the table is obtained by clutching a horizontal internal shaft with bevel-gears. The clutch is worked by the lever near the base of the upright, and access to the gears is had through the small door. The table has screw traverse in both directions, which is often found a great convenience in miscellaneous or spaced work.

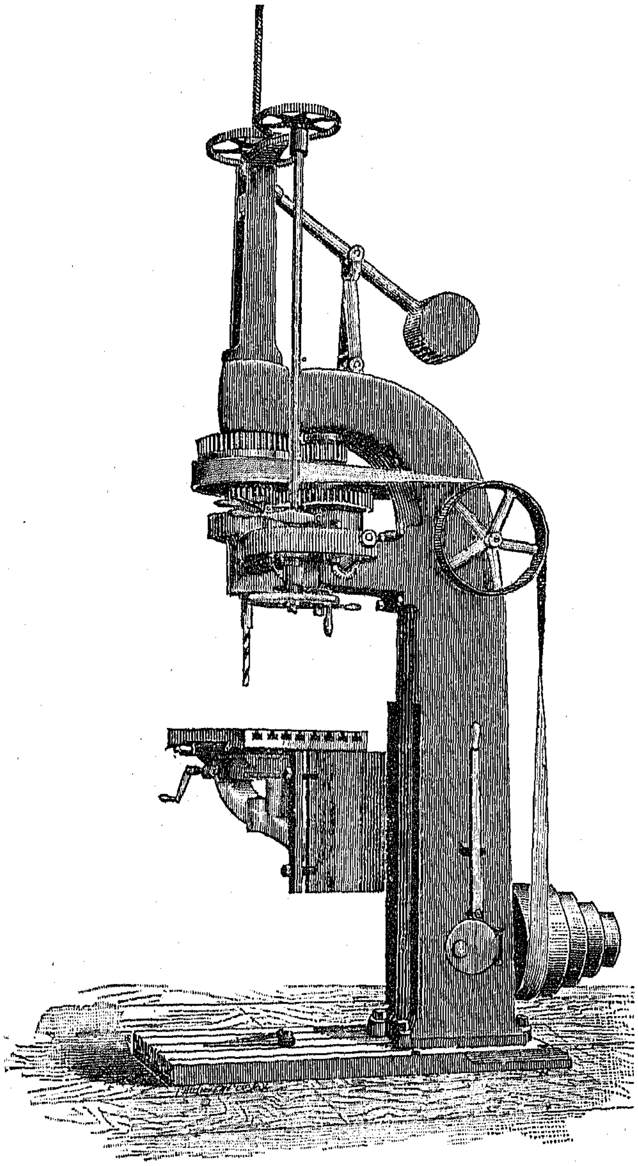

Fig. 173.

§ 22.

RADIAL OR COLUMN DRILLS.

This class includes those in which the carriage bearing the drilling-spindle is adjustable upon a horizontal arm, which swings cranewise around a vertical column. The drill-point can therefore command any point in an annular area, determined by the outer and inner swing of the radial arm around the center of the column. A tool of this sort is especially adapted for heavy work, inasmuch as the drill can be moved to any point of the work more easily than the work can be adjusted under the point of the drill. Moreover, the swinging of the radius permits the drill to command a variety of tables of different levels.

Such a tool is illustrated by Fig. 174. The radius arm is double, to give firm bearing on both sides of it for the spindle-carriage, and has a long internal bearing from the collars upward. The radius is clamped in place by the split in the sleeve at the collars. There is a slotted floor-plate, a tilting-table, adjustable by a screw and clamp, and on a third side may be a pit, if desired, to work on the ends of very long pieces. The tilting-table permits the drilling of angular holes, and is preferred by the builders to the use of an inclined spindle. The tool is driven by a central vertical shaft from a cone-pulley shaft below. A splined shaft takes off the power in any direction from the bevel-gear on the top. The carriage travels over the radius by a rack and pinion from the hand-wheels, and the

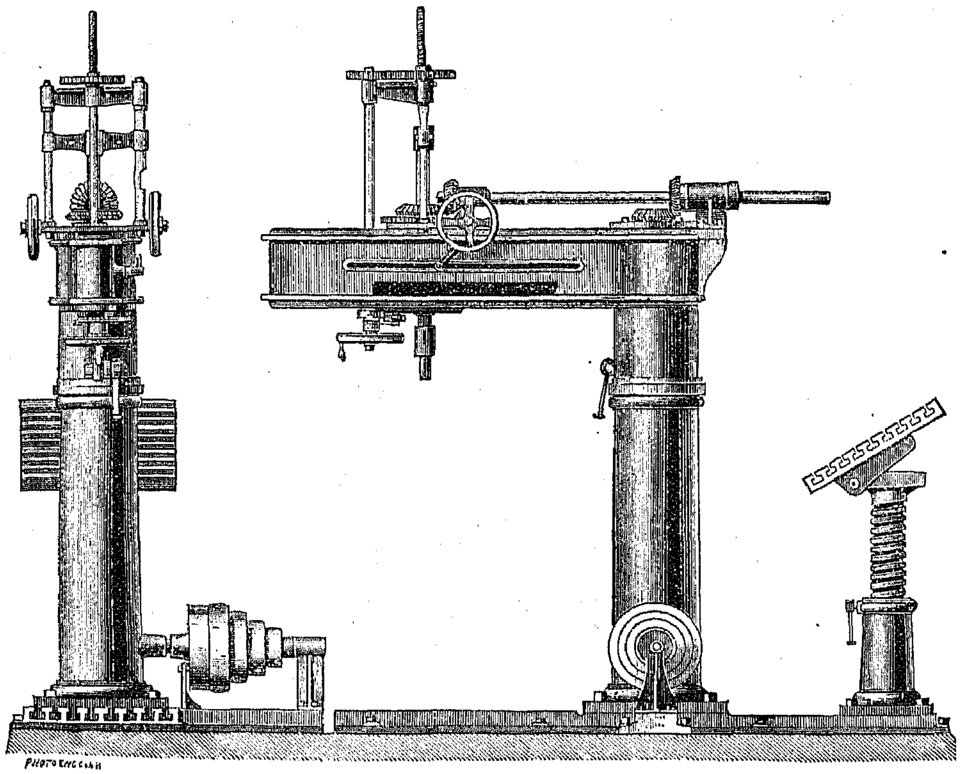

Fig. 174.

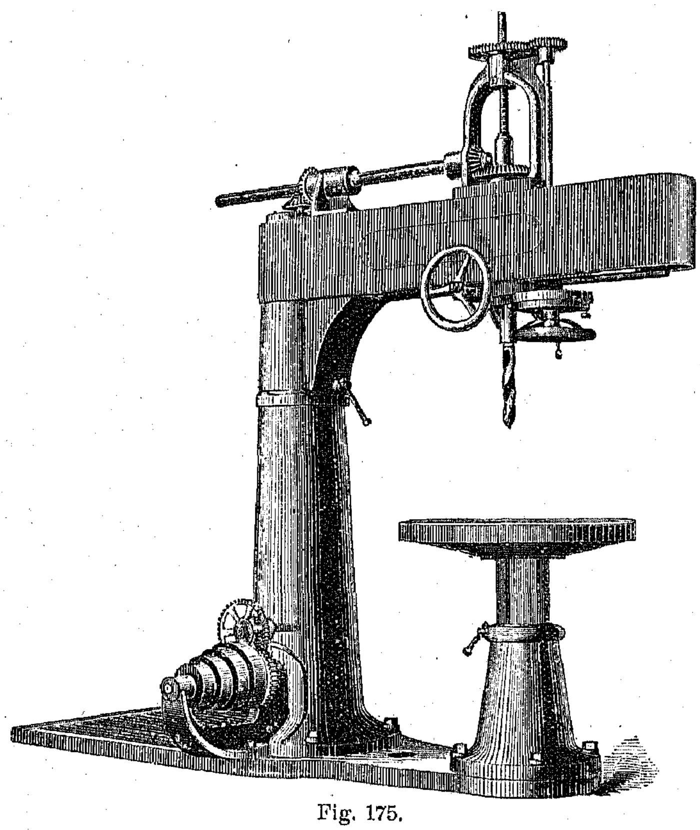

Fig. 175.

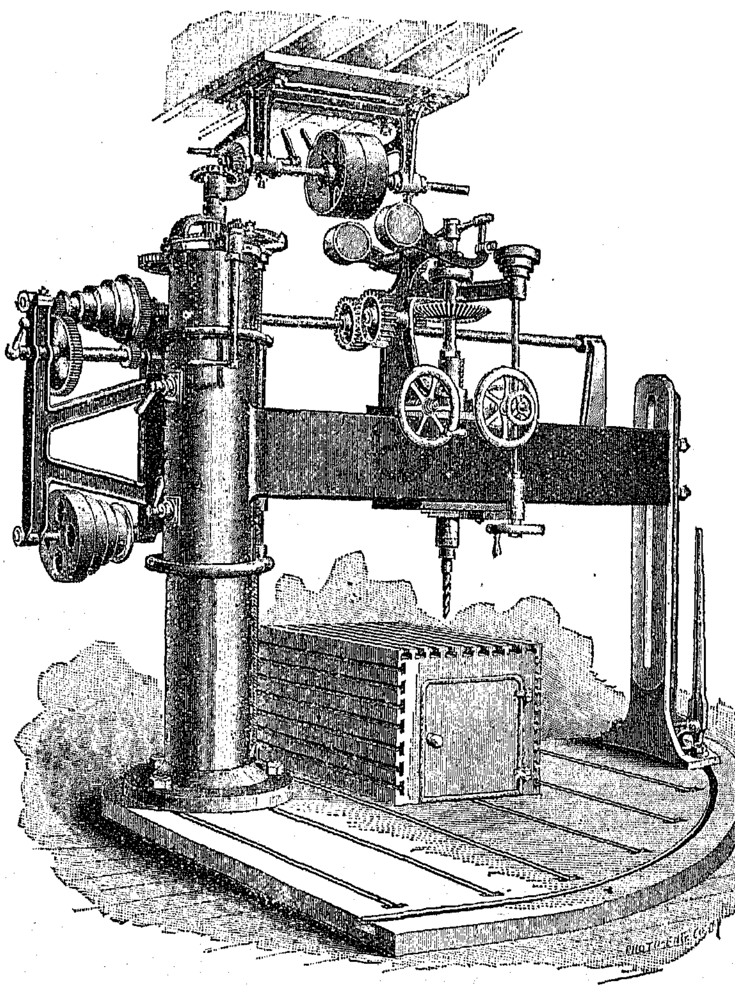

Fig. 176.

tool is fed downward by a screw. The back-gear connection is very compact. Fast to the large pulley of the cone is a small gear. This meshes into a second whose stud is carried by an arm fast to the spindle. This arm is counterpoised on the other side of the spindle, and by this sector the arm can be locked to an internal wheel with which the idle gear is always engaged. When so locked the spindle will turn with the cone. When the internal wheel is locked to the base-plate of the drill and the sector is released, the arm will be carried around as the idle-wheel rolls on the internal wheel, and the speed will be much reduced.

Fig. 175 illustrates a very similar design.

Fig. 176 shows a design intended to increase the vertical capacity of the tool, by making the whole radius move vertically upon the column. This enables the tool to act easily upon very flat, heavy work. The lifting-screw is driven by power from the central shaft, engaged by the lever motion from the handled rod. This tool also avoids a difficulty which results from the overhang of the radius when heavy cuts are made. A slotted post, moving on the arc of the end of the radius, may bolt the latter to the bed, when the tool becomes as rigid as could be desired. The spindle is driven by a pair of gears from the splined shaft, which may be driven directly or double geared. The feed is from cone-pulleys to a worm and wheel, disengaged by friction for hand-feed.

Fig. 177 shows a similar design, where the drilling-spindle is universal, and holes may be drilled at any angle. The spindle is driven from the splined shaft, below the radius, by two pairs of bevel-gears, the axis of the idle pair being in the center of the swivel clamp-plate. The tool is driven directly from a horizontal belt, and the arm is

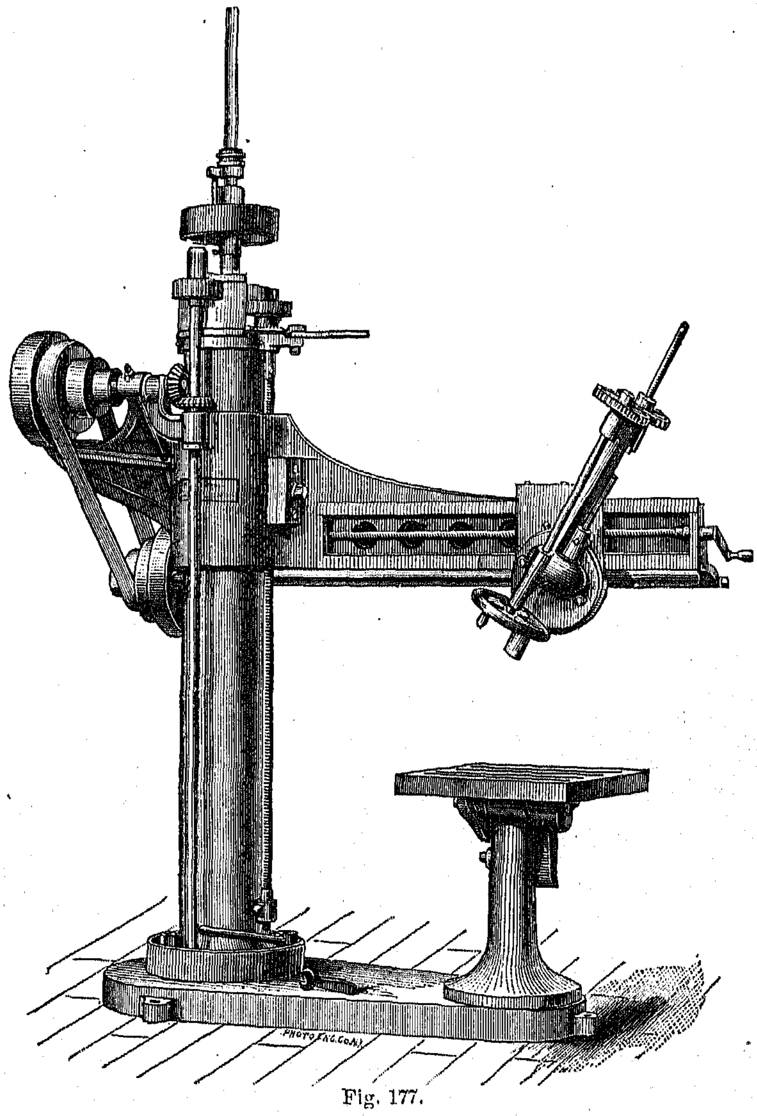

Fig. 177.

raised and lowered by power. In all the tools with this feature the column is a finished shell which turns upon an internal post with a long bearing. The shell is clamped in place by the bolts in the flange at its foot. It will be seen that by the two motions of this tool, a hole may be drilled in any direction and at any angle with the horizontal plane. The radius can bring the spindle into any vertical plane, and the swivel-plate permits the drill to be presented at any angle in that plane. Horizontal holes can be drilled in work of any length, the work lying on the floor or on trestles. Holes may be bored in erected locomotive-frames by using a long false socket.

Fig. 178 shows the spindle mechanism of Fig. 172 applied to a radial drill, and Fig. 179 shows a universal drill by the same builders. The radius slides on a faced slide, and the shell of the upright need not be finished all over. The raising and lowering is by power, the gears being engaged by the handled lever on the upright. The feed is by a screw, and may be made automatic with three changes, also as well as by hand.

Fig. 180 illustrates a belt-driven radial drill. The arm swings cranewise around a splined shaft through a little more than 180°. The guiding-slide is made very long for stiffness, so long as to need no clamping in place

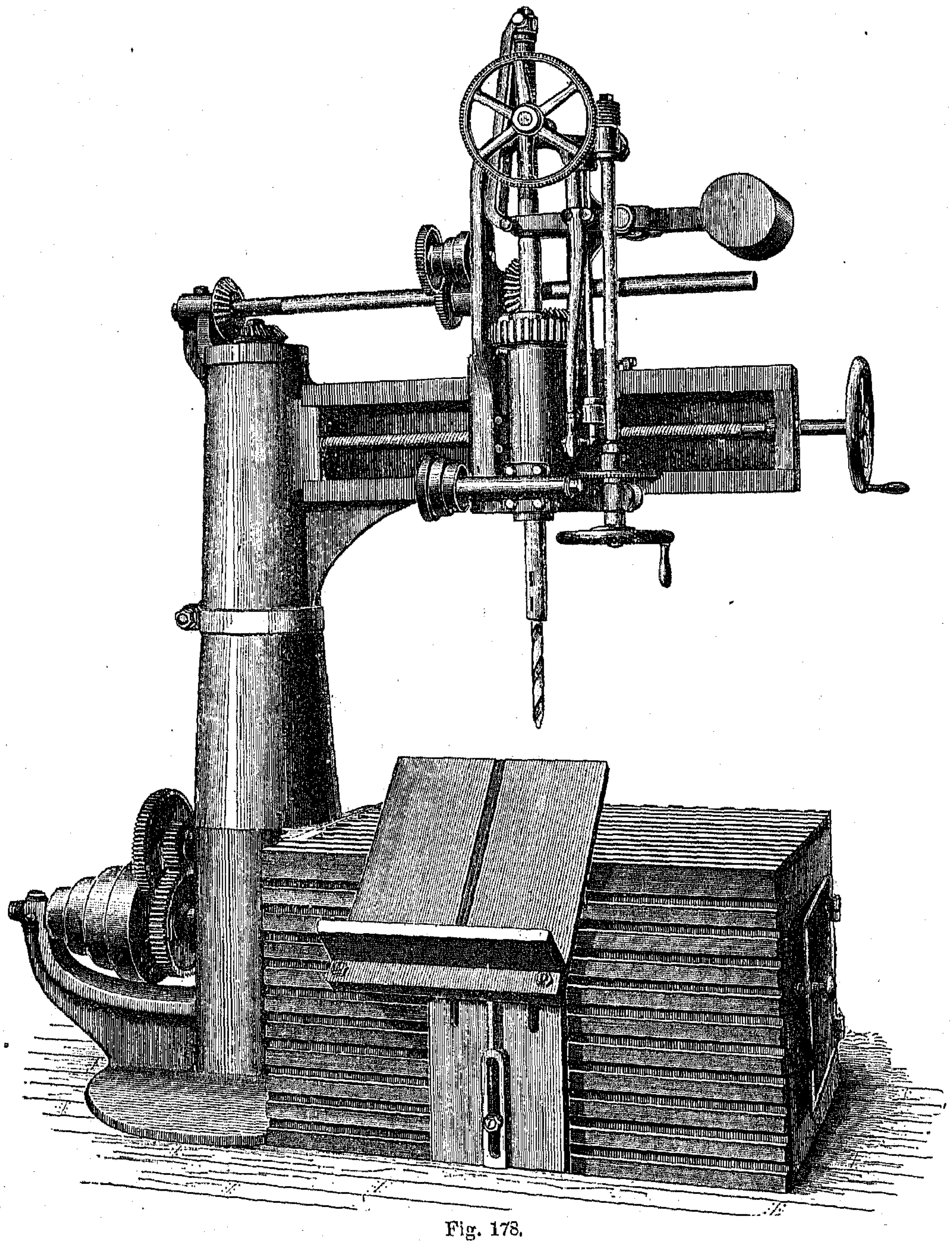

Fig. 178.

under a heavy cut. The arm is raised and lowered by power from the lower shaft. The feed is by a screw-gear, and the carriage traverses by a worm on a diagonal shaft taking into a rack. This cut and several of the others illustrate a form of table which has many advantages. Work may be secured to either top or side, and the interior may be used as a tool-closet.

