed of this machine is 39 feet long.

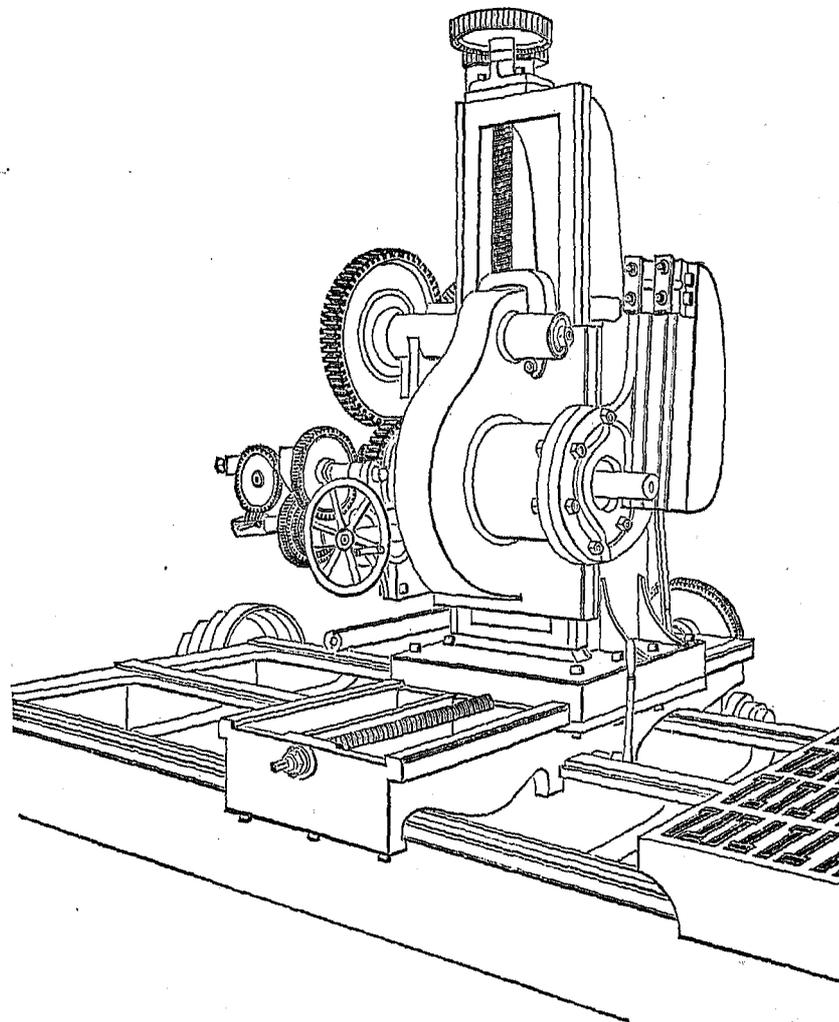


Fig. 159.

§ 20.

DRILLS.

The distinction between drilling-machines and boring machines is not very marked with respect to their function. Usually, however, the drill cuts only at the bottom of a hole in the solid metal, while the boring-tool cuts at the side or bottom of a hole already made. It is possible in the case of most large holes to have them either punched or cored, whence their enlargement to exact size will be effected by boring. Drilling will be usually resorted to for small holes. A drill will, therefore, turn more rapidly than a boring-machine, and will usually be a much lighter and smaller machine.

The question of feeding the drill-point forward against the work was for a long time debated. Some held that it was unwise to have power-feeds; others approved them. Practice of to-day favors a disengageable feed from the spindle, permitting a quick-return by hand, or a hand-feed if desired.

The prevailing drill properly so-called has its spindle vertical. The motion from the horizontal shafting of the shop must, therefore, be transmitted to the spindle through a pair of bevel-gears or else by belt over guide-pulleys. The bevel-gear combination is in the majority. The work will be secured to a T-slotted floor-plate under the spindle, or to a table, according to its size, and according to the type of machine.

The drill-presses may be variously divided, according to their form. For convenience they will be discussed under the heads of upright drills, radial or column drills, and other forms. The latter will include such types as the suspended and multiple drills and special designs.

§ 21.

UPRIGHT DRILLS.

The upright drills (so-called) are usually made to be self-contained. The counter-shaft, with fast-and-loose pulleys and the nest of cone-pulleys, is put at the back of the machine and conveniently near the base. This position of the cone-pulleys makes the shifting of the belt quite easy. The horizontal driving-spindle will be at the top of the machine, both being carried in journals which are on brackets from the main upright of the tool. There are two types of practice with respect to the manner of securing these brackets. Some designers cast the upright and brackets all in one piece. This type is called a "gooseneck" drill, and is illustrated by Figs. 162, 167, and 168. It has the advantage of stiffness and cheapness of fitting. The other type has the brackets bolted to flat seats made for them. By this means is avoided the risk of failure of an entire large casting because of defects of small parts of it.