Fig. 181 illustrated a similar adjustable double-faced table for a vertical radial drill. The spindle is carried at the lower end in a bearing on a slide, which is guided and receives the downward feed. The spindle itself, therefore, does not overhang its supports so far when fed out. The feed is by cone-pulleys from the spindle, with an axial spline device for altering or disengaging the power-feed. This has been utilized in an appliance for gauging

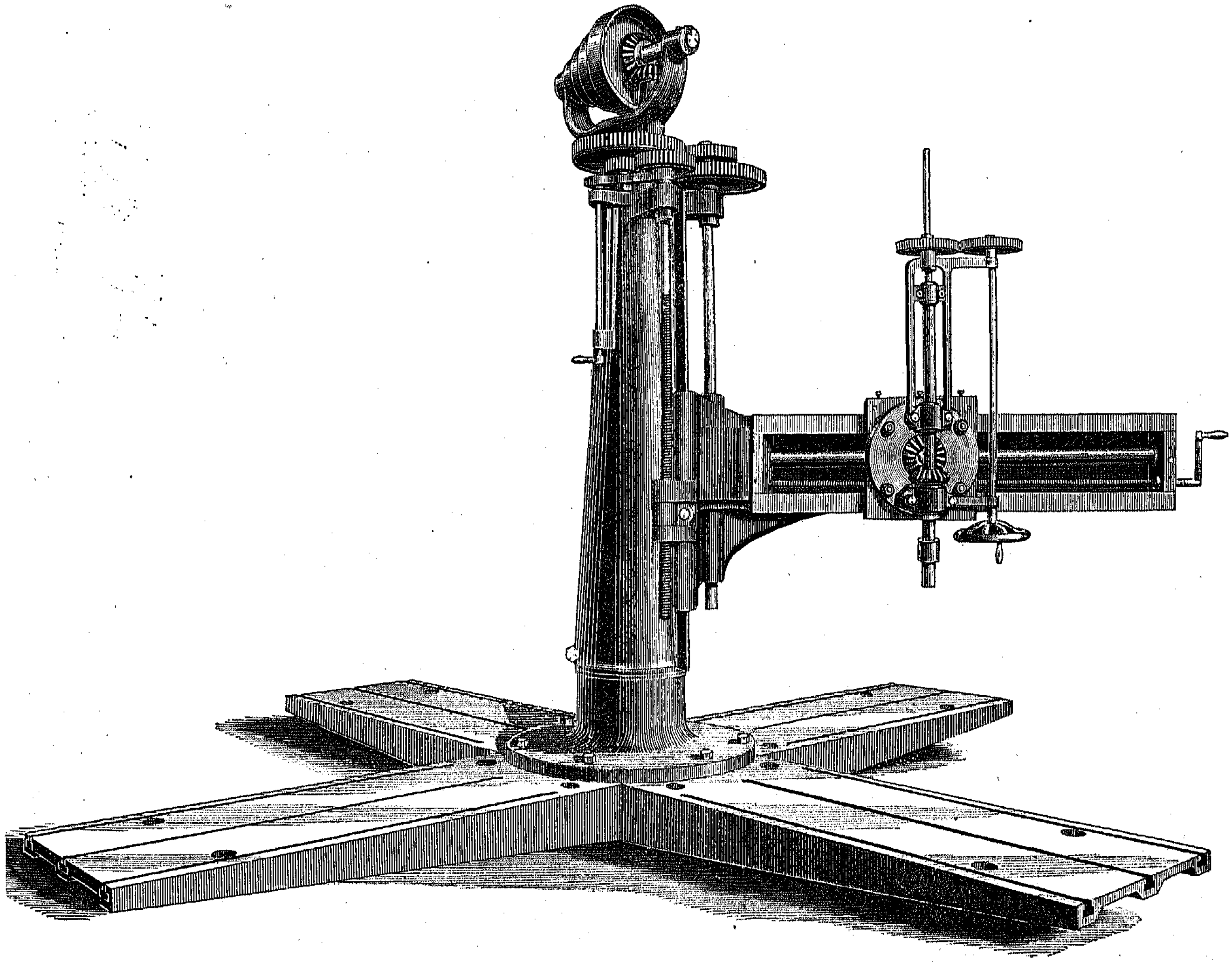

Fig. 179.

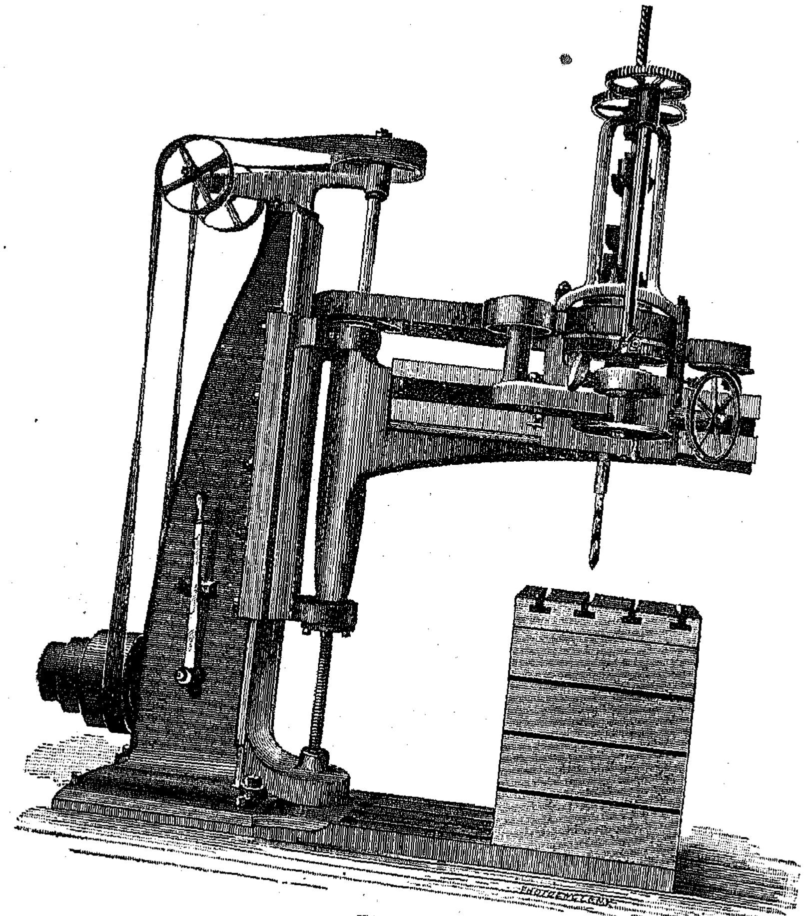

Fig. 180.

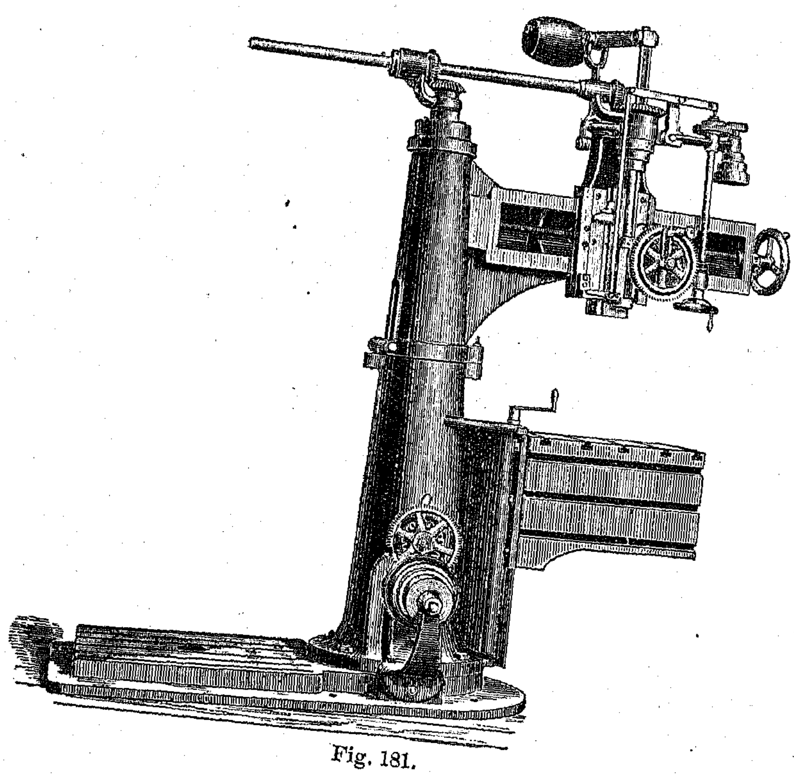

Fig. 181.

and tripping the feed for holes of uniform depth. The spline-rod is attached to a horizontal lever. A dog on the slide strikes a tripping-lever and disengages the feed-spline when the depth has been reached for which it was set. The hand-feed is engaged with the power worm-wheel by an annular friction-clutch.

Fig. 182 illustrates an improved universal radial drill, where all the motions are by power. The crane may revolve around the stump and rise and fall, and the feeds are by power. The jib may also turn around its own axis for oblique work, and the spindle may swivel to any angle. The engagement of the power motions is by hollow shafts and splines.

Belonging to the class of radial drills is the portable drill illustrated by Fig. 183. A short hollow post carries the column of the drill, which can thereby swivel to any radius by worm-wheel and tangent-screw. A long slide feeds the point of the drill in and out on the radius. The spindle-frame is held in a spherical clamp on a ball surface, by which the spindle can be set to drill at any angle up to 30° in any plane. A second sleeve,

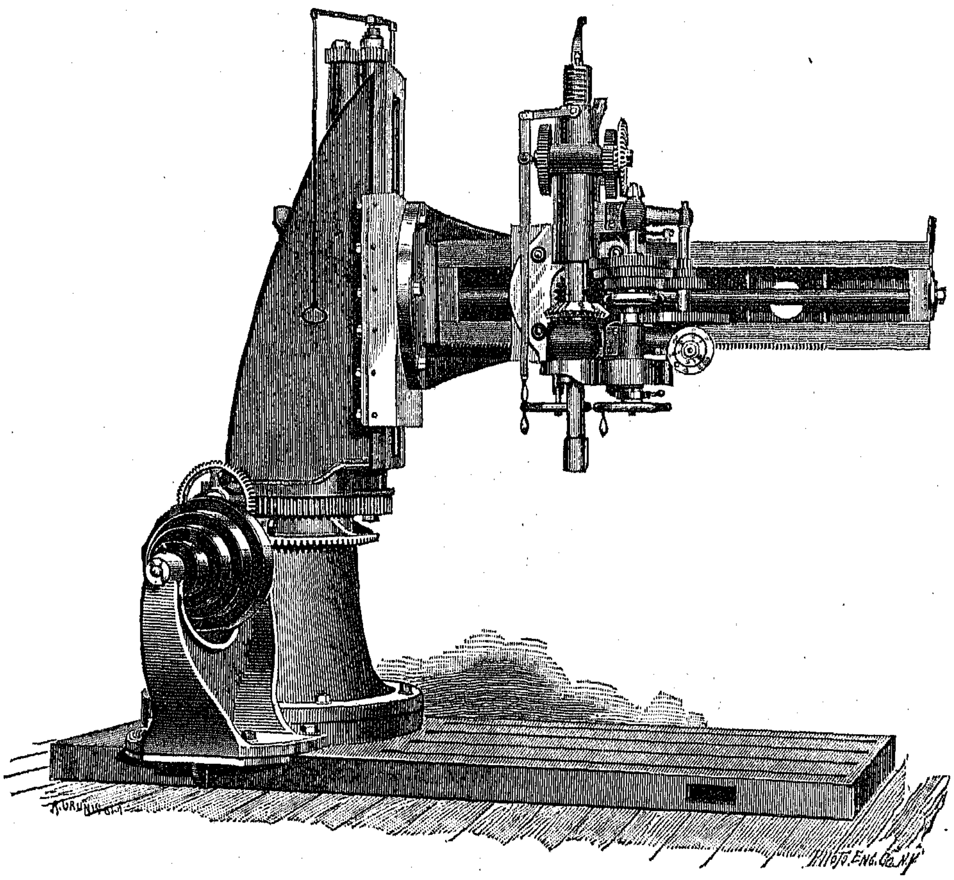

Fig. 182.

on the hollow post, will take the short column horizontally and give the same latitude of motions from horizontal plane. Power is transmitted to a cone of grooved pulleys by a round rope of Italian hemp, which passes over a guide-pulley at the counter-shaft and under another which is free and weighted to maintain the tension on the rope. The overhead guide-pulley is swiveled so that its periphery is always in the plane through the center of the driver in whatever direction the drill may be or at whatever angle. The entire adjustability of the drill in any position over a large area to drill at nearly any angle peculiarly fits this tool for erecting large work. The drill can more easily be brought to the work than the work can be presented to the drill. Of a very similar type of construction are the drills and boring-machines intended for the erecting shop, which are driven from counter-shafts upon the walls of the shop through rods with universal joints. A universal joint at the counter-shaft and another at the tool are connected together by telescopic shafts made of gas-pipe, with collars and set-screws. The two joints neutralize each other's irregularity. Even better than this is the similar use of flexible shafting. Coils of wire wound alternately into spirals, right-handed and left-handed, will transmit the power from a counter-shaft at any angle, and the necessity for supporting the shaft is entirely avoided. This must be done with the telescopic jointed system.

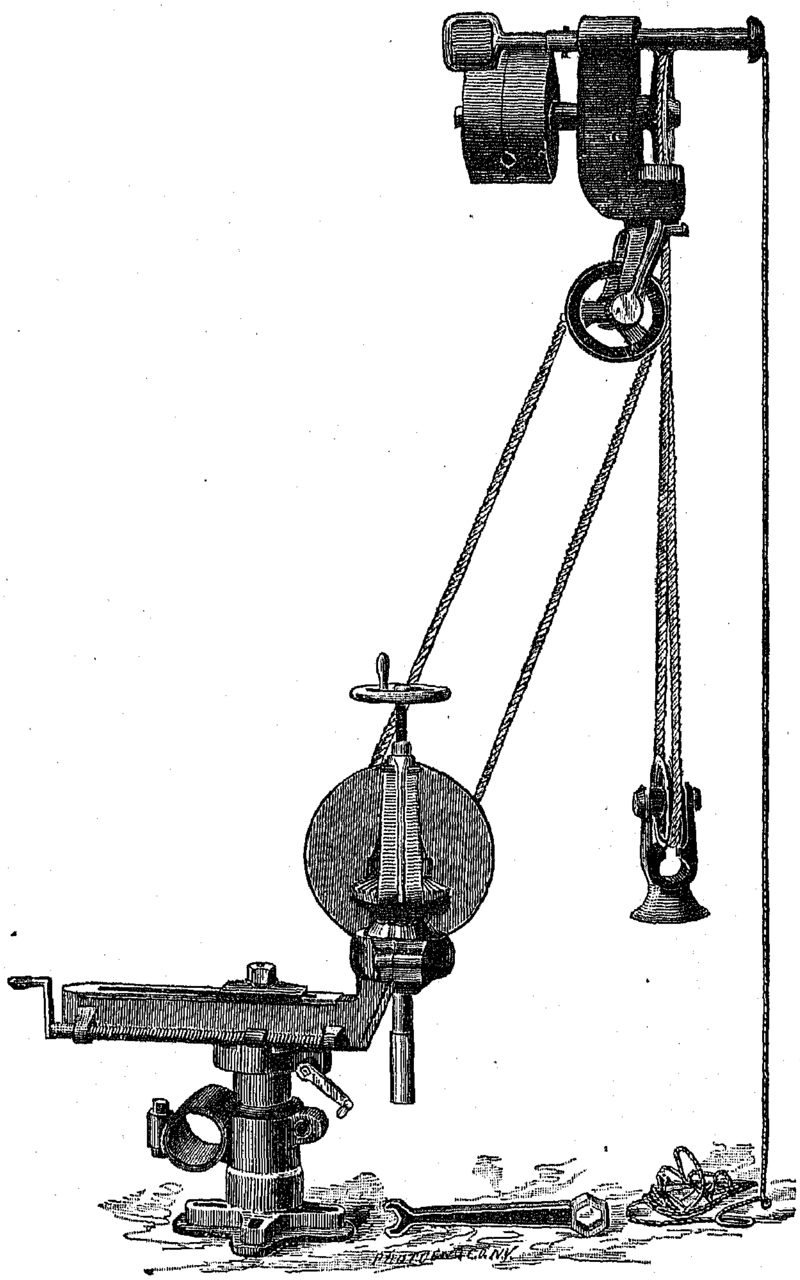

Fig. 183.

§ 23.

SPECIAL FORMS.

Fig. 184 illustrates a form of drill especially designed for drilling and boring the holes for the pins in the eyes of bridge-links. To insure accuracy in length it is wise to bore both holes at once, so that all may be alike. The heads slide upon a bed, and are arranged right and left. The links enter under one head and pass out through the other. Horizontal driving-belts pass from the drums over guide-pulleys to the driving-shaft. When the two heads are upon a wrought-iron screw for adjustment in length of the links, any changes of temperature will affect the link and screw equally, and the heads will slide on the cast iron to keep the lengths of all links the same. In other forms of this tool the spindles are carried on a cross-rail, receiving separate motion and feed from splined shafts geared to cone-pulleys. A primary advantage of this double system is that, by holding the work between centers, two holes may be drilled exactly parallel to each other and perpendicular to the axis of the work; or by putting bushings in the table, such a machine may be used for parallel boring, as in finishing the brasses of connecting-rods when keyed up in the stub.

C.—TOOLS ACTING BY PARING.

Fig. 185 shows a machine for drilling the holes for crank-pins in the driving-wheels of locomotive engines. These holes need to be on radii at exactly 90° on the two sides. While the wheels are held by shoes upon their

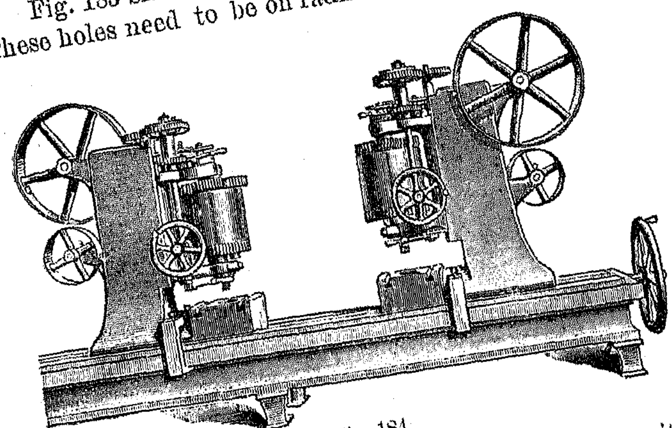

Fig. 184.

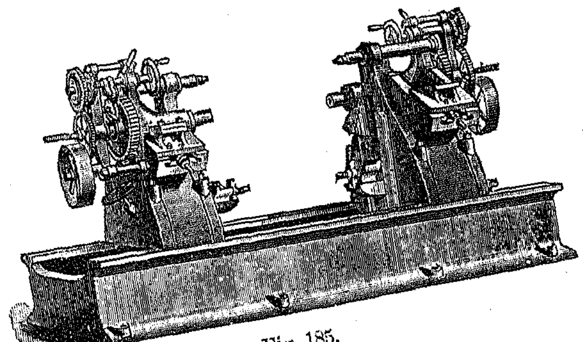

Fig. 185.

tread, and so adjusted as to bring the axle in line with the centers of the machine, the two drilling-spindles move on ways which are in planes at right angles to each other, and can be set for any radius of crank from 5 to 13 inches. The feed of the spindle is automatic, and variable within wide limits.