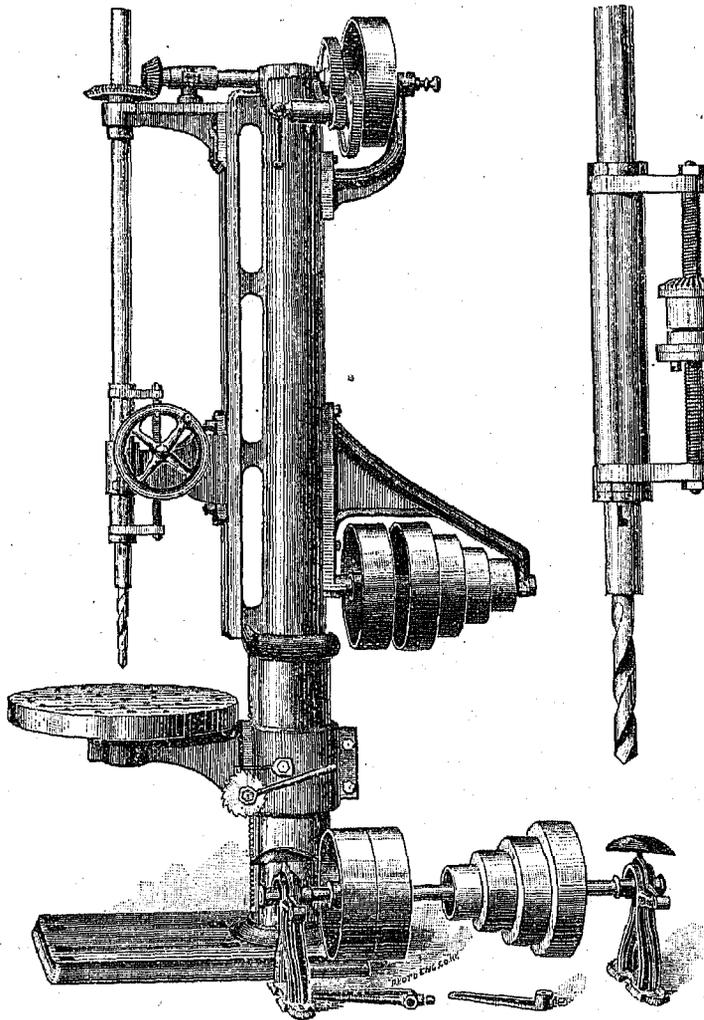


Fig. 160.

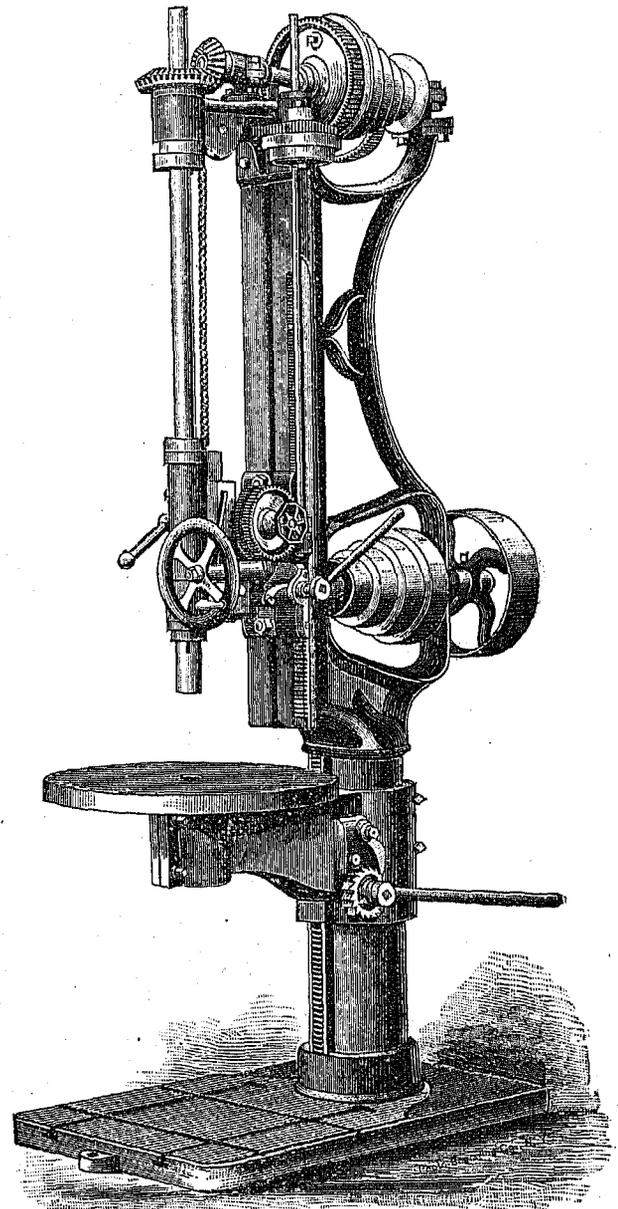


Fig. 161.

A type of this design is shown by Figs. 165 and 170. Upon the lower part of the principal upright a cylindrical surface is turned. Upon this fits a bracket, very usually split so as to clamp in place, which carries the table. This table is made with slots and T-holes in it for securing work, and its top surface must be truly horizontal when the tool is in place. This table is made to raise and lower by a pinion meshing into a rack. This pinion will be turned directly in lighter tools by a crank or ratchet-lever, or indirectly by a worm and wheel. One form uses

a worm (Fig. 167) meshing directly into the rack whose teeth are inclined to conform to the obliquity of the screw. This rack is not cast on the cylinder but fits between collars at top and bottom of the turned surface, and is kept in its vertical position by its fit through the knee. By this expedient, not only is the fitting of the table made more easy, but the table can be made to swing around the upright out of the way of the spindle, if desired.

The foot of the upright rests in a foot-plate in a long, deep socket. In newer practice this foot-plate is planed and slotted to secure deep work to, that it may serve also as a table. The table is usually held in the bracket by

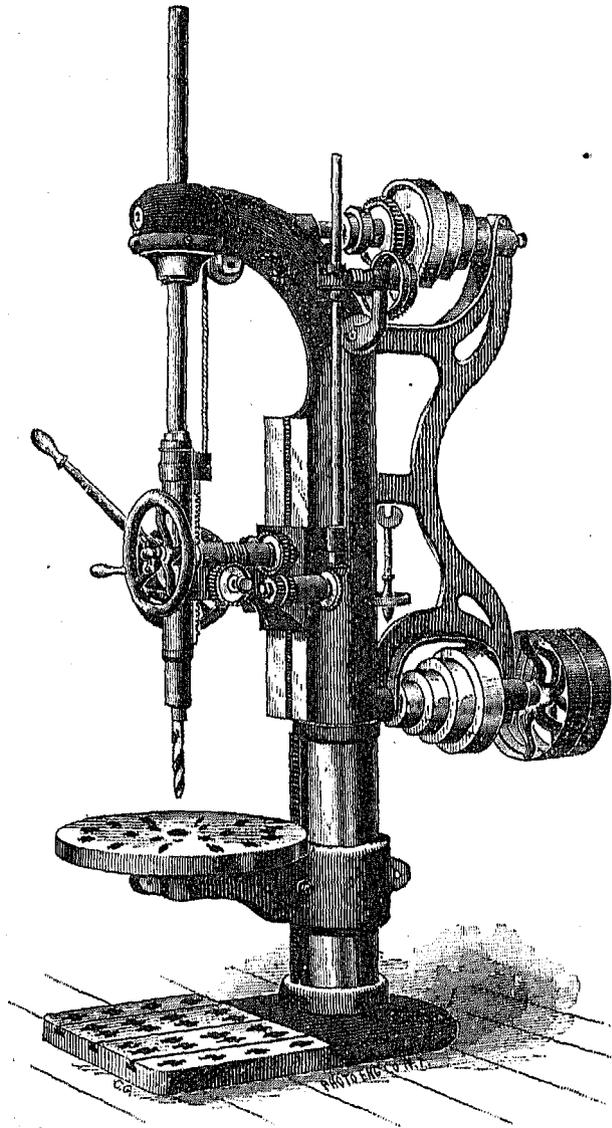


Fig. 162.

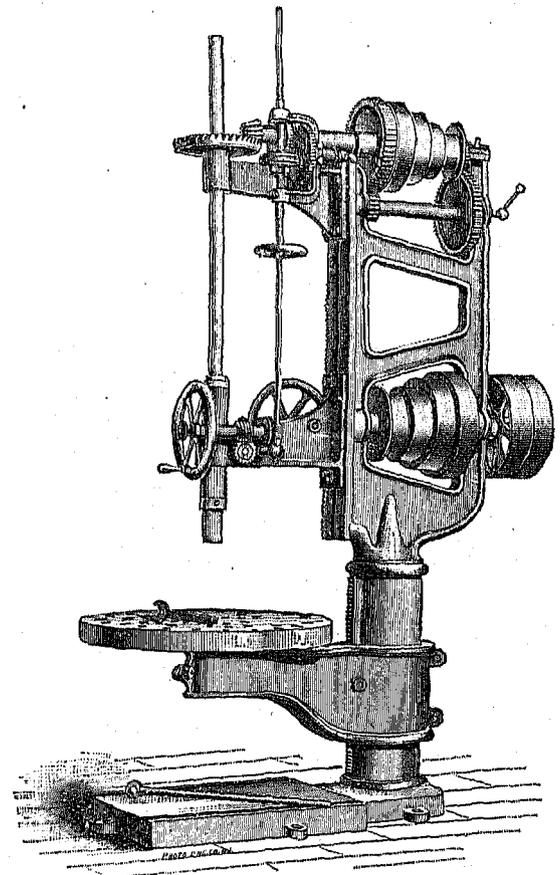


Fig. 163.

a clamp, taking hold upon a cylindrical post, on the lower side central and perpendicular to the finished face. Sometimes this post is screwed into the clamp-nut of the bracket, for finer vertical adjustment. Perpendicular to this table and to the planed foot-plate must turn the spindle of the tool. This is driven from bevel-gear on the upper spindle, the horizontal gear being usually the larger, that the belt-pulleys may turn at high speeds. The horizontal gear usually turns in the bearing in the upper bracket, being provided with a very long hub. This is splined to permit the motion for feed and for adjustment, while the driving bevel-gear remains stationary. The lower bracket, which guides the lower end of the drilling-spindle, is made adjustable vertically for work of differing depths. It is provided with a long knee, which clamps to a planed slide in the front of the tool. Where the bracket is not counter-weighted, the bracket is lifted by a pinion turning in a rack cast in the slide (Fig. 161). The newer types are arranged to move by the unaided hand.