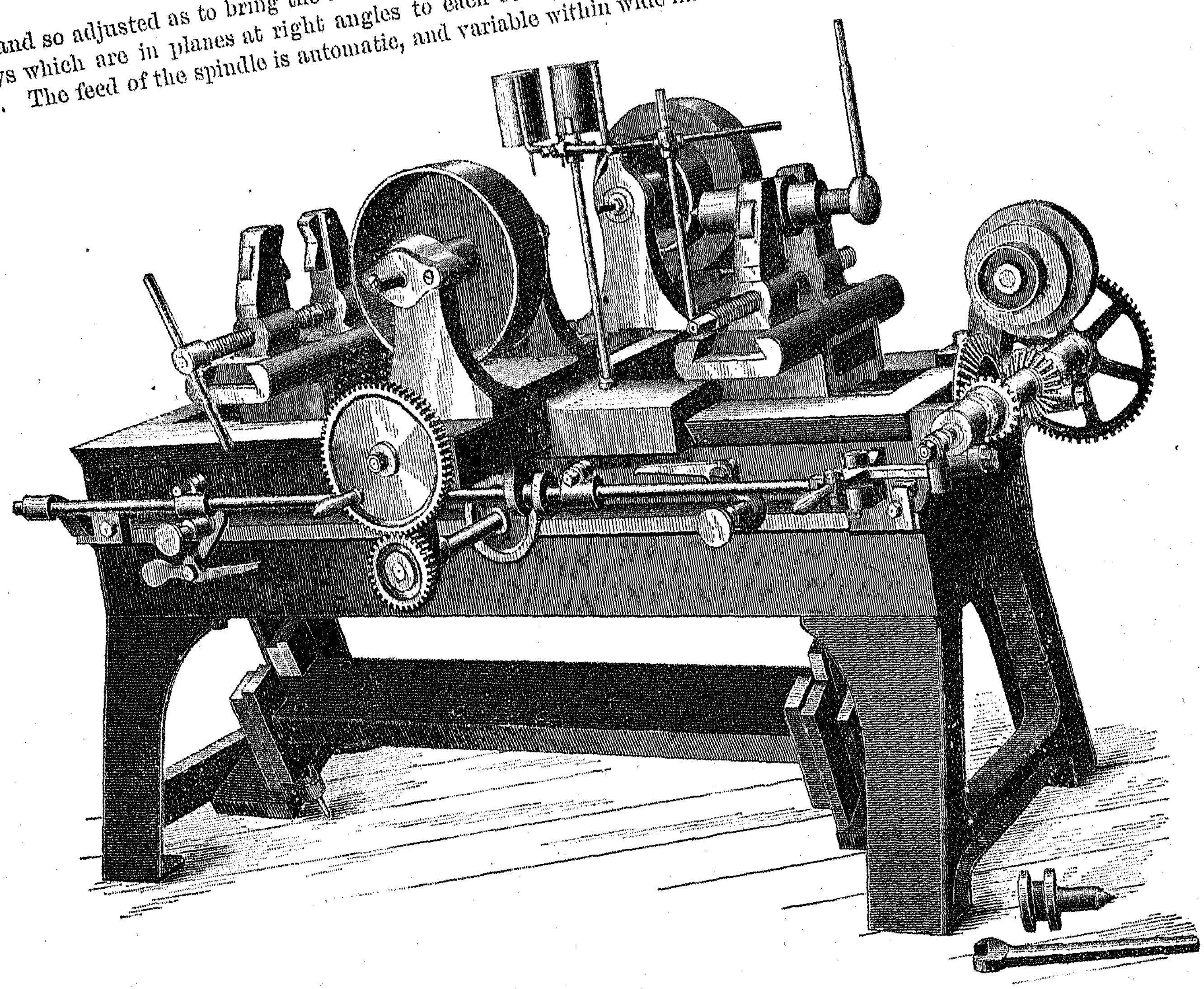

Fig. 186.

Fig. 186 shows a machine for drilling and mortising the seats for keys and cotters. Each drill has a longitudinal traverse of 36 inches and a transverse adjustment and feed of 10 inches. The feed is self-operating in all directions, self-reversing by the clutch and bevel-gears on the shaft at the right head, and the depth of the slot may be limited by a stop. The jaws are self-centering by right-and-left screw, and have capacity for a 7-inch shaft.

Fig. 187 shows a machine specially adapted for drilling the holes for the set-screws of pulleys without piercing the face. The drill is driven by a train of gears incased in the projecting arm, and the pulley is held upon the adjustable mandrel below. The machine has a capacity for pulleys from 56 inches in diameter down to 12 inches, and can also be used to tap the holes for the screws. The different speeds for drilling and tapping are obtained by the two belt-pulleys, and the motion of the tap is reversed by the clutch-lever in the head.

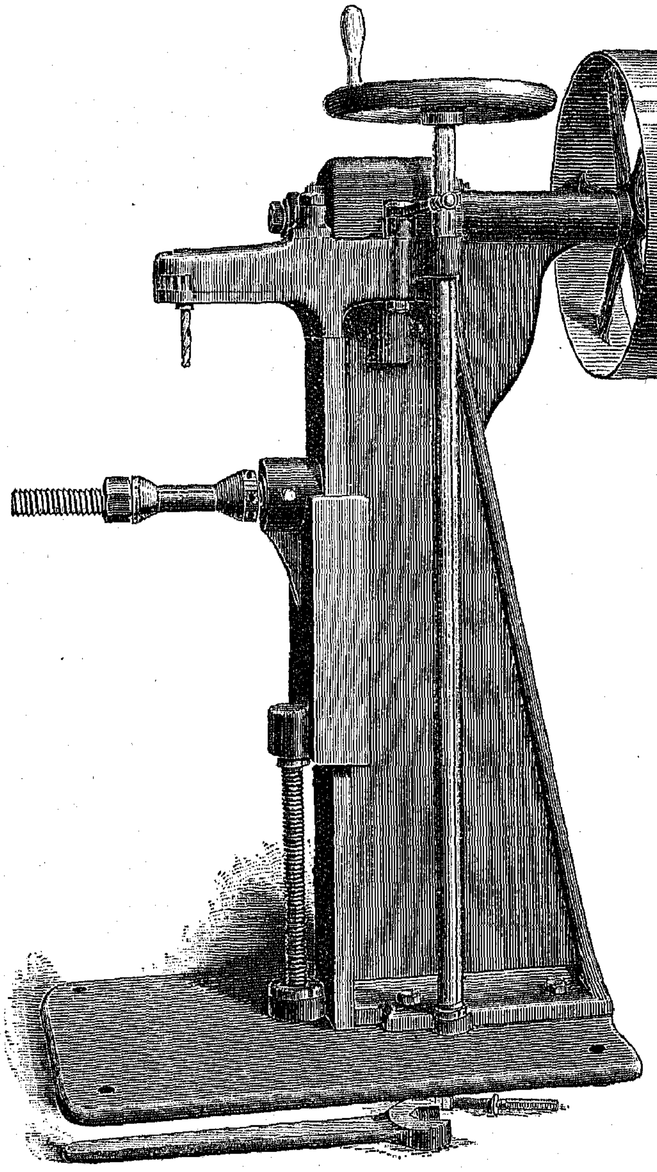

Fig. 187.

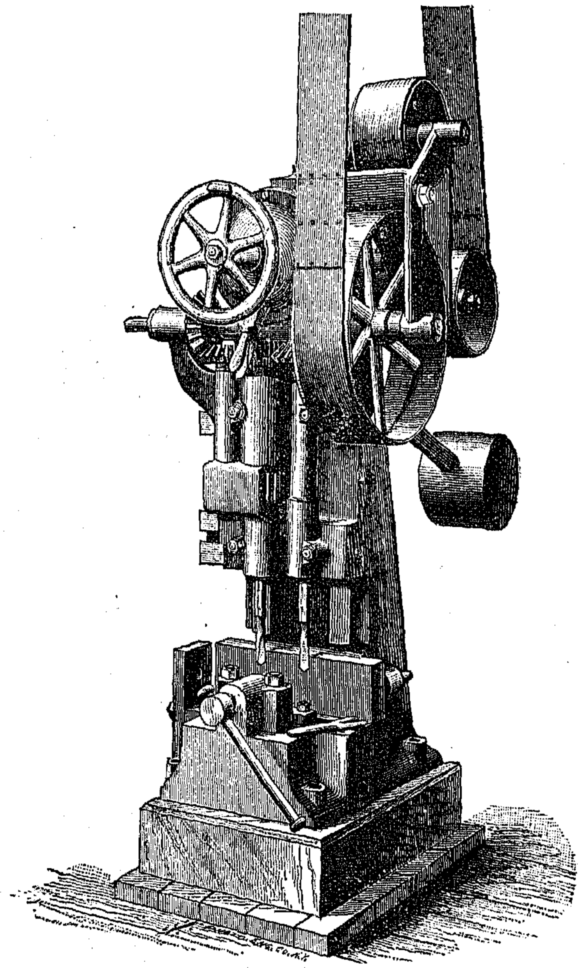

Fig. 188.

Fig. 188 shows a drill for the ends of steel rails, that the bolts for the fish-plates may pass through the web. The drills are fed down by a power-feed, positive and unvariable, the return being rapid by hand. The slide is counter-weighted, and the slack of belts is taken up by an idle-shaft linked to the driving-shaft. The rail is clamped in a vise upon the bed of the tool. These tools attain a rapid cut by high speed and fine feed. They are usually used in pairs, one at each end of the rail.

For drilling a number of holes at exact distances apart great economy of time results from the use of multiple drills. Fig. 189 shows a gang of four. The spindles are driven from a splined shaft, and can be adjusted to any distance apart greater than 7½ inches. The spindles are self-feeding and counter-weighted, and may be readily changed in relative height to suit drills of unequal lengths. The saddle which carries the drills is adjustable by rack and pinion on a cross-slide, which is long enough for sheets of 8 feet in width. The table is stationary, and the spindles are fed down by double worm-gear.

In the machine of Fig. 190 the spindles are six in number, and have no vertical feed. The machine is designed for truck-frames, and the spindles are made extensible by socket-arbors secured into the sleeve of the spindle by set-screws. The table is fed against the drills by a pair of cams driven by the worm-wheel at the right, so that the

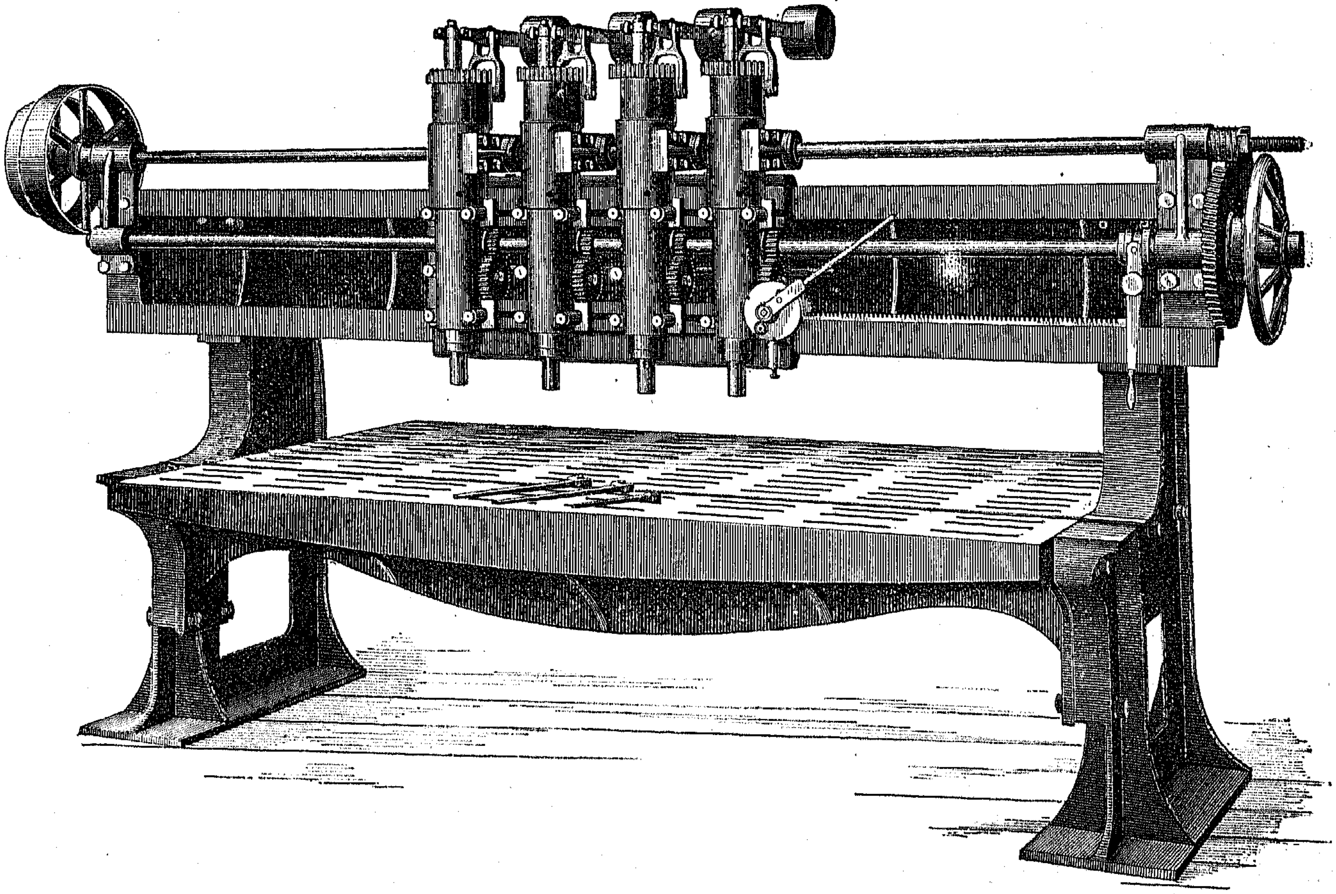

Fig. 189.

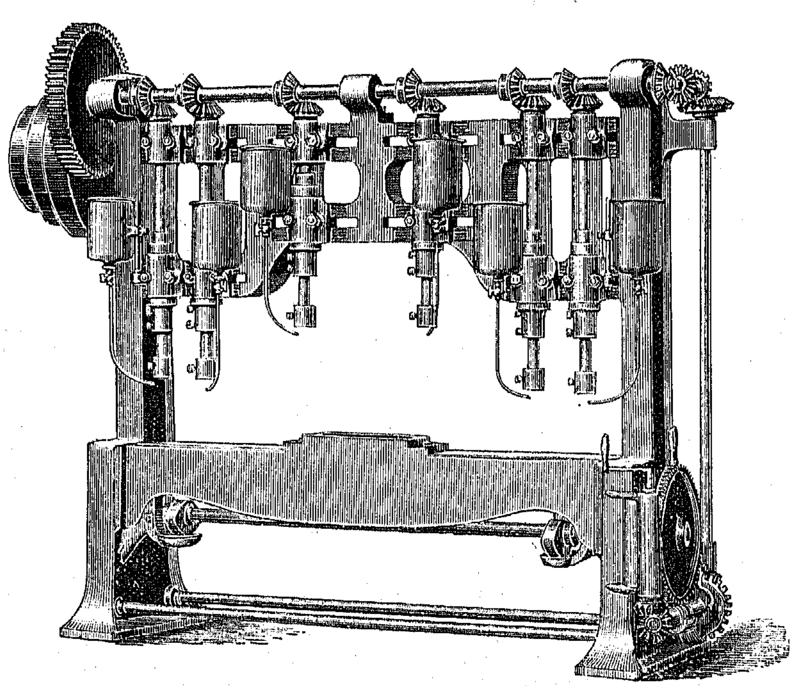

Fig. 190.

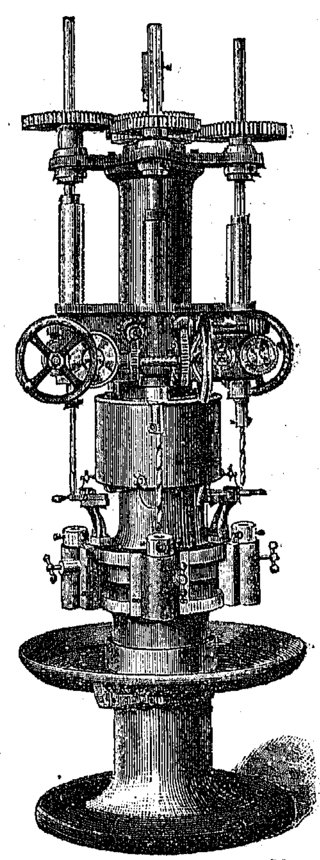

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Fig. 191.

feed and return motions are automatic. Sometimes the spindles are driven by a many-threaded screw of steep pitch, meshing into a helical gear on the spindle. This permits the spindles to be brought very close together. On account of friction, this helical system only works well against small resistances.

For a different class of work, where the holes are to be drilled deep in small work, the type of gang-drill shown in Fig. 191 is approved. It will carry a starting-drill, a through-drill, an enlarging-drill, and a reamer, or four pieces of work may have the same operation performed on them at once. The feed is automatic, and one operator can attend to several machines.

Figs. 192 and 193 show the belted gang-drill in two forms. The pulleys on the spindles may be of different

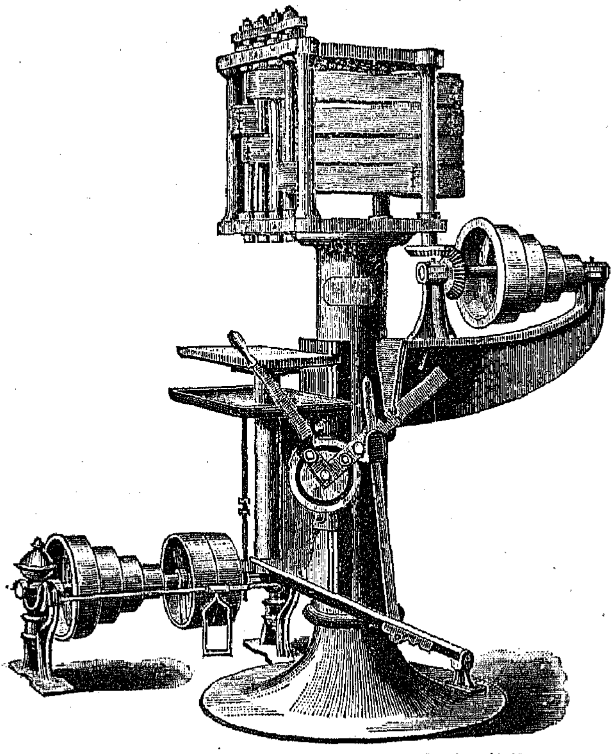

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Fig. 192.

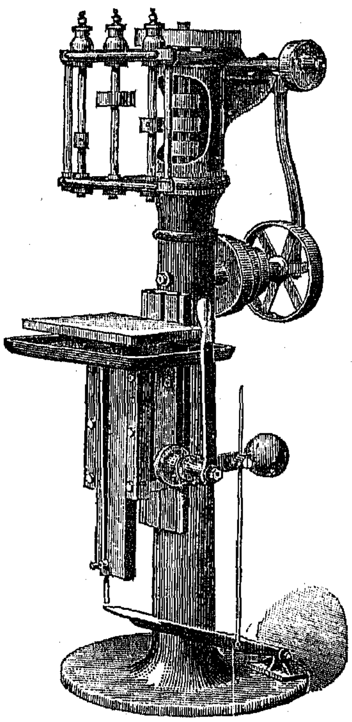

Fig. 193.

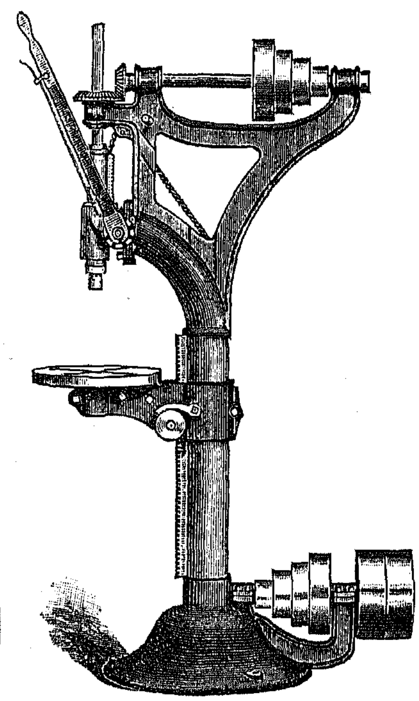

Fig. 194.

diameters if for different duties. The work is lifted against the drill by treadle or by hand-lever. The wear of the spindles is compensated for by take-up devices in the boxes, and the trouble caused by expansion of the spindles is avoided. The belts are made as long as possible.