Fig. 160 illustrates one of the older types with separate counter-shaft and hand-feed only. The feed was by a screw bracketed out from a sleeve through which the spindle passed. The sleeve only is fitted to the bearing in the bracket. At the bottom of the sleeve is the point at which the thrust of the cut is borne. Present practice

puts a brass washer, or a hardened steel washer, or a washer of rawhide at this point, and any lost motion or wear is taken up by different devices above the sleeve. In place of the screw, the practice of to-day favors a rack, usually cast as part of the sleeve and fed downward by a pinion, driven through worms.

Fig. 161 shows the rack and ratchet device for lifting the feed-bracket. This is made necessary by the fact that the spindle only is counter-weighted. It is of course more important to counter-weight the spindle in order that its weight may not be released suddenly if the drill-point enters a blow-hole. The edges would be likely to catch,

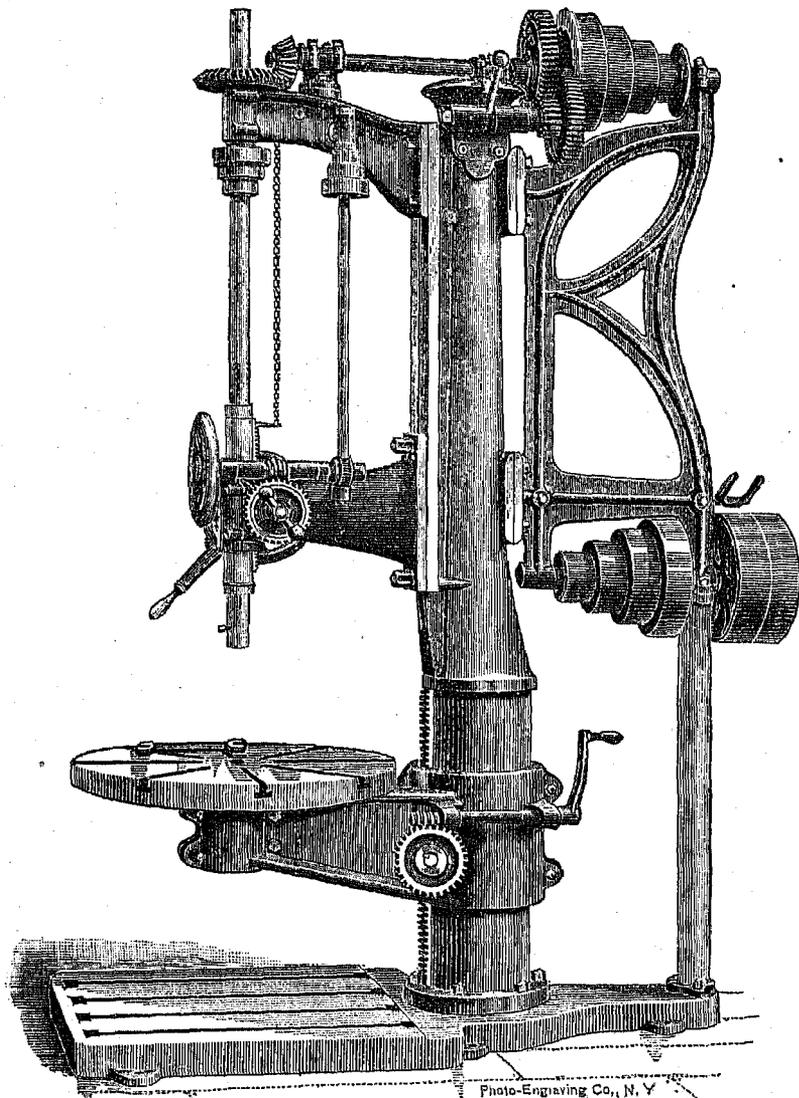


Fig. 164.

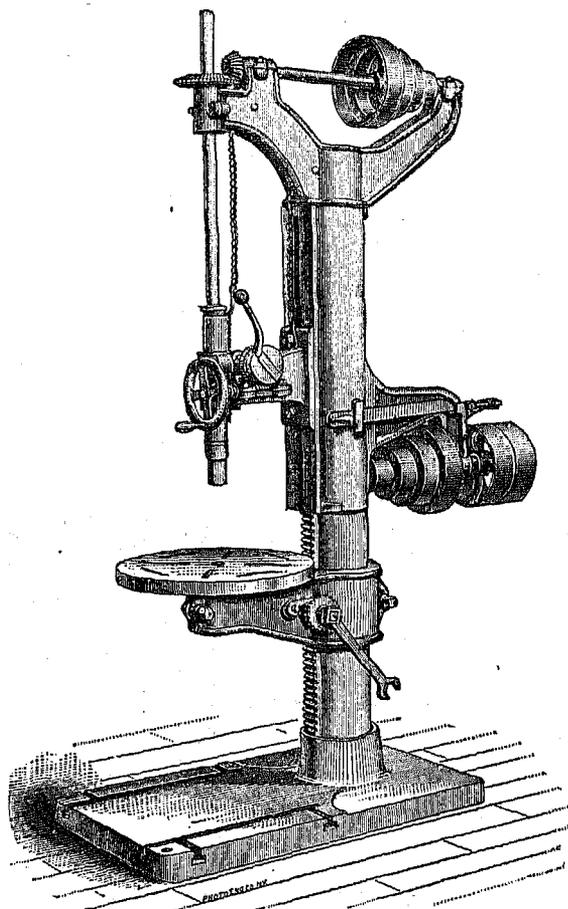


Fig. 165.

and the drill would break. The power-feed is from cone-pulleys on the hub of the horizontal driven bevel-wheel, which drive a splined worm-shaft by reducing gear. Hand-feed through a second worm is disengaged by friction, and a quick-return lever, for use when both are thrown out, is on the farther side.

Fig. 162 shows the typical gooseneck drill. The counter-shaft is on the back of the tool, and the bevel-gears are incased from dust. The feed changes are made without shifting the feed-belts by shifting-splines on the movable bracket spindles. The hand-feed and quick return are engaged by friction. The counter-weight hangs in the column.

Fig. 163 shows a drill of 48 inches swing, fitted with a variable power-feed by a brush-wheel combination. The power is gained by two worms. The hand-feed is disengaged by friction.

Fig. 164 shows a counterpoised spindle design. The rear post is introduced to stiffen the frame against the thrust of the cut. This flexure of the upright is one of the great defects in the single upright system. The same drill illustrates the lifting of the table by worm-gear.

Figs. 165 and 166 show a counterpoised drill in which the quick return and hand-feed are original. The bent lever swings on a pivot in the diameter of the disk, and a tooth on the end of the rectangular part may catch in notches in the face of the worm-wheel. The power-feed may be disengaged by a friction-clutch.

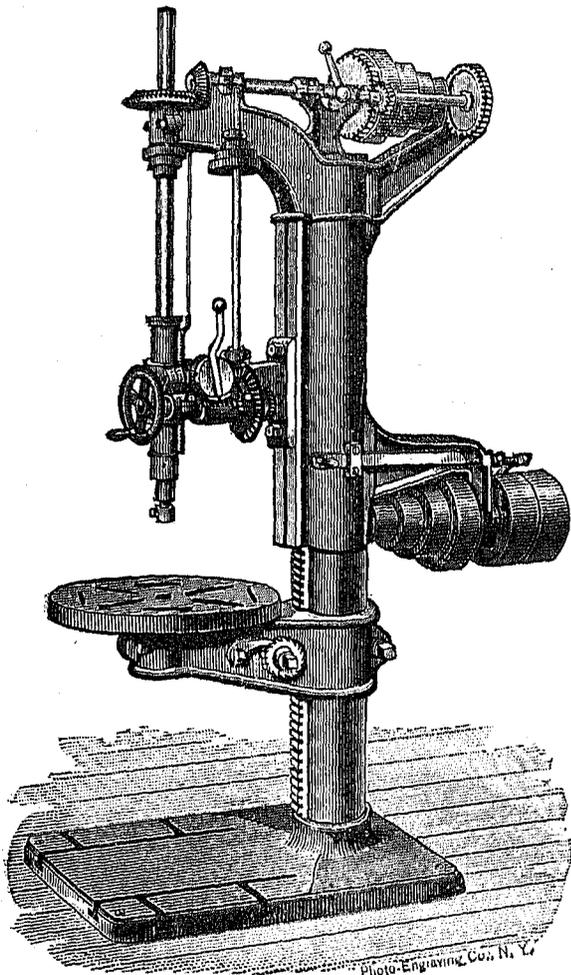


Fig. 166.

Photo-Engraving Co., N. Y.

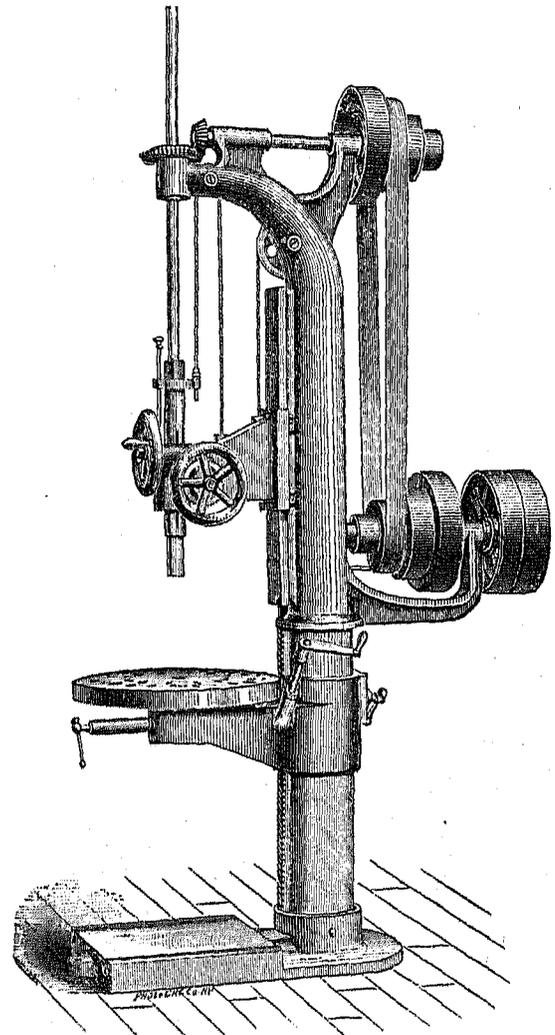


Fig. 167.