Fig. 194 shows a type of drill approved for light work at high speeds. It makes a cheap design for a large class of manufactured articles.

Fig. 195 shows a tool for similar work arranged to have the work lift against the drill, which is belt-driven, and there is a stop device by nuts on a screw to gauge uniform depths.

Figs. 196 *a* and 196 *b* show a tool which has been approved in railroad and boiler shops on account of its limitless swing. The tool is called a suspension-drill, and is hung by the ring from the ceiling. Sometimes it is arranged so that the ring is on a carriage, which may traverse in two directions at right angles, making the adjustment of the drill-point more easy to the marks of the punch.

Fig. 197 shows a combination tool, drill, and slotter, which has found its use in certain shops. The slotter is disengaged by adjusting the wrist-pin into the center of motion and clamping the slide. The drill is fed by a screw from a worm on the spindle. It is disengaged by lifting the horizontal bevel-wheel out of gear by a milled head in the bracket.

Fig. 198 shows a special machine for drilling and countersinking centers for lathe work. The work is held by a scroll-chuck whose center coincides with that of the drill. The latter is fed forward by the ball-handle. Fig. 199 shows a similar tool, arranged vertically.

In all the tools which belong to this class of drills the workmanship in standard practice is of the best. The spindles are of hammered steel, the gears are cut, the important guiding surfaces are scraped to true planes. In the lower end of the spindle is made a taper socket, in which may be fitted a boring-bar or a secondary socket for drills. The sockets are most of them made with the Morse taper of $\frac{5}{8}$ of an inch to the foot. This is apparently displacing the so-called American taper of $\frac{9}{16}$ of an inch to the foot. At the top of the socket a slot is cut through the spindle, in order that a taper flat key driven through the slot may force out the drill without marring either spindle or drill, and the end of the drill taper is so milled as to prevent the drill from turning in the socket, and yet it is certain to "center" as the two conical surfaces come together. The old collet and set-screw is rapidly disappearing.

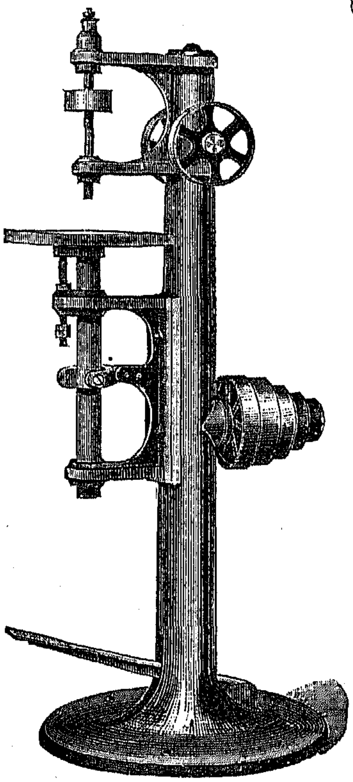

Fig. 195.

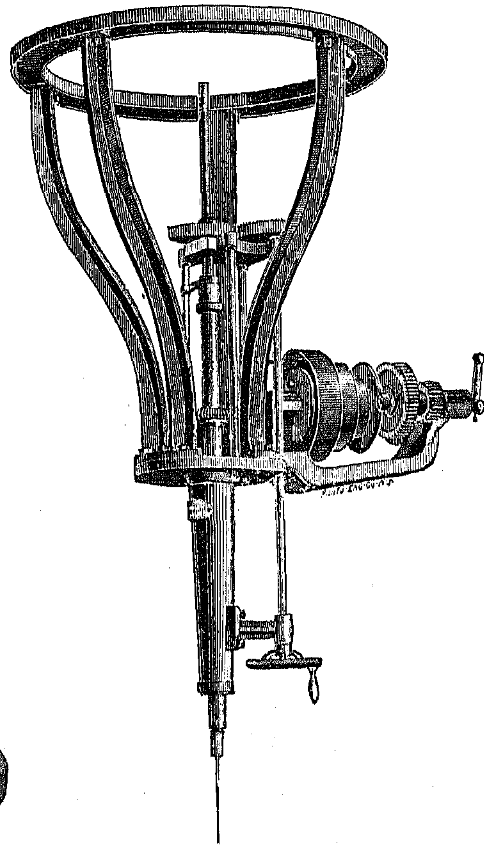

Fig. 196 *a*.

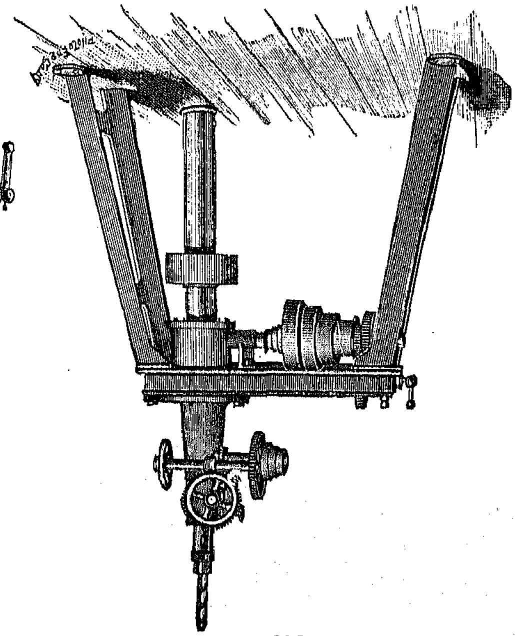

Fig 196 *b*.

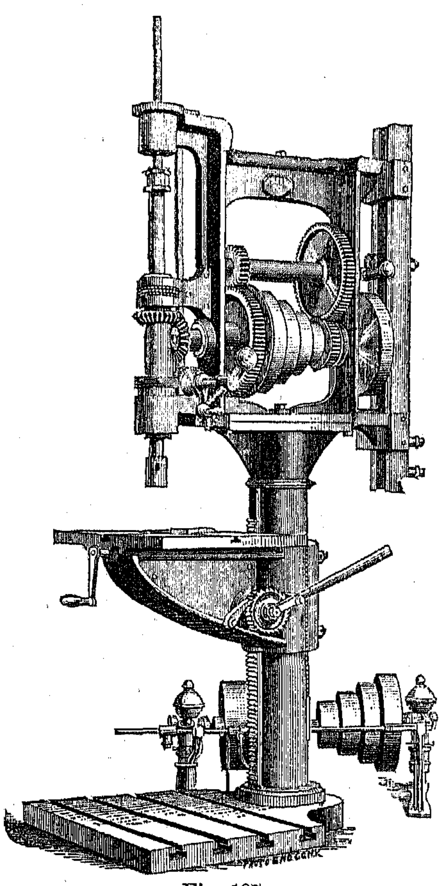

Fig. 197.

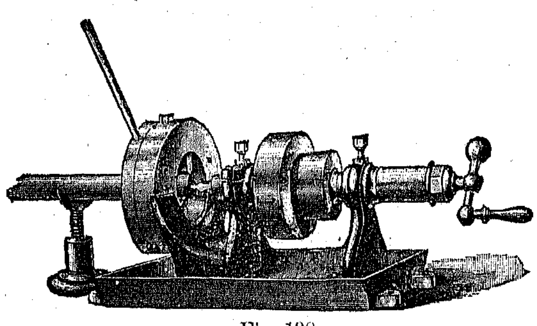

Fig. 198.

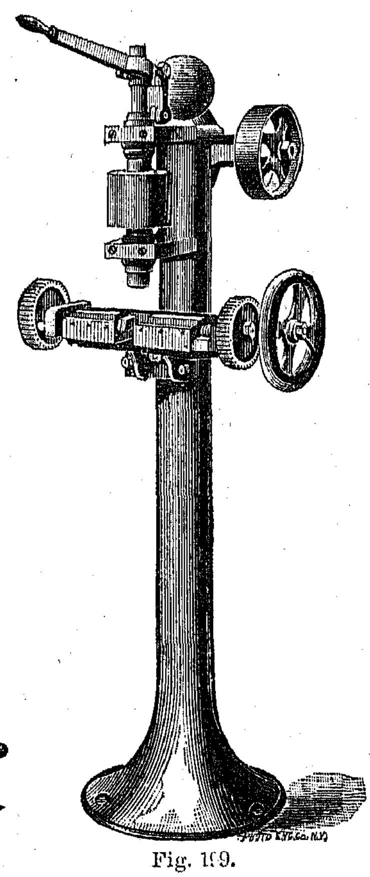

Fig. 199.

§ 24.

BOLT-CUTTERS.

These tools for producing the screws on bolts might come perhaps under the head of the lathes. They have become, however, of so much importance as to be separate machines, and to form a class by themselves. They belong to two classes. The first includes those in which the work is held stationary and the dies revolve. The second class includes those in which the work revolves, while the dies are held stationary. Advanced practice rather favors the first class. The bolt-cutters may be again subdivided into the fixed die-machines which must be reversed to release the work, and the movable die-machines wherein the bolt is released by the opening of the dies, so that the machine need not be stopped. The latter system is preferred because the integrity of the thread is not endangered by running the die backward over the thread. Any chip from the cut getting into the relief of the die may tear away or mar several threads. The movable die system is also more rapid.

There are differences with respect to the number of chasers, and the position of the cutting-points upon the

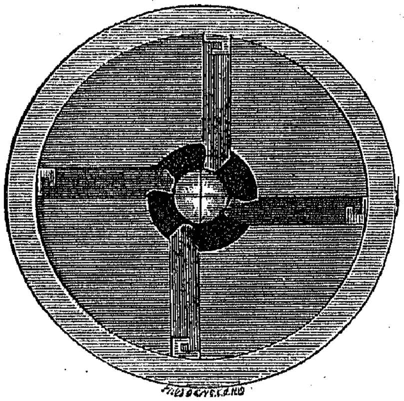

Fig. 200.

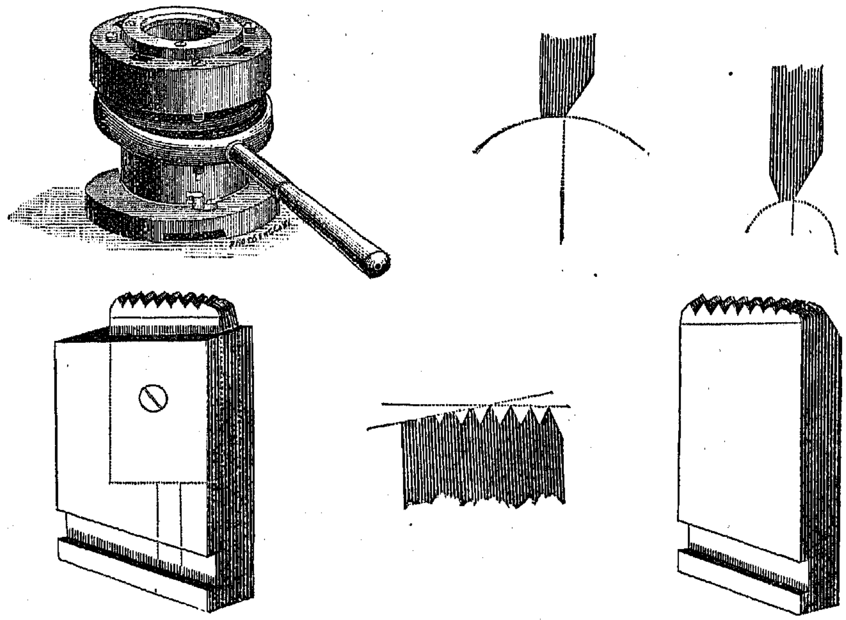

Fig. 201.

bolt. Prevalent practice prefers four cutters, although three are approved in some quarters. Against the three jaws it is urged that the rod is never cylindrical, and that when the long diameter is on any one cutter, the other two are resisting near the short diameter. This permits the stock to recede from the one cutter, and the thread will be uneven and the nuts will bind.

With respect to the position of the cutting-edge, the analogy of lathe practice has induced the system of Fig. 200. The cutting takes place at the ends of what corresponds to the horizontal diameter of a cylinder in the lathe. It is claimed, however, that when the cutter "leads" or cuts above the center the thread will be smoother than in the other case. On account of the play for adjustment of the jaws, a jaw nominally on the center line will often be really making a scraping cut below it. When this scraping occurs the edges tear the stock, instead of making a clean cut. Several good authorities, however, put the die on the center line, and nearly all favor the exact center for solid heads on account of lessened friction. When the dies are on the center line, the cutting or "hobbing" of the dies

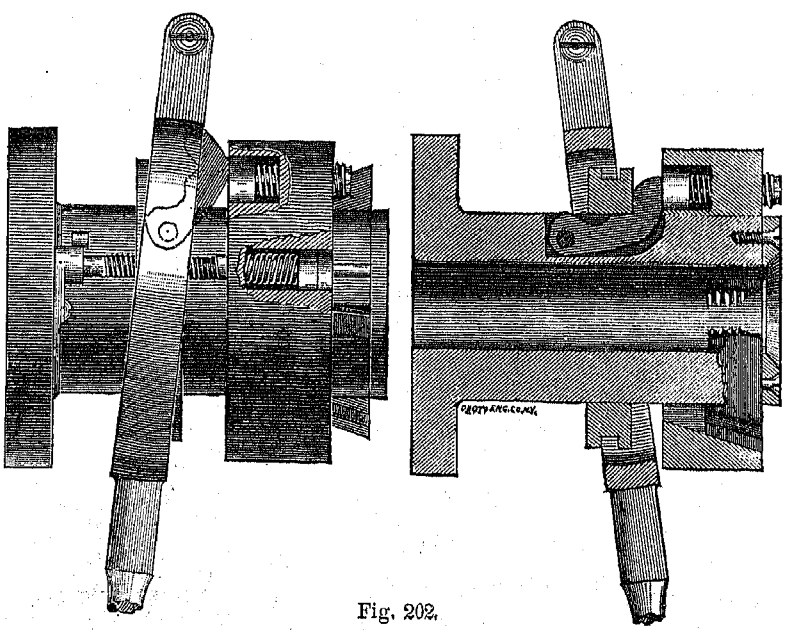

Fig. 202.

is done by a master-tap larger in diameter than the size called for, to secure the necessary relief at the heels of the cutters. When the cutters lead the center a smaller tap is necessary for the same purpose. The adjustable heads make this variation in size very easy while being cut.

Fig. 201 shows the hand-relief given to the tap, to give only the required amount of cutting-face, and also the relief for the entrance of the blank. The length of the cutting-face will vary with the speed and the severity of the work of the cutters. The same figure shows a case-die, in which the die proper is held in a holder. After being properly shaped the cutters are hardened, the threads being coated with soap to prevent scaling. The temper is drawn to a medium straw color, and the quenching is done in linseed oil or in water. The oil is thought to toughen the steel. While domestic steel has given results fully equal to those of imported grades, the tool-makers complain of the lack of uniformity and reliability which they encounter in its use. On this account only the imported product is preferred to the American at this date.

Fig. 202 illustrates one of the types of adjustable head in very general use. The dies fit in rectangular slots, by which radial motion alone is permitted. The dies have an oblique gain or mortise on one side, which fits a corresponding tenon in the external chucking-ring. When, therefore, the ring is moved forward the dies will close inward. When it is moved backward, the dies will open and release the bolt. The position of the heavy ring, and therefore the size of the thread cut, is determined by a small latch, which is held and released by the grooved ring pinned to the lever. This latch abuts against a screw in the heavy tenon-ring, which may be set at pleasure. The head is retracted by the long screws which pass through the tenon and grooved ring, thus uniting them together. The end of the long screw abuts against a stop, to prevent the rings from coming back too far. When this stop is swung out of the way, the dies are released, and can be exchanged for others. The shifting of the lever can be made automatic, so that the dies may be released when any desired depth of thread is reached. The entire machine is shown by Fig. 203.

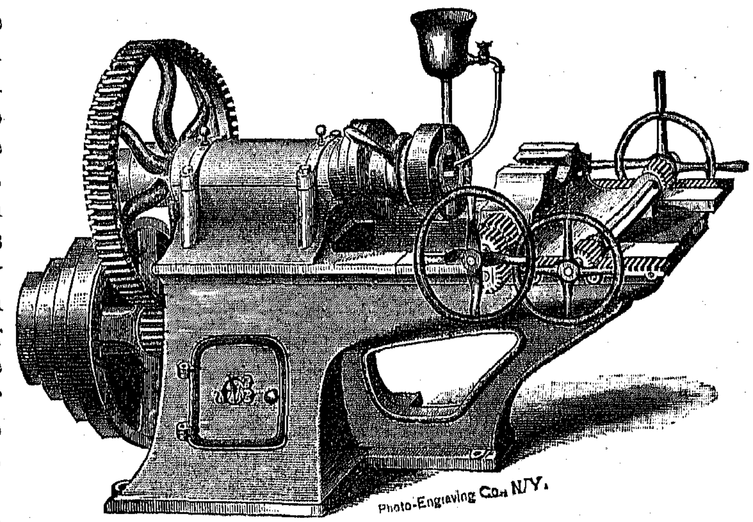

Fig. 203.

Fig. 204 shows a similar device for setting the jaws. The machine is entirely automatic. When

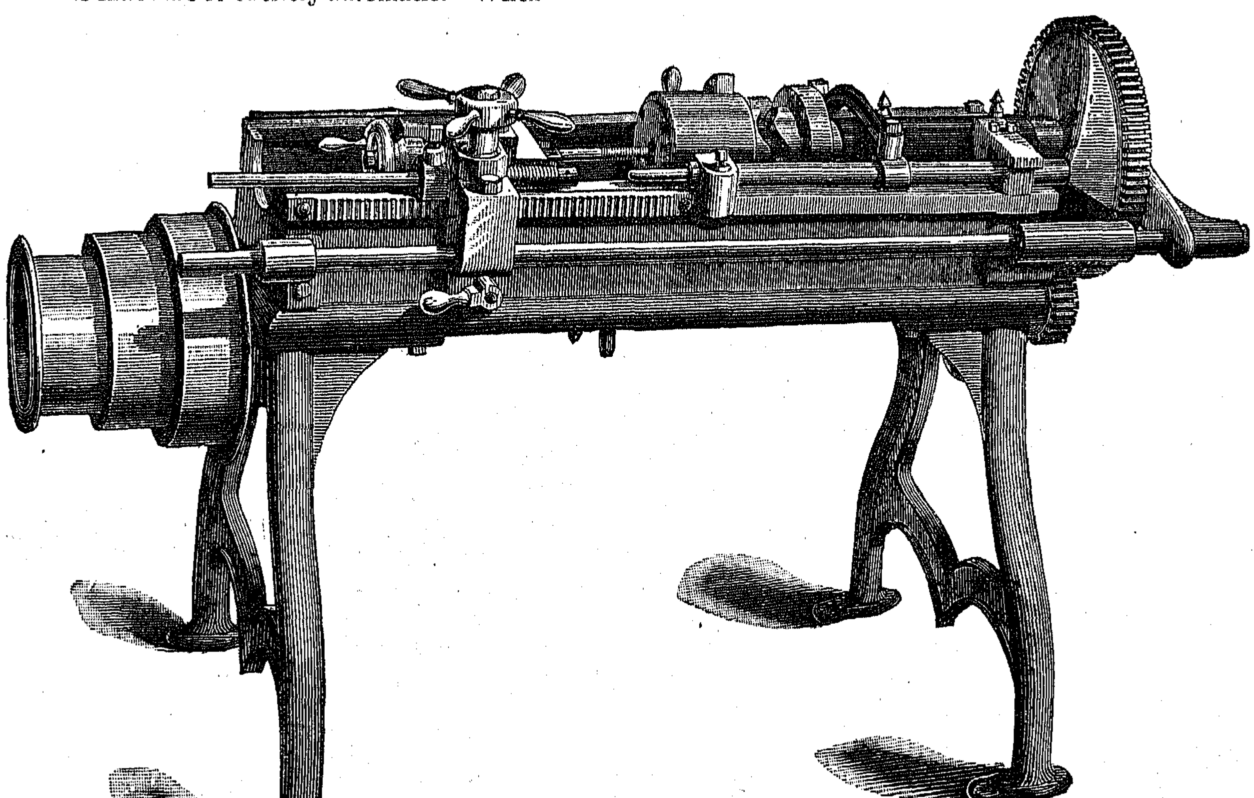

Fig. 204.

a latch is engaged with the ratchet-tooth on the head at the proper depth the outer ring is arrested and the flat groove on the inner sleeve retracts the keys on the jaws by virtue of its continued motion. At the same time the inclined plane on the large gear forces back the carriage and the finished bolt. The continued motion of the inner sleeve resets the jaws and locks them by the straight part of the groove. These tools are also arranged to hold the bolt between centers while being cut, in order to secure the same diameter of all threaded stock.