Fig. 167 uses but one weight to counterpoise both spindle and bracket. The wire rope is continuous, and passes under a sheave in the bracket from over pulleys in the upright. There is also an adjustable depth-gauge attached to the lower stock. This is an accurately graduated scale, which enables the operator to determine the penetration of the drill by an index on the feeding-sleeve.

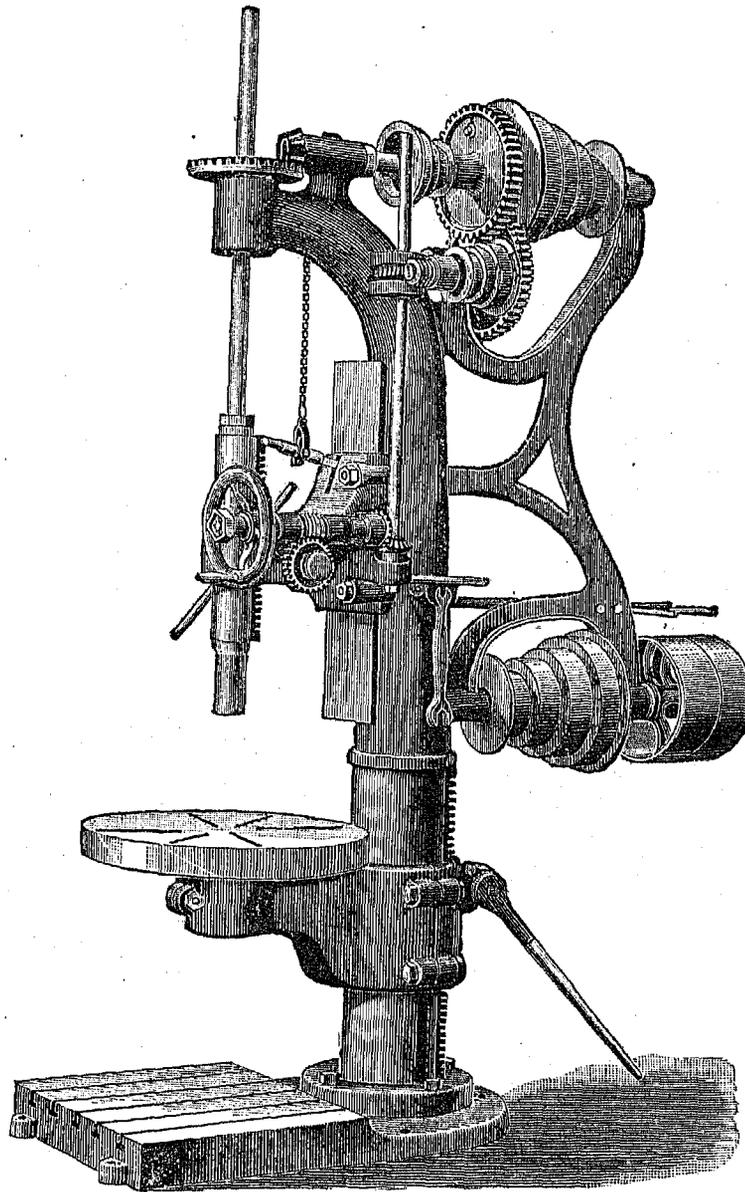


Fig. 168.

Fig. 168 shows a New England design where one weight counterpoises both spindle and bracket. The chain lifts both by a hinged lever, attached to the bracket near its center of gravity by a link. This link compensates for the motion of the spindle, and the adjustable clamp of the clevis D permits any proportion of the counter-weight to be distributed upon the spindle joint as the weight may vary in the socket. The power-feed and quick-return are controlled by friction-clutches. This tool also illustrates the compacting of the back-gear mechanism upon a short axis. This is very general in the newer tools.

Fig. 169 illustrates the same arrangement of back-gear, but the spindle has but one long bearing instead of two. The table has a very long vertical adjustment by a screw let into a slot in the column. The brass nut of the screw can be disengaged by the pin below the table in front, so that the table may swing aside. The changes of feed are accomplished by the three bevel-gears on the worm-shaft. The vertical gears are engaged with the geared spindle by a movable spline operated by the rod and milled head at the rear end. The counterpoise is annular over the top of the spindle-cap.

Fig. 170, by the same builder, illustrates the bolted system for the upper brackets.

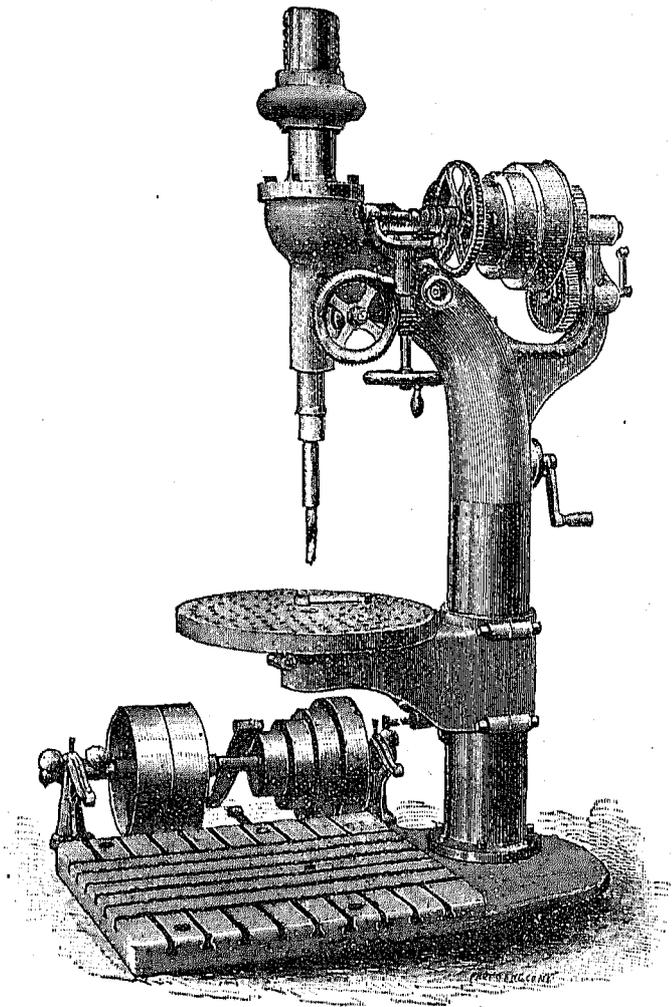


Fig. 160.

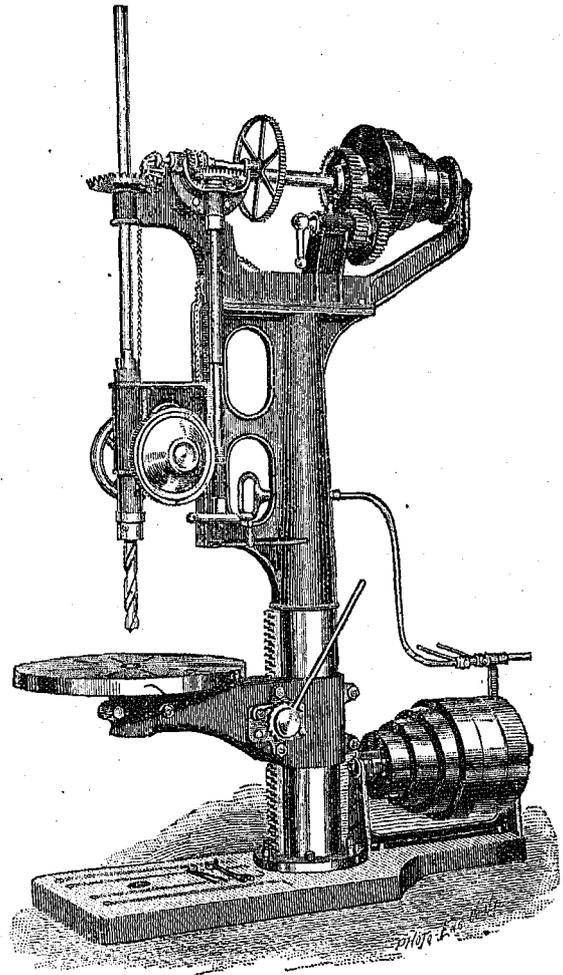


Fig. 170.

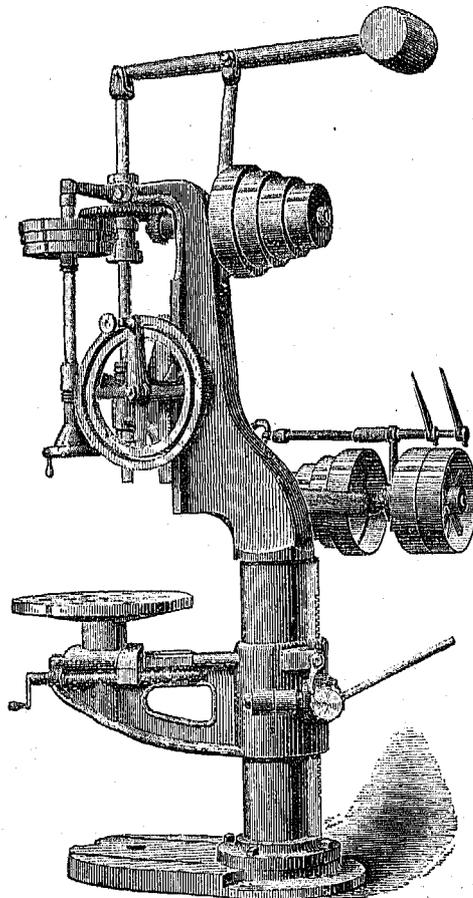


Fig. 171 shows a lever counter-weight drill, with the feed driven by a cone of belt-wheels. The hand-feed and quick-return device is by a frictional clip in the sunk ring of the worm-wheel. The handle of the crank forms a screw-clutch. The table has a horizontal traverse by screw.