Fig. 205 shows another type of automatic machine, and Figs. 206 and 207 show its details. Three dies are held in radial slots in the head which is driven by the outer and larger gear-wheel M. This wheel is fitted loose on the hollow spindle B, and is secured to the latter by two bolts. These pass through the plate of the wheel and through circular slots in two arms, D and D′, which form part of the main spindle B. The position of M upon the spindle B is thus adjustable, and may be noted by a pointer, *d*, on the arm D, which moves over a scale upon M. The inner and smaller wheel, M′, is keyed to an outer sleeve, B′, which fits over B and carries a set of three cam-plates, *b*, upon the flange of the head. These cams are milled out on their inner edges to a spiral curve. These curved edges resist the radial motion outward of the dies when cutting, and it will be seen that the opening between the cutters will be determined by the relative position of the sleeve B′ and the driving-spindle B. If B′ were to revolve faster than B, the cutters would abut against a surface of *b*, which would get gradually farther from the center, and the dies would open. The wheel M′ is driven from the wheel M when the tool is cutting by projections E E upon their hubs. When these projections are in driving contact, any desired relation between the dies in B and the cam-plates upon B′ may be secured by bolts in the slotted arms D and the index pointer *d*. Any adjustment for wear, or any varied sizing of thread, large or small, may thus be effected. The large wheel M is driven from a pinion, F, keyed on the cone-pulley shaft. The wheel M′ meshes into a little larger pinion, F′, loose on the same shaft. A spiral spring, I, abutting against an adjustable collar, K, presses F′ against F, the adhesion being increased by a leather disk between them. When the spring is permitted to act, F will drive F′ by friction until the projections E upon the hubs come in contact, when the friction-disk will slip and B and B′ will move together. But F′ may be moved by the hand-lever H and the counter-weight L so as to bring a male cone on it into a female cone which is fast in the leg of the machine; this arrests F, M′, and B′, while B still moves. Small spring cams, *c*, move out the dies in the head as they are relieved from the spiral of *b*, until the projections E on the hubs engage on the other side. The head then turns with the dies open until the lever H is latched back, when the spring I is permitted to act and the dies slowly close by the more rapid motion of M′ and B′. A rod in the axis of the cutter-head may be set to release the latch of H when any desired length of thread has been cut. This compact method of causing different relative speeds in the two large gear-wheels and utilizing the differential motion for moving the dies renders this a very notable machine.

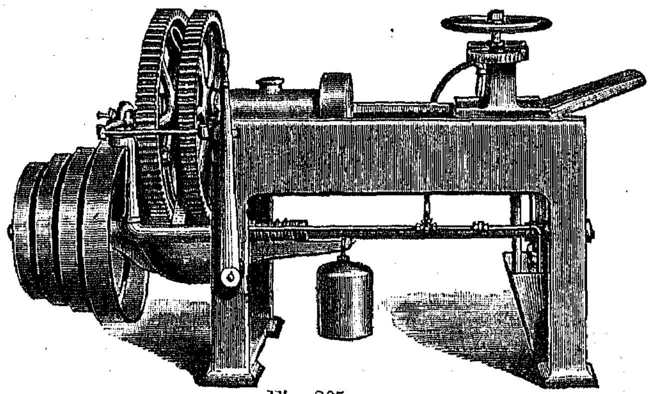

Fig. 205.

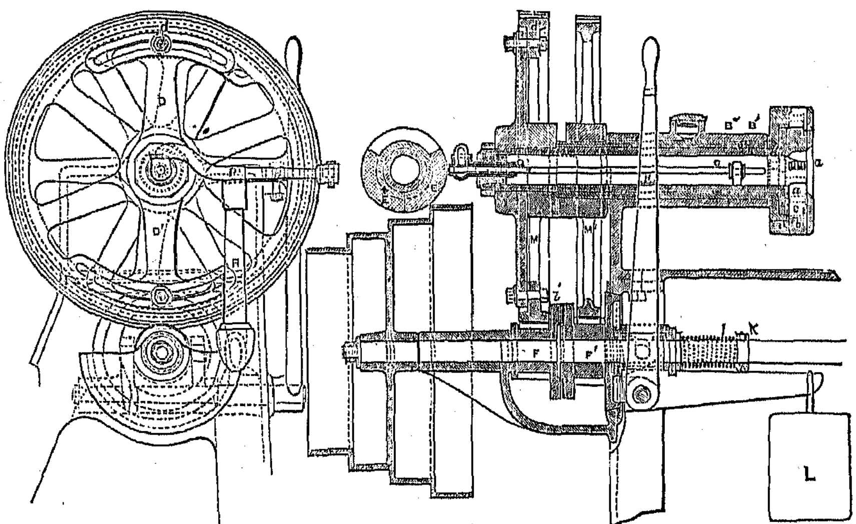

Fig. 206.

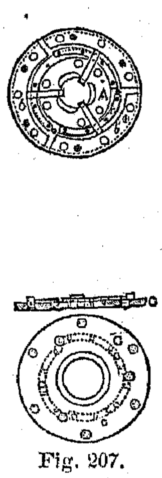

Fig. 207.

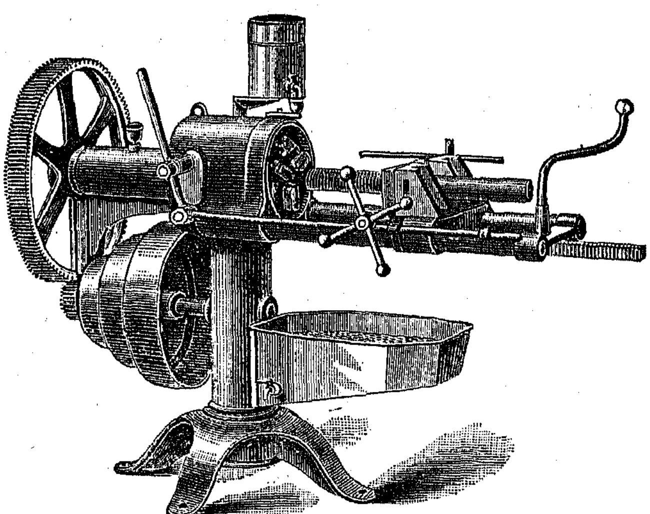

Photo-Engraving Co., N. Y.

Fig. 208.

The tool shown in Fig. 208 illustrates another arrangement. Each of the cutters is carried in a species of holder made of a steel casting. The die is held in the holder by two set-screws on the side and one on the end. The holder has a turned stud near one end whose axis is parallel to that of the bolt to be cut. This stud fits into the head so that by the rotation of the holder around the stud the cutter-jaws approach or recede from the center. The holders are forced and held to their cut by a pin with inclined end, which moves parallel to the axis of the head and bears upon the back of the holder. The motion away from the cut is effected by stiff springs. These holding-pins are attached to a sleeve, which is moved forward by a spiral spring, and is moved backward when a pin is

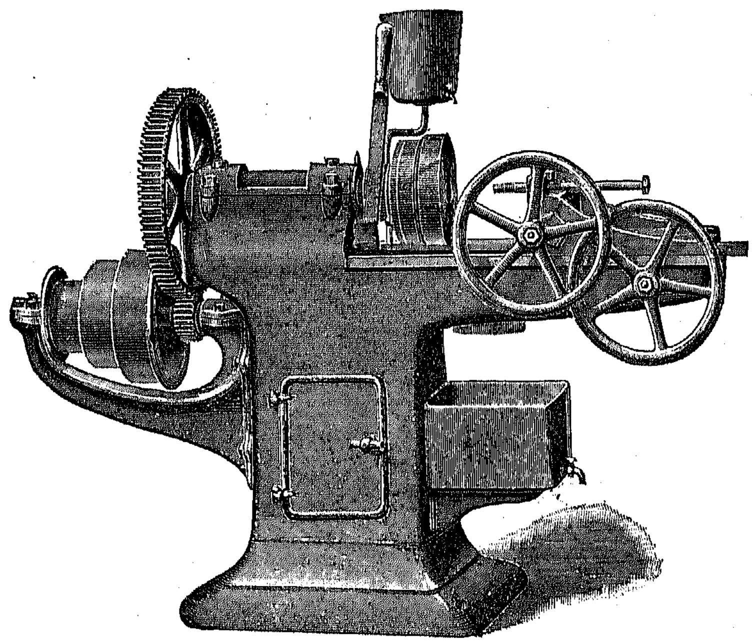

Fig. 209.

released by a latch and drops into an inclined groove in the sleeve. This latch is moved by the bolt being cut, so that any desired length of thread may be produced. The bolt-cutters of Figs. 209 and 210 show the standard New England form of this type of machine.

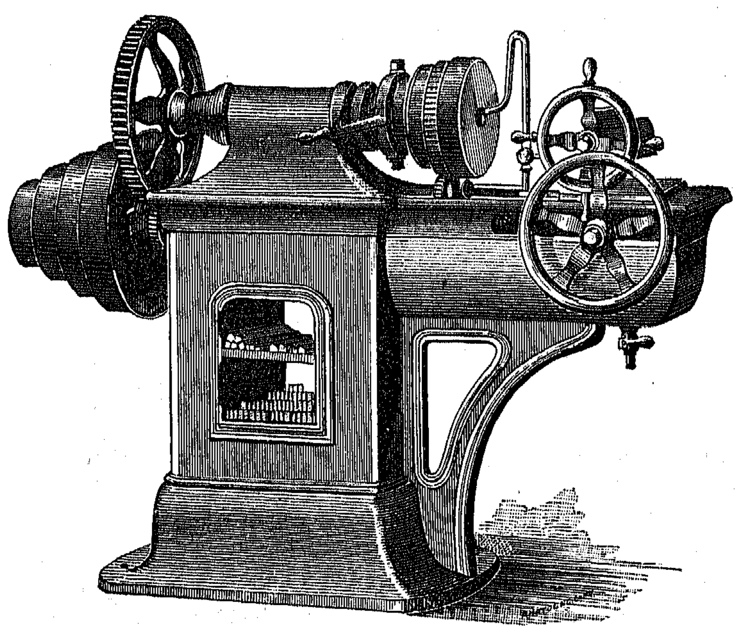

Fig. 210.

Fig. 211 shows one of the largest machines of this class ever made, designed to cut the threads on 6-inch rolled iron. It was first built for the heavy bolt and turn-buckle work in the pumping and hoisting plants in deep mining in the state of Nevada. The machine weighs 10 tons, the large gear is 5 feet in diameter, and the 6-inch tap alone weighs 200 pounds. The same builders make smaller machines, presenting the same advantages as the other designs.

All these machines are fitted with self-centering jaw vises for holding the stock (Fig. 215). In one type the vise is geared differentially, giving great power. Usually the jaws are worked by screws only, either right-and-left handed, or else geared together. They are fed forward to the jaws by a rack and pinion and hand-wheel, or else by a lever. The designs and motions of the vises are shown in the cuts.

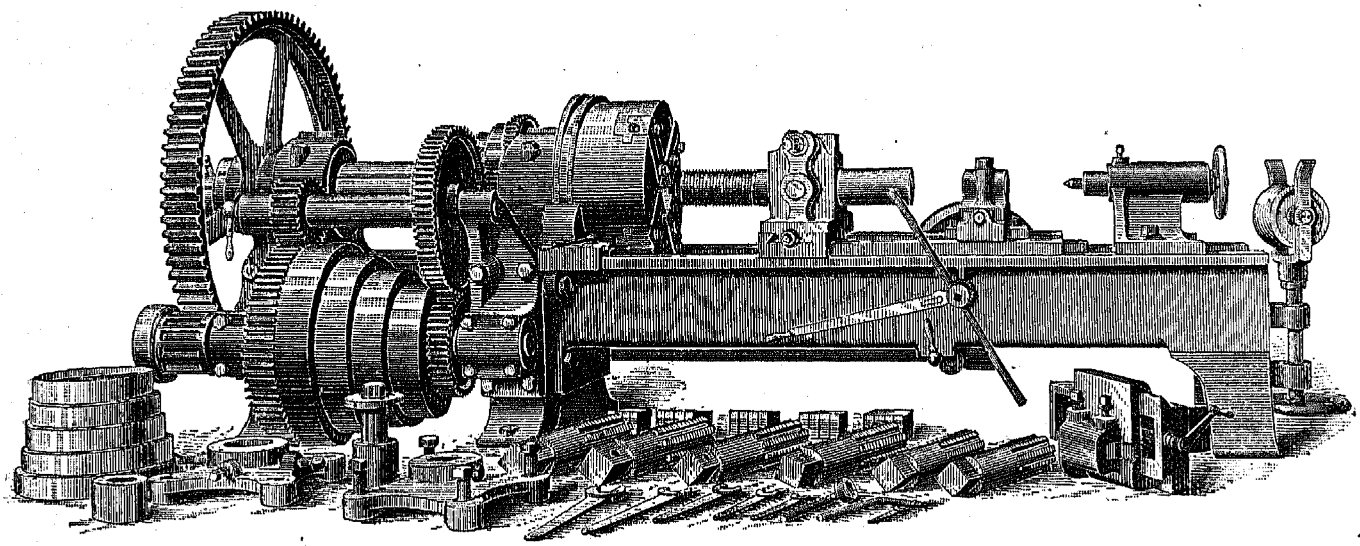

Fig. 211.

For bolt-cutters of the second class, where the bolt revolves and the die is stationary, a solid die is used. One of the types is shown by Fig. 212 *a* and *b*. The cutting-chasers are inserted in an iron collet, encircled by a wrought-

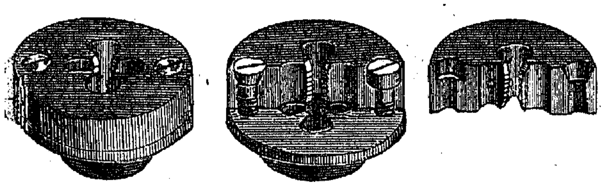

Fig. 212 *a*.

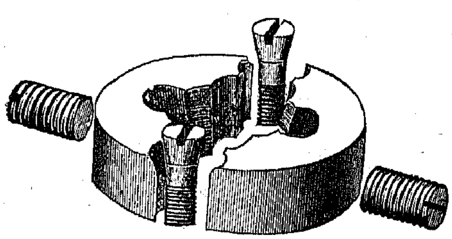

Fig. 212 *b*.

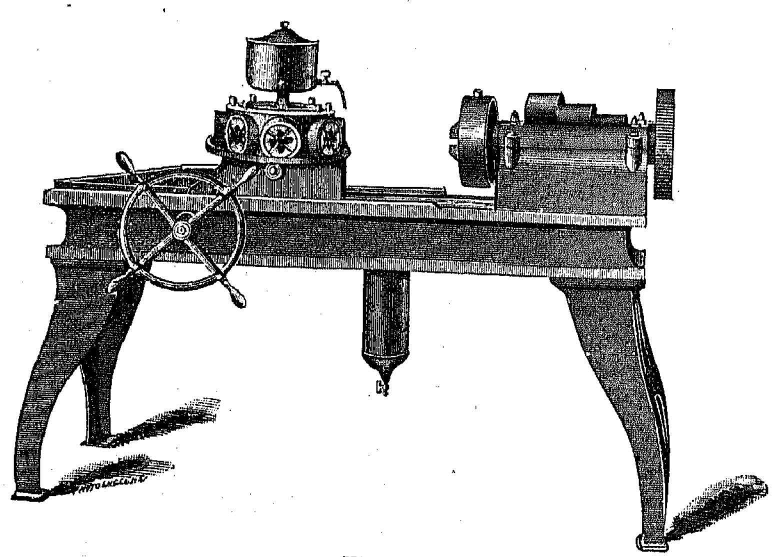

Fig. 213.

iron ring, beveled on the inside. The chasers are beveled to fit the ring; and the latter is secured to the central flange of the collet by adjusting- and distance-screws. An adjustment of $\frac{1}{32}$ of an inch or more may be made in the cutting size of each die. The collet is split, and the opening may be lessened by slacking off the conical screws.

Figs. 213 and 214 show the types of the entire machine. A number of dies are held in a turret-head, and are fed against the revolving bolt by the hand-wheel, pinion, and rack. In Fig. 214 a slide is fitted with sockets for various sizes of nuts. The taps will be held in the jaw of the head (Fig. 215).

A type of movable jaw-head for cutters of this class is shown by Fig. 216. The cutters fit into chuck-plates, which have spiral grooves in their back. The size of the thread will be determined by the position of the stop in the curved slot at top. The blank is released by the revolution of the holder by the hand-lever shown. For tapping-nuts any of the machines illustrated may be applied directly by the simplest inversion, or by replacing the cutting-jaws by a pair adapted for holding a tap.

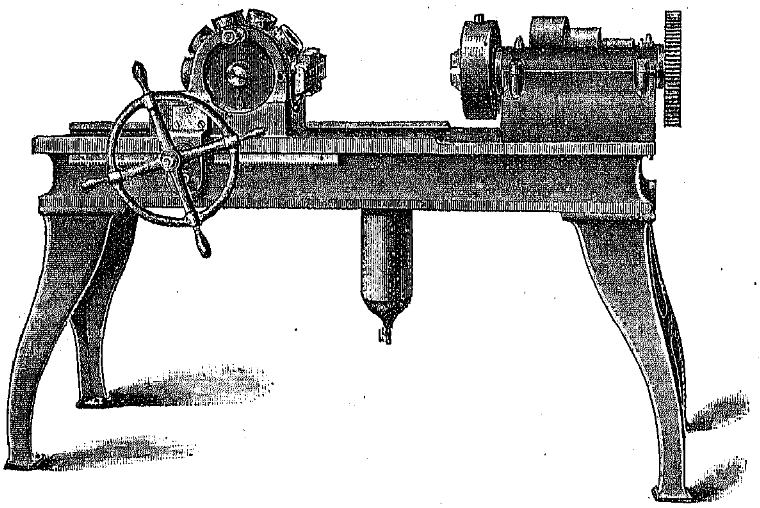

Fig. 214.