Fig. 172 shows a lever counterpoise drill, the links being curved so that the short lever may not cause binding upon the spindle. The quick-return is by a lever on the left-hand side, the worm of the feed-motion being moved laterally away from the pinion wheel by an eccentric on the vertical rod at the right. The power-feed has three

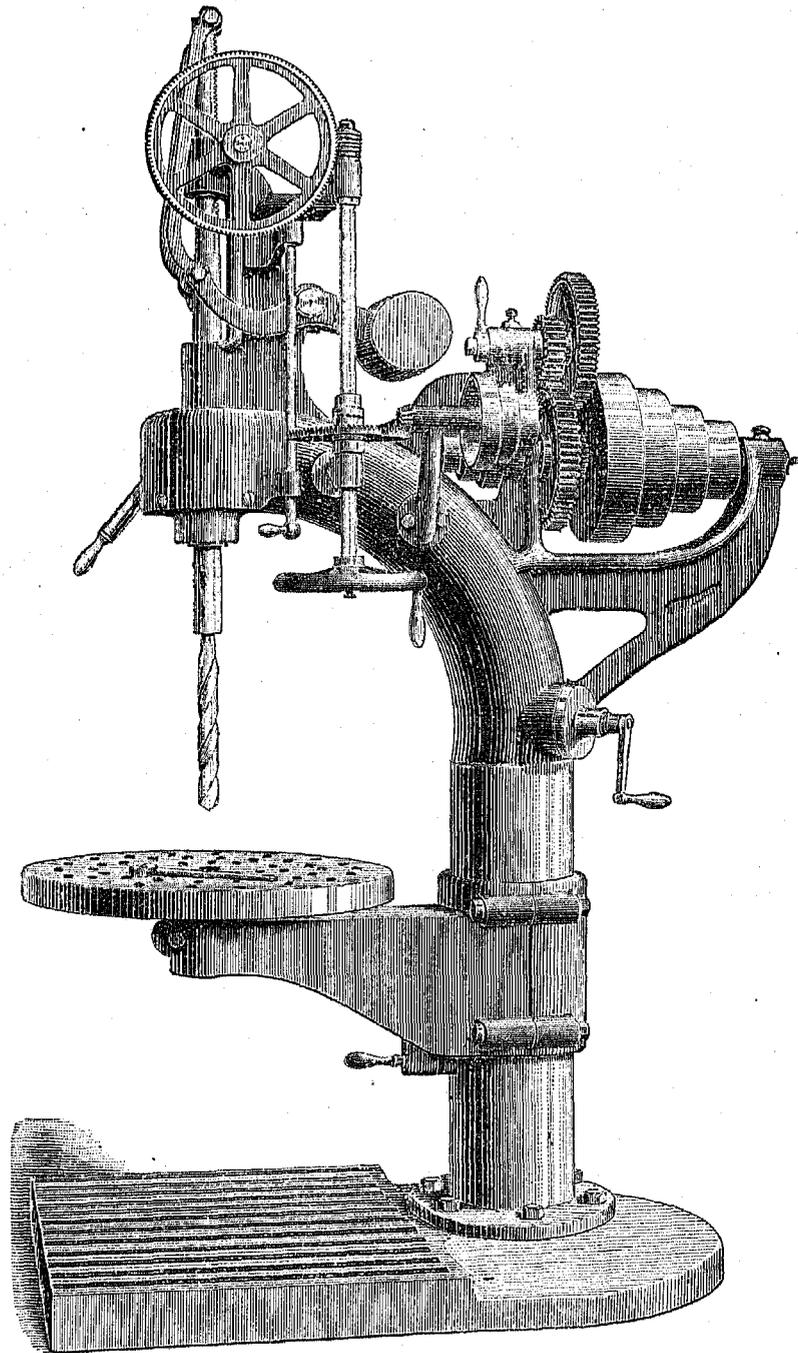


Fig. 172.

changes by a belt cone, the horizontal gear being disengaged for hand-feed by a jaw-clutch. This is lifted by the rod, in the axis of the worm-shaft, by the milled button below.

Fig. 173 illustrates a type of drill in which the spindle may be driven by belt only, when the back-gearing is not required. The belt passes over guide-pulleys, on the back of the square upright. The direct use of a belt gives a smoother running for very small drills. The feed is by a screw of steep pitch engaged by a clutch worked by the latch-lever. The thrust is borne on the very long nut of the feed-screw. The table is gibbed to a flat slide in front of the upright, but by loosening two bolts the table is released and swings to one side. The axis of the swinging of the table is the lifting-screw, which is at the left side, and is turned by power. The power for this motion of