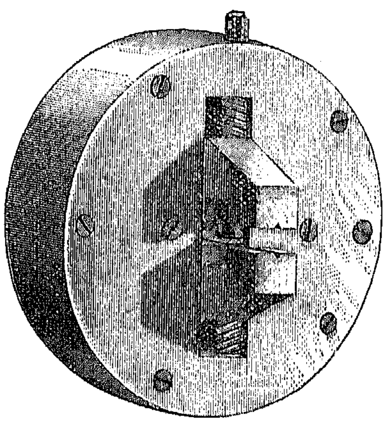

Fig. 215

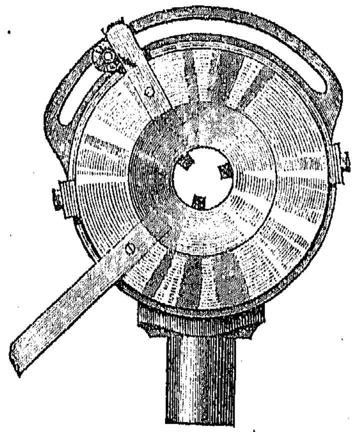

Fig. 216.

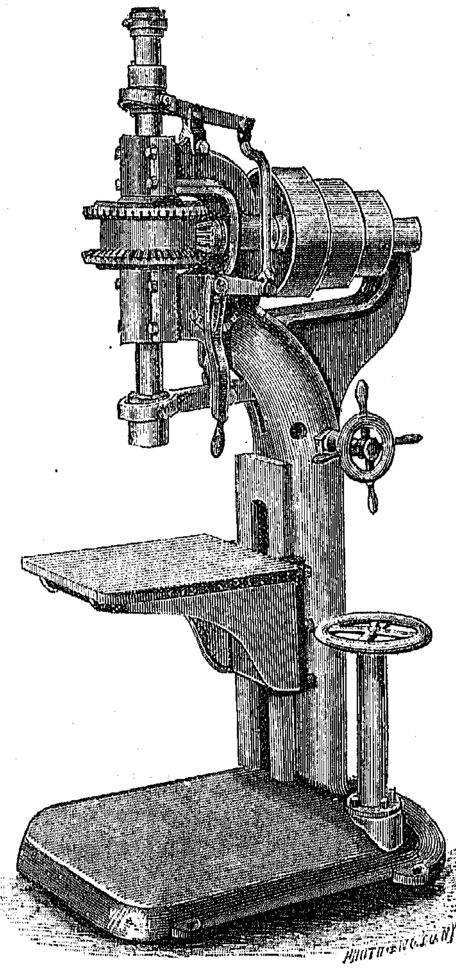

Fig. 218.

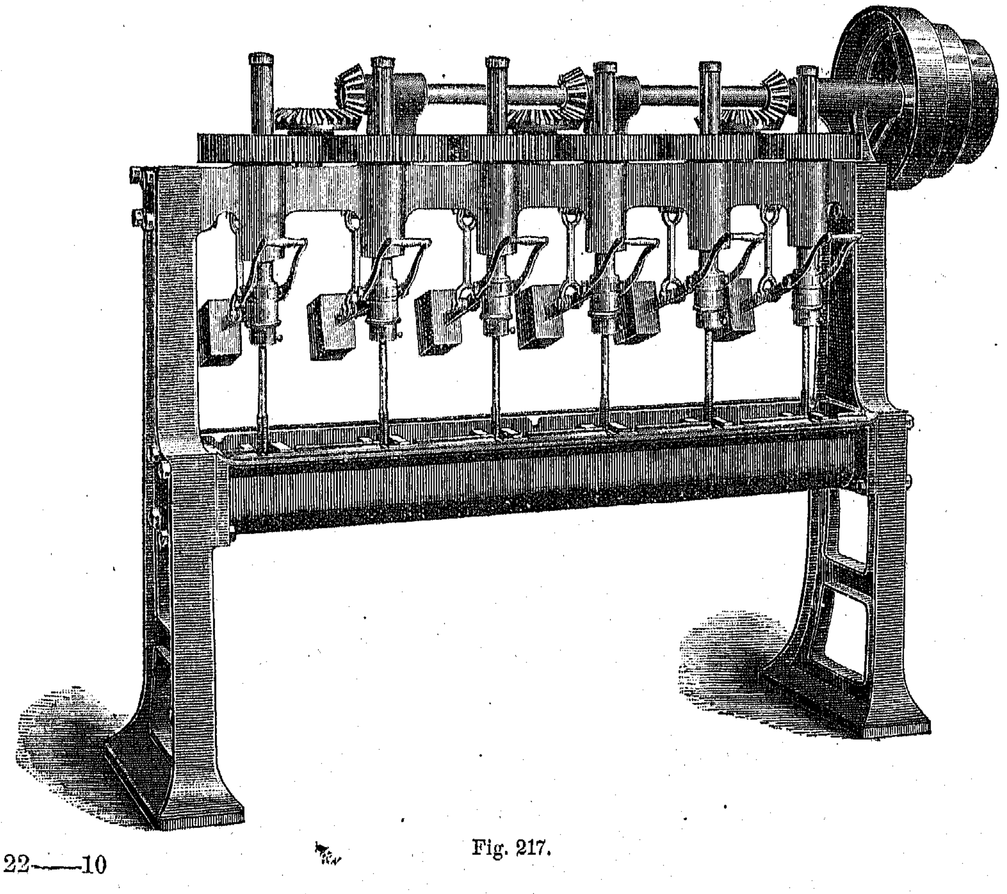

Fig. 217.

Fig. 217 illustrates a multiple vertical machine of six spindles. The spindles are counterpoised, and the nuts are immersed in oil while being tapped, and slide into their fit in the holders. The vertical tappers have the advantage of washing away the chips from the cutting-edges. On the other hand, in the tank-machines the tap may revolve in a film of oil on the surface of water. The water cools the tap, and the oil relieves the friction. The

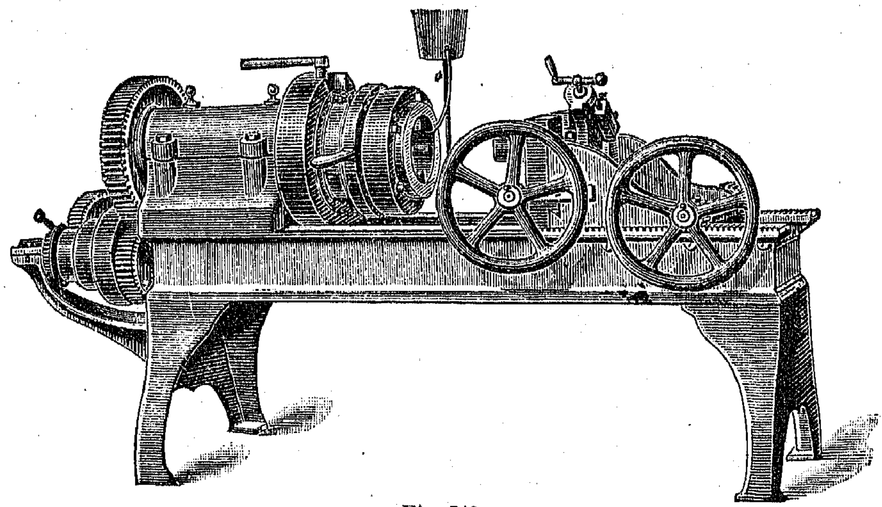

Fig. 219.

mineral oils do not answer for these purposes. Animal oils must be used, or a soda water, or an alkali mixture, made up of 10 pounds of carbonate of soda, 4 gallons of whale oil, 3 gallons of lard oil, and 40 gallons of water. These lubricant mixtures are either held in cans and delivered from a long spout at the cutting-point, or else are pumped on the work in excess to wash away the chips. The spent oil is strained into a reservoir and used over and over again, whence results a notable economy.

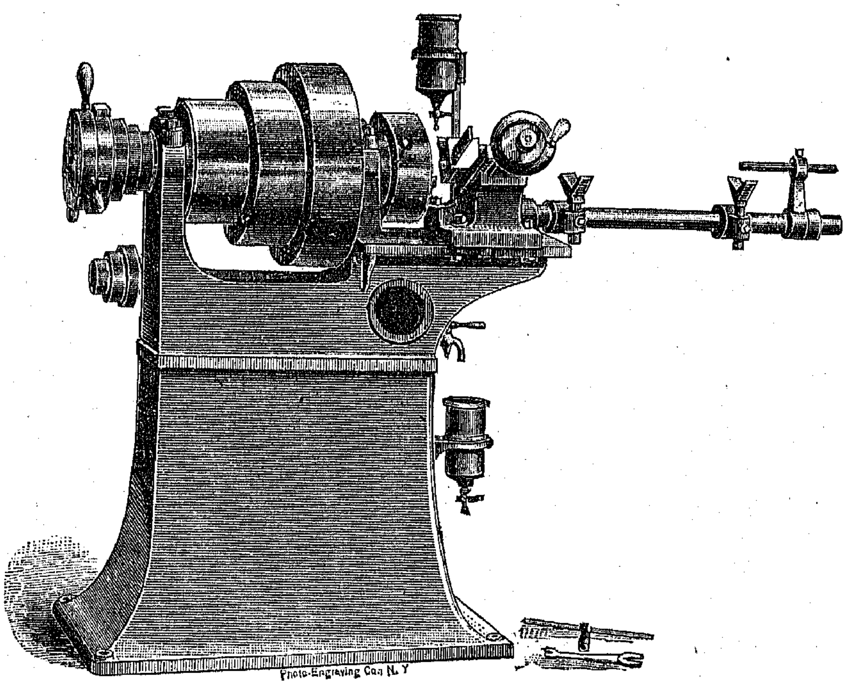

Fig. 220.

Fig. 218 illustrates a machine for tapping general work in cast iron, where the work will be run dry. The spindle is driven in one direction or in the other by a clutch between the horizontal bevel-wheels, which is operated by the lever. The spindle is fed down by hand, and the table is adjusted by screw and hand-wheel.

The machines for threading pipe differ in no essential respects from the bolt-cutters. The smaller sizes are usually worked with solid dies, the pipe being held in jaws in the head and passing through the hollow spindle. The larger sizes use adjustable dies in a revolving head (Fig. 219). Where the pipe is held stationary the required length may be cut by fed cutters in the head. Where the pipe revolves, the lengths must be cut either by a cutting-off tool, on a rest, or else in a separate machine. This latter class of machine is known as a cutting-off lathe, and types are illustrated by Figs. 220 and 221. The spindle is hollow, with a jaw at one end and a bushing, or, better,

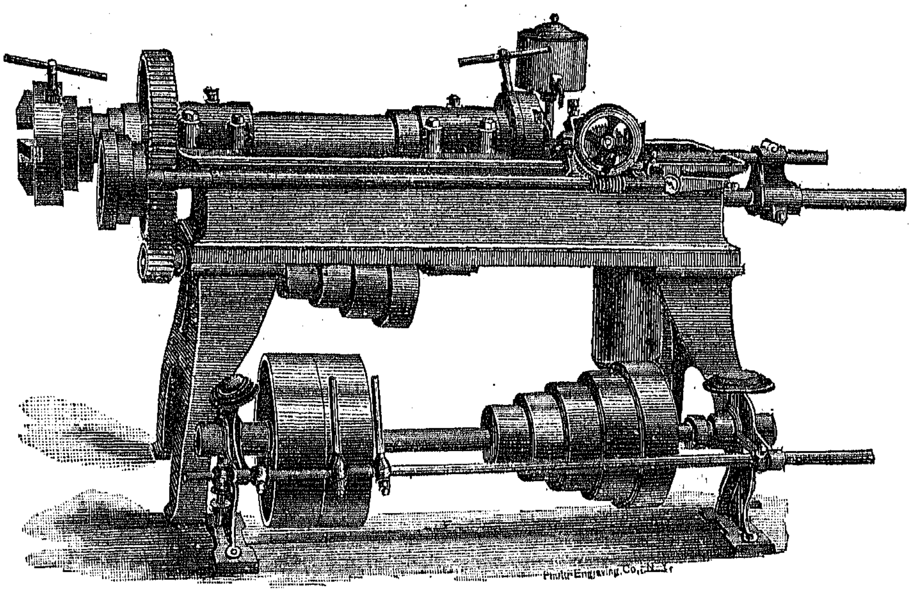

Fig. 221.

a self-centering chuck, at the other. The tool is fed obliquely downward by hand and by power, the required length being gauged by a stop. The tool may be forged of such a shape as to be efficient until it is ground so short as to become useless. Tools in holders are frequently used.

§ 25.

SCREW-MACHINES.

For making machine- or set-screws from the bar which has the shape for the head, a screw-machine is required. This may have several forms. For large work, a machine of the type of Figs. 222 and 223 would be used. The

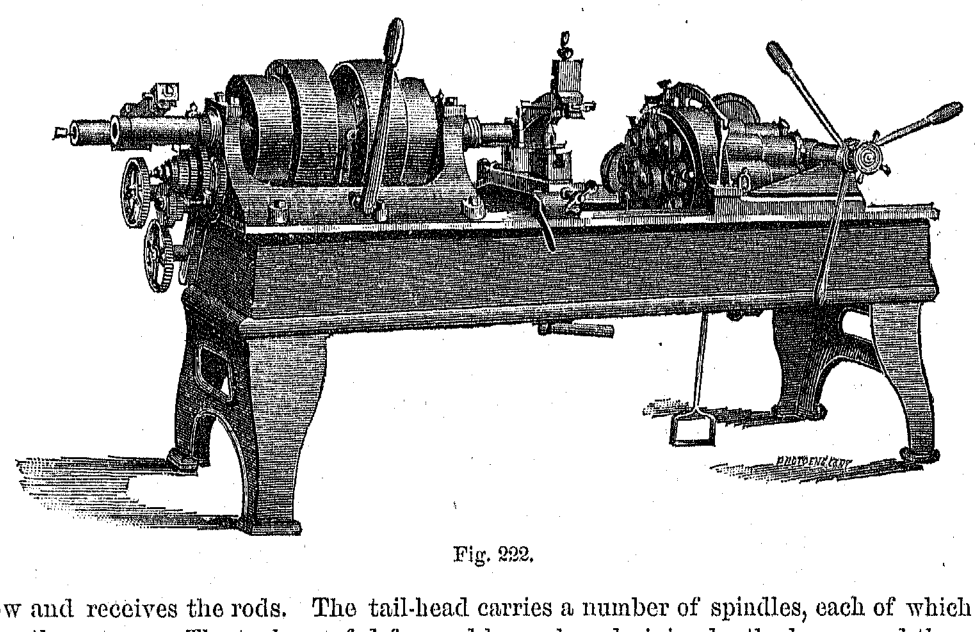

Fig. 222.

spindle is hollow and receives the rods. The tail-head carries a number of spindles, each of which is adapted for one operation on the screws. The tools are fed forward by rack and pinion by the levers, and the one in operation is held from motion by a pin on the treadle-lever. Larger screws will be chased by the slide-rest and hobs; smaller ones will be cut by dies in one of the spindles.

Fig. 224 shows a similar arrangement of tools. The linear motion is assured by the slotted disk on the tail-disk spindle, and an adjustable stop controls the lengths. Tools of this type may use tool-holders with detachable cutters for sizing, etc., thus avoiding the expense of hollow mills.

Fig. 225 shows the very usual application of the turret-head for this class of work, with a chasing-rest.

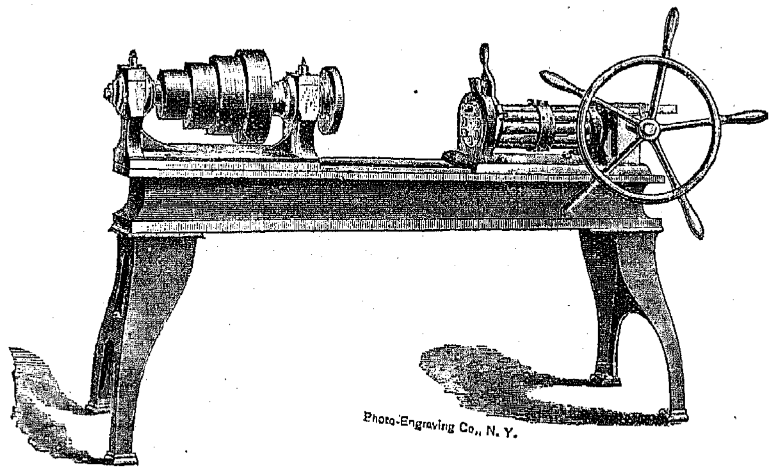

Fig. 223.

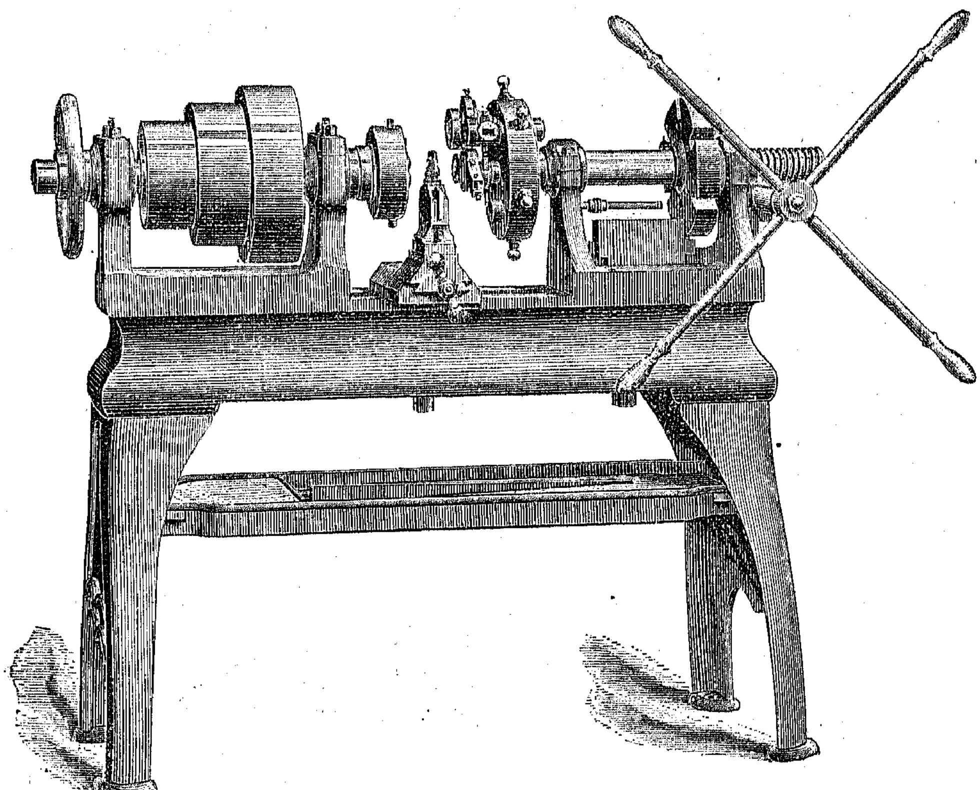

Fig. 224.

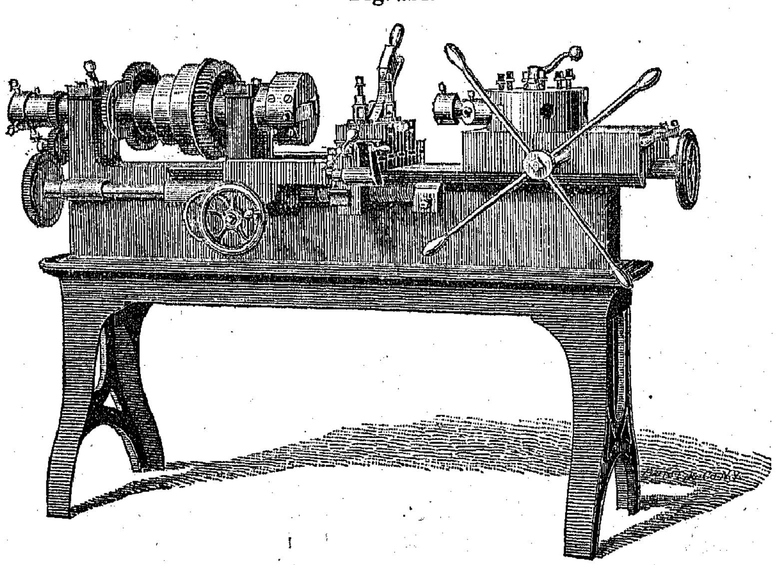

Fig. 225.

Fig. 226 illustrates the smaller machines without chasing-head the slide-rest being used for sizing and cutting off only.

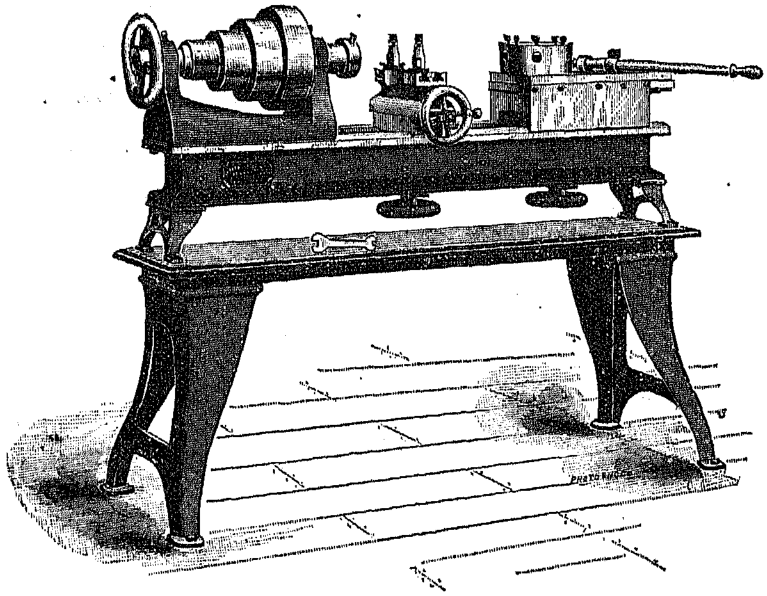

Fig. 226.

Fig. 227 shows the detail of this rest, giving the stop and gauge adjustment at the left, and Fig. 228 illustrates types of tools and holders. Machines of this class are capable of doing a great variety of work with very close accuracy and at high speed. They are especially adapted for finer grades of work, and when so applied will operate to a margin of error within $\frac{2}{1000}$ of an inch.

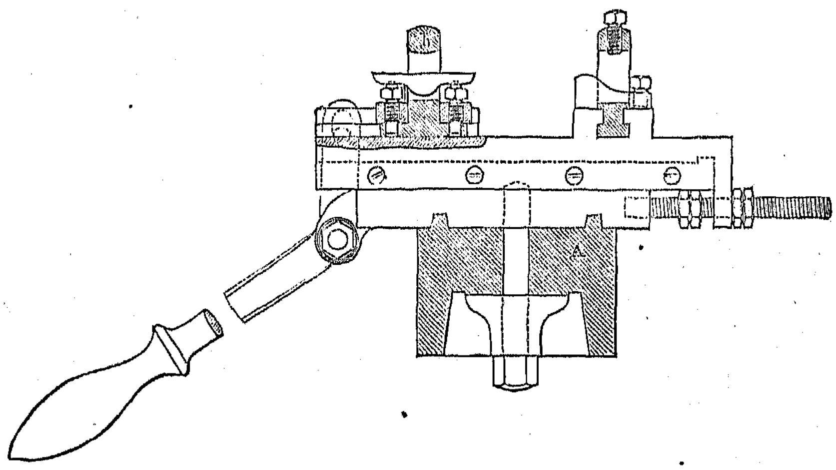

Fig. 227.

Fig. 229 illustrates specimen products of such a machine.

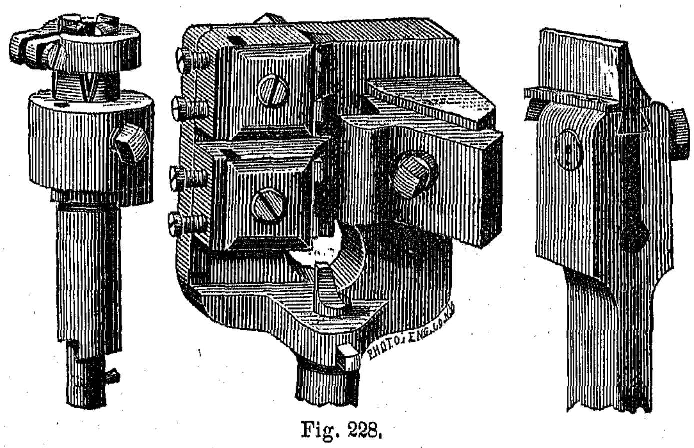

Fig. 228.

Fig. 230 illustrates a type of screw-machine, designed to give better support to the turret. The turret swings on two horizontal supported journals, instead of on one overhanging stud. The tendency to wear the turret loose upon its supports is thereby reduced. Several of its other excellencies are visible from the cut.

The smaller screw-machines are usually equipped to produce the sharp V-thread, which remains in very general use at distances from the centers of enterprise. The larger tools cut the flattened V-threads of the American standard unless specially ordered otherwise. Pipe-threads are uniform all over, and consist of a sharp thread cut with a taper of $\frac{3}{4}$ of an inch to the foot.

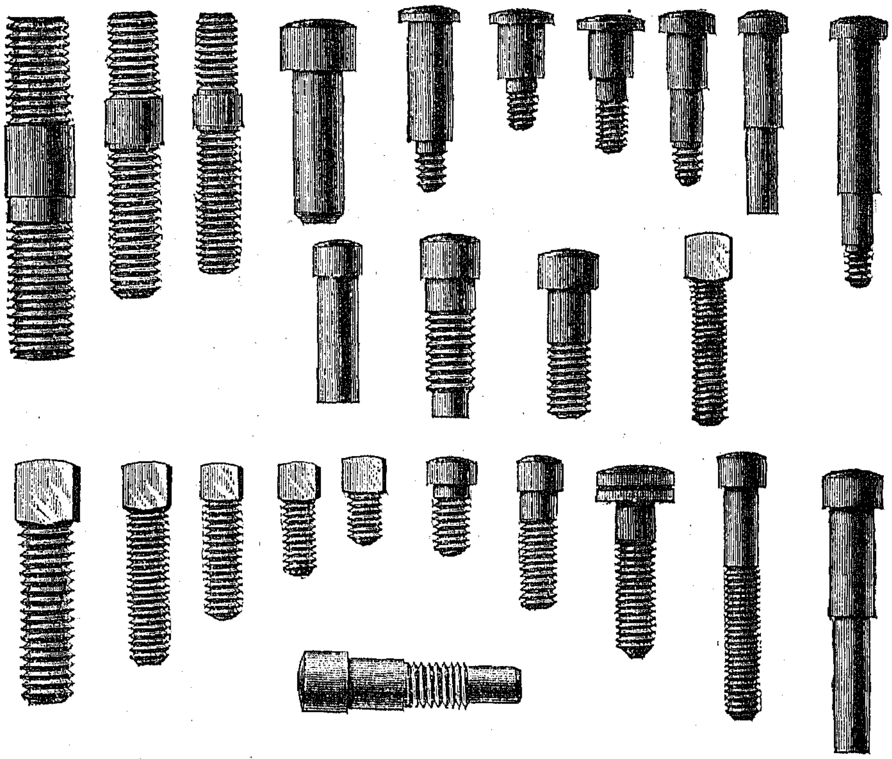

Fig. 229.

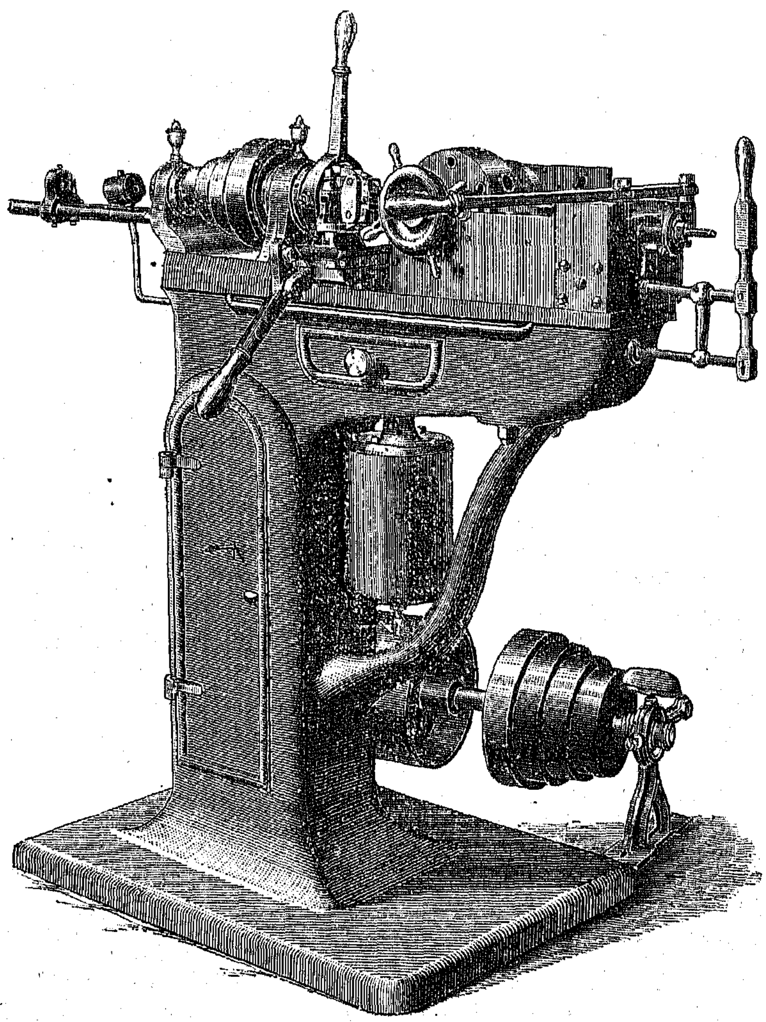

Fig. 230.

§ 26.

PARING-TOOLS WITH LINEAR MOTIONS—PLANERS.

The tools with rectilinear motions of work or of the cutter are especially adapted for producing plane or flat surfaces. The shaper and slotter are adapted for smaller work, or for work where the tool traverse need only be short, and they will readily work out curved profiles by cutting along their elements. But the planer is especially applicable for the production of large or long surfaces which must approach true planes.

The planer will consist of a table or platen moving backward and forward upon ways in a bed-casting. This table moves below a cross-head, which is borne upon two uprights, bolted to the bed-casting. The tool is secured to a slide upon this cross-head, and receives feed-motions in different directions. The gear for driving and feeding are the points in which there is the greatest divergence in the practice of to-day.

There are several reasons for making the table and the work move under the tool, which is stationary, except for its feed-motions. If the tool had to travel any distance, it would be very difficult to produce true horizontal planes. The overhang of the tool, varying at different points, would cause the chip to be always lighter when the slide was farthest out. Beside, the freedom of the slide for ease of motion would cause errors. By reversing this system the tool has its lost motion a constant, for the play of feed is the same at all points of the surface. Moreover, the weight of the table and work acts in the same direction as the strain of the cut, all being downward upon the ways of the bed. The play for motion is therefore resisted by the constant weight of the table and work, and there can be no yielding of the support for the work. If, therefore, the ways be true, and the upright and cross-head are stiff enough, true planes will be produced by this system. There is less gained by this form of tool when planing vertical surfaces. But its capacity for this class of work is small on the medium sizes, on account of the proper support of the tool. When these smaller machines are called on to do extensive vertical surfacing it is not unusual to invert their system and secure the work to a floor-plate, while the tool-holder is bolted to the bed,

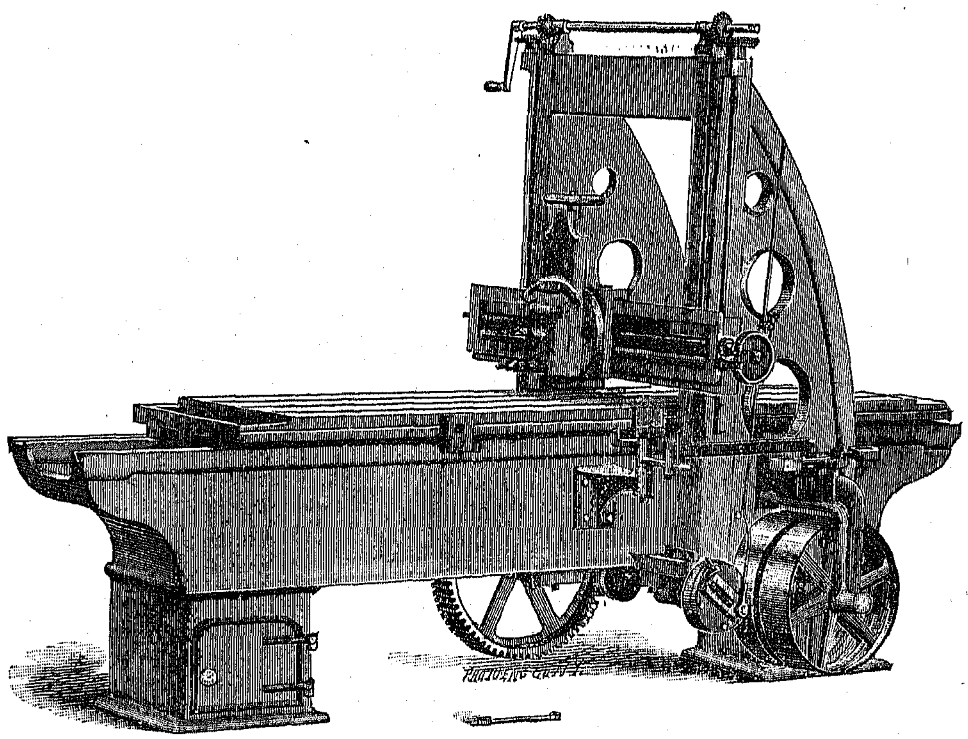

Fig. 231.

and thus reciprocates. The larger machines have vertical surfacing holders upon their uprights. For the convenient holding of work the tables or platens are cast with a large number of **T**-holes. **T**-slots are often planed in the top in addition. Upon the under side of the table are two longitudinal **V**-guides, planed and scraped, truly parallel. These **V**'s rest in corresponding ways in the bed, and guide the motion of the table in a true straight line. The table is often cast with the top side up, in order that any blow-holes or defects may come in the upper side, so as to secure the soundness of the **V**'s. The trough-shape of the lower **V**'s enables them to retain the oil necessary for their lubrication. This could not be done were the arrangement of the **V**'s reversed. To insure the lubrication of all the bearing-surface of the guides, curved channels are chipped out from the faces, running from the bottom of the **V** to near the top. By this means the oil is carried to those places from which it would naturally drain off. It has been suggested to use flat, thin disks, which might turn in counterbores in the ways and effect the same purpose. To catch the oil which would be displaced from the ends of the **V**'s a cell or pocket is put at the ends of the troughs, and one designer planes a bead on a flat at the top of the troughs to prevent loss of oil over the sides. An objection to the use of the two **V**'s results from the difficulty in securing perfect parallelism of the four planes of the guides throughout their whole length, or of retaining that parallelism where the surfaces wear. If there is any difference in the hardness of different parts of the bed and table castings, the wear at different places will be uneven. If this wear be on one side of the **V**'s, the table will crowd over and produce curves on vertical cuts. If on both sides, the table will either dip or wind, producing errors of horizontal surface. To avoid the tendency of the bed to creep and bear a little harder on one side of the **V** or the other one designer uses one flat and one **V** groove. The bearing area of the two is calculated carefully to compensate for the different angles of resistance to the downward pressure (Fig. 231). A form of planer with two flat shears offers certain points worth noting. The surfaces for wear and bearing are large and are easily made true. Side-play is prevented by adjustable gibs. Special oiling devices by flanged rollers counter-weighted so as to lift oil against the under sides of the slides prevent dry seizure of surfaces, and they promise excellent results of exactness and durability.

The bed of large planers will rest directly on the foundation, which will oppose any flexure from the strain of the weight or the cut. On the smaller sizes the bed must be made deep enough so as not to sag between the legs or supports which lift it from the floor. There has been considerable improvement in this respect in the newer designs. A very excellent arrangement is to lessen the span between the legs by making them columnar and hollow, to serve as tool-closets. The ends of the troughs are strongly bracketed out beyond the legs for the same

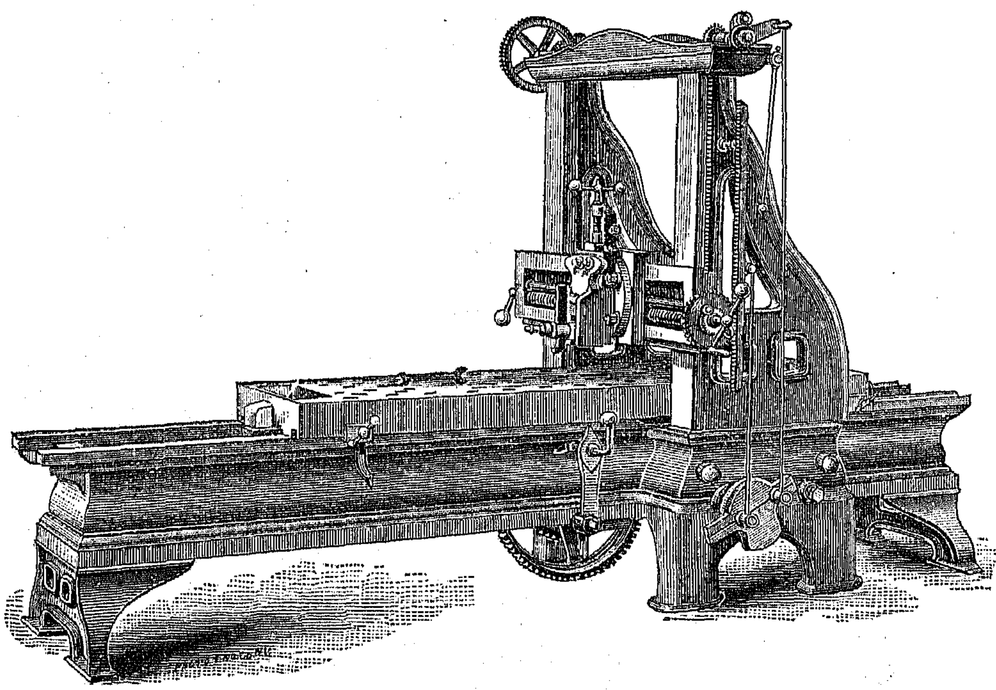

Fig. 232.

object, since the heaviest strain will always be upon the length between supports, and by the use of brackets the legs come nearer together, with a given length of trough. The bed must also be longer than the table, for while it is not necessary that it be twice as long, yet there must be no tendency for the table to tip when loaded at one end. By making the table itself deep the pressure is distributed more uniformly, and the tendency to spring is diminished. The uprights or cheeks have to resist a strain tending to bend them backward by pressure against the cross-head. This pressure will have the greatest leverage when the cross-head is near their top, and therefore the uprights will be of greatest depth and section near the bottom. There has also been great improvement in the design of these uprights with regard to stiffness. The amount of metal and its disposition is much more judicious than in the earlier forms. Openings are made in the cheeks for lightness of their web, considered as a girder, and to enable the operator to look through them at the work. The uprights are bolted very firmly to faced surfaces upon the sides of the bed. They are united by a strong girt at the top. In older practice this was an entablature bolted to the top of the sides. In modern designs the girt is cast as part of the uprights, or bolted to their sides, and is curved horizontally to act as an arched brace, to stiffen further the uprights and distribute an unsymmetrical pressure more equally on both. The uprights are put a little behind the middle of the length of the bed, in order that in front of them may be a clear space for securing and examining work. They are faced on the front side for the bearing of the cross-head, and upon some rear surface to admit of clamping the cross-head by a gib. This clamping surface may be either an outside flange or one made by a slot down the face, which divides the bearing surface into two parts. The cross-head is upheld and adjusted by two screws, which are coupled together by a horizontal cross-shaft overhead through pairs of bevel-gears. By turning the horizontal shaft by a crank- or hand-wheel the two ends of the cross-head are raised equally at once, and require no repeated adjustment. In the larger tools this cross-shaft is driven by power, usually by a belt-wheel. Since the weight of the cross-head and attachments are opposed to the strain of the cut the screws can be used to reinforce the clamps. After the head is secured in place by the clamping-bolts, an attempt to screw down the screws will take up all lost motion and give extra points of resistance. On account of the necessary play in the number of joints, it is not generally thought judicious to attempt to feed downward by the adjusting-screws. It has been done (Fig. 232), but recent practice

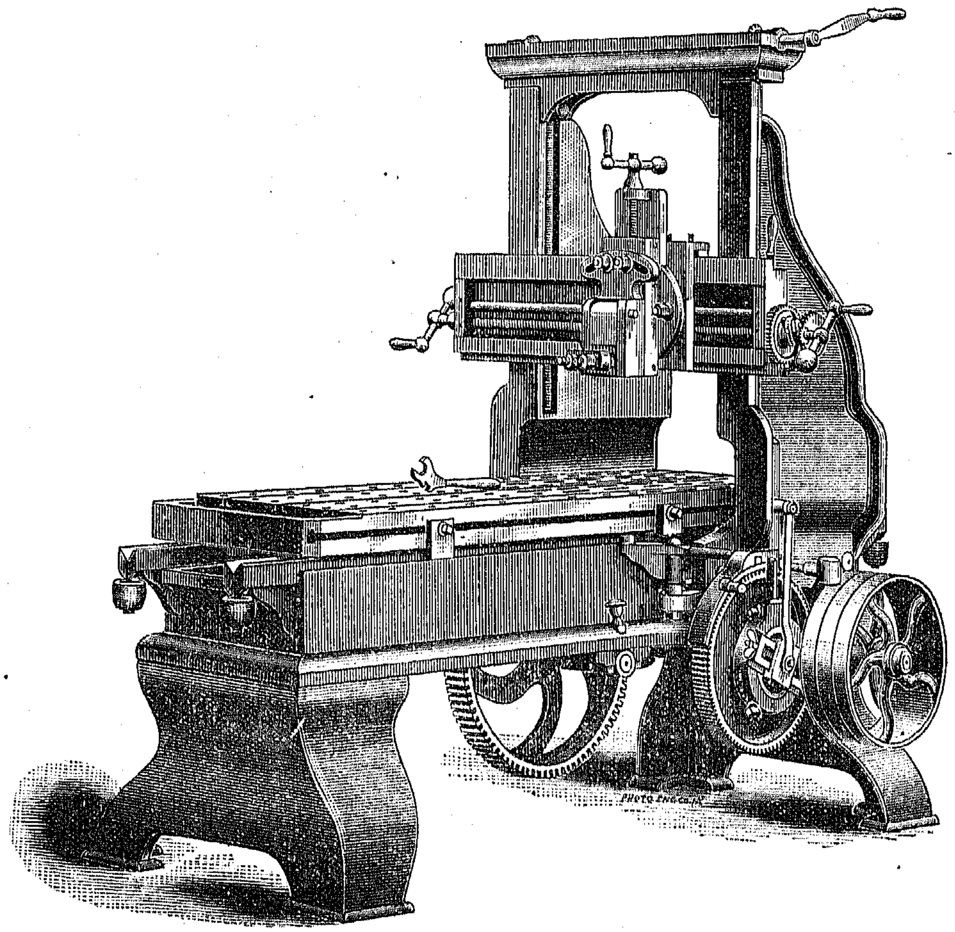

Fig. 233.

prefers to clamp the cross-head, and give all the vertical feeding at the slide to the tool-point and apron. The clamping is usually effected by two bolts at each check, which tighten a gib or plate, clasping the faced guide surface of the upright. The lifting-screws are carried either inside the uprights when they are of box-form, or outside of them at the back or sides. In the former case the projecting lugs which form the nuts pass through slots in the upright and serve as guiding-slides. In the latter arrangement the nuts are often separate and are bolted on to the back of the head. The uprights are often arranged so as to carry extra tool-holders (Fig. 248) for vertical surfacing.

The cross-head itself must be straight. It is very often strengthened against flexure sidewise between the uprights by stiffening-ribs at the back (Fig. 235). To lighten the web of its depth, holes are often cored out in the casting in the central part. Since it is designed to carry the slide or saddle which holds the tool stiffly and yet permit the feed-motions, there must be a track or shear planed on the front surface, in order that the saddle may be gibbed to it. These shears appear in three different forms. The upper part is made square, to resist the pressure due to the weight of the saddle (Fig. 233). This embraces the square on the top and front and rear, the top and rear bearing being gibbed to take up wear and lost motion. The under side of the shear is planed to a **V**, sloping inward and upward. In the second form both upper and lower surfaces are inclined inward, and the third form has the upper and lower **V** parallel, the lower face in all cases sloping upward and inward. The first form is by far the most prevalent, though some very excellent designs retain the second. The squared surfaces oppose the strain on them by normal resistances, and therefore move more easily than where there may be a wedging action.

The lower **V** resists the upward oblique strain of the cut, and prevents any jarring by its shape. The gibs are adjustable by screws bearing against them in shallow counterbores, or else they are tapered, and adjustable by screws and jam-nuts.

The front of the track is flat and of sufficient breadth to resist the horizontal pressure. What surface is not required between the top and bottom rail is cut away, and accommodates the rod and screw for the feed-motions of the saddle and apron (Figs. 234 and 235). The saddle fits upon the track on the cross-head, and has a horizontal motion upon it. The saddle is either rectangular, as in the cut, or in more recent practice has wings at the top for increasing the length of bearing surface, thus diminishing wear. Into the back of this saddle is secured a brass nut, through which passes the feed-screw. This screw usually runs near the bottom of the hollow of the rail, and its rotation in either direction will accordingly carry the whole saddle across the table. The front of this saddle-plate is finished off with a boss and a circular **T**-slot, into which bolts may fit, by which a swivel-plate may be

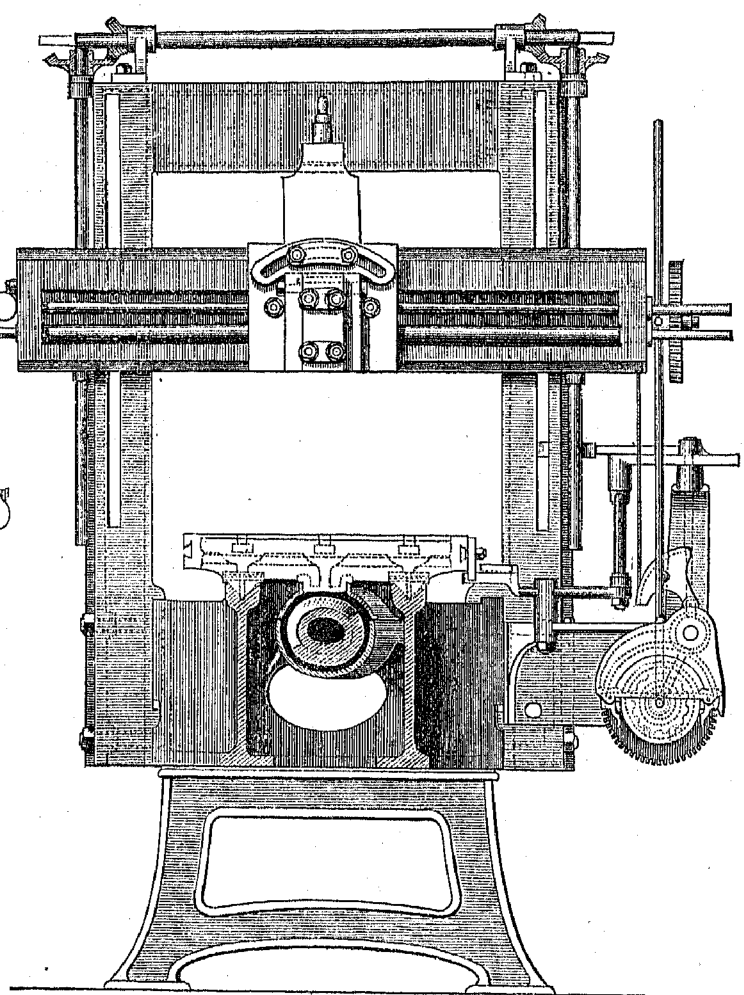

Fig. 234.

secured in any angular position. This swivel-plate carries a second flat shear, planed on its edges to a **V**, sloping inward. Upon this guide is gibbed a slide, to which the tool is secured. The slide is fed along the guide at whatever angle it may be by a screw with ball-handle or hand-wheel. To produce this vertical or angular feed of the tool-slide is the object of a splined shaft which lies along the hollow of the cross-head above the screw. This shaft carries a bevel-gear which drives a short idle shaft of bevel-gear in the axis of the swivel-plate. The third gear turns a fourth upon the axis of the downward feed-screw, so that rotation of the splined shaft will turn the screw of the feed at whatever angle the latter may stand. The fourth gear will roll around the circumference of the third when the swivel-plate is adjusted. The fourth gear may be splined to the angular feed-screw, or it may be made to serve as the nut for the latter. In this latter arrangement, when the automatic feed is in use, the screw must be locked either by a friction-clamp or by a locking-pin. When fed directly, the friction of the splined horizontal shaft is the dependence for holding the nut. In the former arrangement it is not expected that the direct feed will be much used. In fact it is not. Very often in large tools the top of the saddle is out of reach, and in smaller ones the end of the cross-head is more accessible without reaching over the work. The ends of the screw and the splined shaft are squared to receive crank or ball-handle when feeding by hand.

The power-feeds are intermittent, as they should be. The cutter, after being set, makes a stroke with the feed at rest, thus cutting always in lines parallel to the guiding **V**'s. The feed-shafts are fitted at their ends nearest the operator to receive a loose gear. This gear carries a pawl or dog, which may turn a slip-gear in one direction or the other. Motion is imparted to the loose gear through a small angle from a slotted crank, the variation in the amount of feed being caused by greater or less length of crank. A link from the adjustable pin of this crank gives

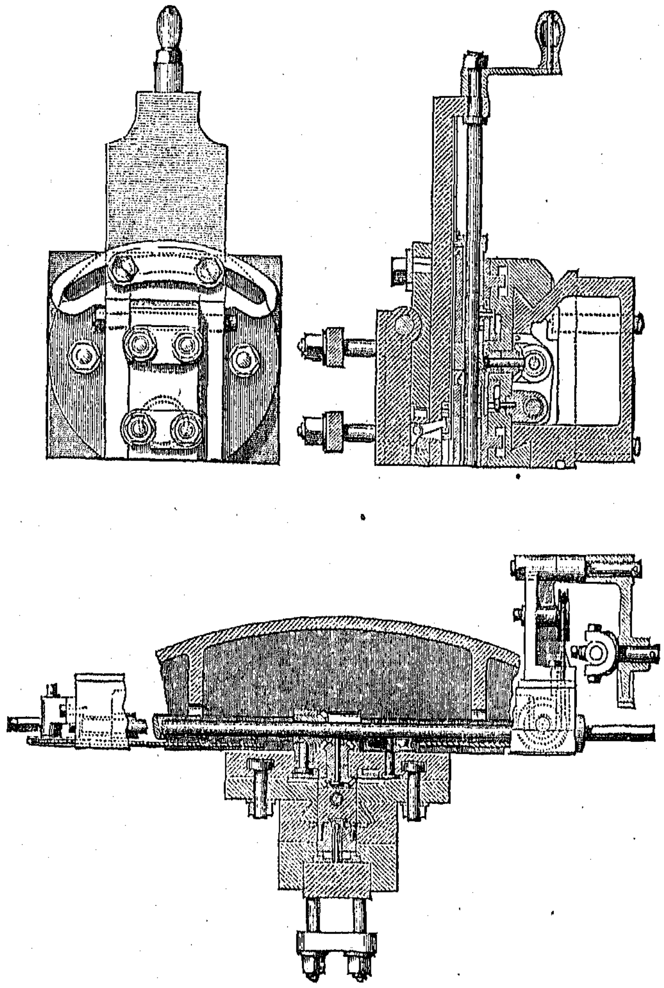

Fig. 235.

an alternating motion either to a rack, which thus turns the loose gear, or else to a sector, which acts similarly. The reason for the use of the rack is that thereby the cross-head may be at any elevation and yet the feed mechanism will be always in gear without adjustment from the operator. Where the sector or its equivalent is used, the link which moves it is clamped to it by a short set-screw, which must be loosened when the cross-head is to be reset.

In the type shown in Fig. 236 the adjustment for height is permitted by the vertical shaft with a spline. Motion is imparted to it by partial bevel-gears. The reason for using geared transmissions is that if jointed linkages were used the leverage of the ratchet would be continually varying, and a coarse feed would be impossible with a compact arrangement and short levers. The slotted crank, from which motion is received for the actuation of the pawl, should be made as part of a wrist-plate, so that the pin in the slot may be on either side of the center of motion. This is necessary, because the stroke of the link in which the pawl slips over the teeth of the wheel must always be made at the end of a cutting traverse of the bed. Otherwise, before the return of the bed under the tool the feed for the ensuing cut would have been made, and great wear of the cutting-edge would ensue. Hence the acting stroke of the feed must be on the lifting or falling stroke of the dog according as the feed of the tool is in one direction or the other. There are but few tools which do not permit this adjustment.

This alternating motion for the feeds is either received directly from the driving mechanism or from some of the levers which control it and make it automatic.

The earlier driving mechanism consisted of a screw in the middle of the bed, whose long nut was made part of the table. The screw was square-threaded, of quite steep pitch, and was turned at one end by bevel-gears from a transverse shaft. These gears had to be small, in order that the rear end of the table might pass over them when planing long work. To effect the quick return of the table on the stroke when the tool was not cutting the screw carried two bevel-wheels of different diameters, driven by two others of corresponding diameters, whose axes coincided with that of the transverse shaft and were on different sides of the axis of the screw. Of these latter bevel-wheels one was keyed to the transverse shaft, and turned the wheel of largest diameter on the screw. This was driven by the outer belt-wheel of three equal wheels, which was keyed also to the transverse shaft. The

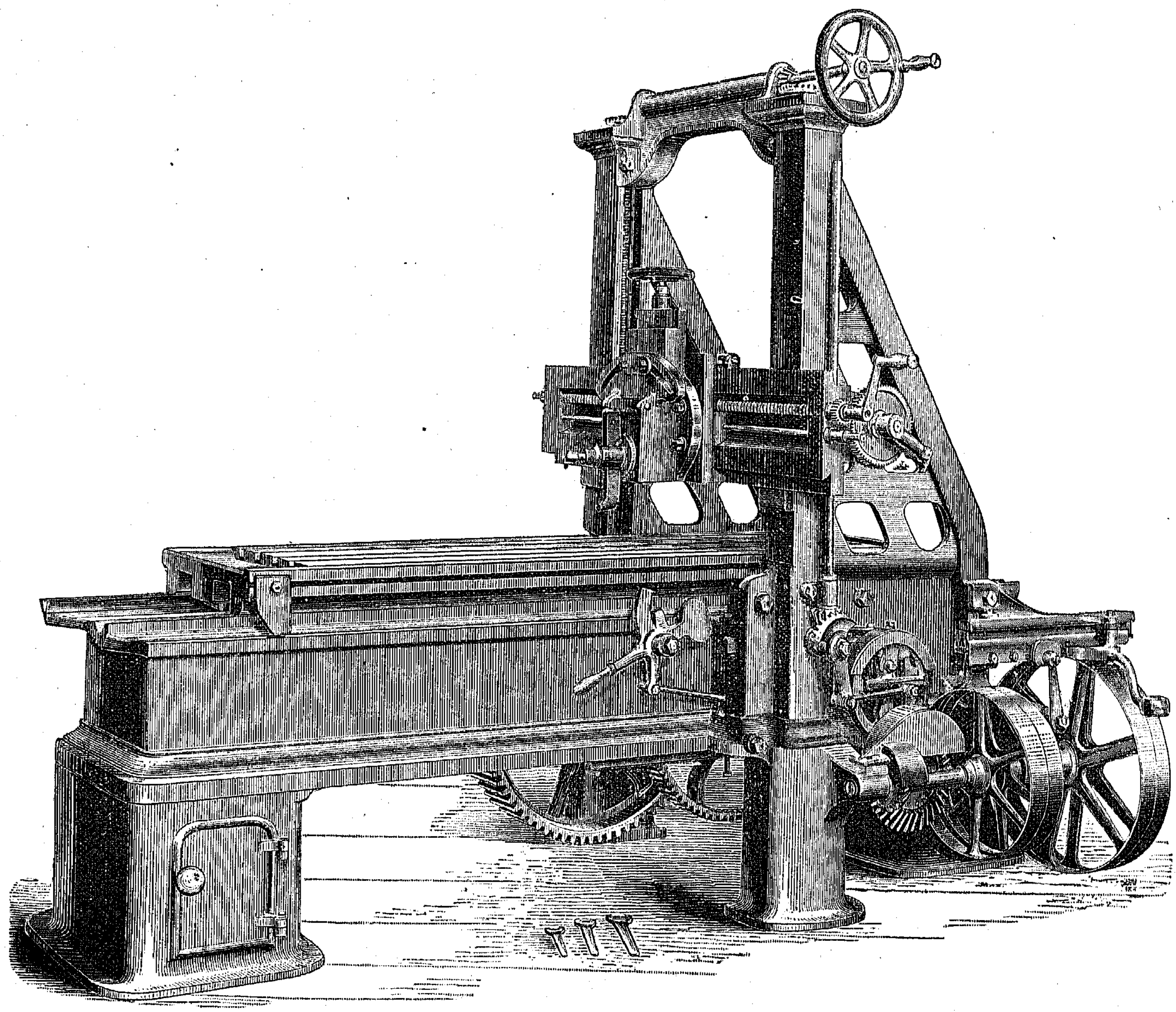

Fig. 236.

other bevel-wheel geared into the smaller wheel on the screw, and instead of being fast on the transverse shaft was secured to a sleeve, turning freely upon the shaft. To the sleeve was also secured the inner belt-wheel, while the intermediate third wheel was loose. It will be seen that while the driving-belt was on the outer wheel the screw would turn slowly with leverage for the cut. When the belt was shifted to the inner wheel, the screw would turn faster and with less leverage in the opposite direction, thus producing the quick return. The idle loose wheel is necessary that the belt may not be upon two pulleys at once which move in opposite directions. The shifting of the one belt from one pulley to the other was effected (and still is) by a pair of dogs or chocks, which bolt at any point in a T-slot planed in the side of the bed. These dogs strike an arm, which gives the transverse motion to the shifter-eyes by a bell-crank. The inertia of the moving bed, coupled with the high speed of the belts, renders the stalling of the machine with the belt on the loose pulley practically impossible. In place of the screw of the earlier types modern practice approves a rack in the middle of the table, driven by a spur pinion. This rack, in the best practice, is cut out of the solid. In the smaller tools it is a plain rack with linear teeth. Some of the larger use a rack and pinion with V-teeth. The object of this is to gain the advantage of strength which comes from large circular pitch, while securing the smoothness of motion which comes from smaller circular pitch and greater numbers of teeth. Something of the smoothness of helical gearing is obtained without the sidewise thrust which they produce. Any sidling is counteracted by the convergence of the lines of each tooth. The pinion which drives the rack is driven by a train of gearing from belt-wheels. This train will differ according as one or two driving-belts are used in any one type of arrangement, and they will also differ in the arrangement. The most usual arrangement consists in a train of spur-gears, by which the velocity is reduced from that of the belt-wheels. The gears are heavy and are cut. Some are using steel castings for this train. The disadvantage of this system is that the long dimension of the tool is at right angles to the line shafting of the shop, while all the

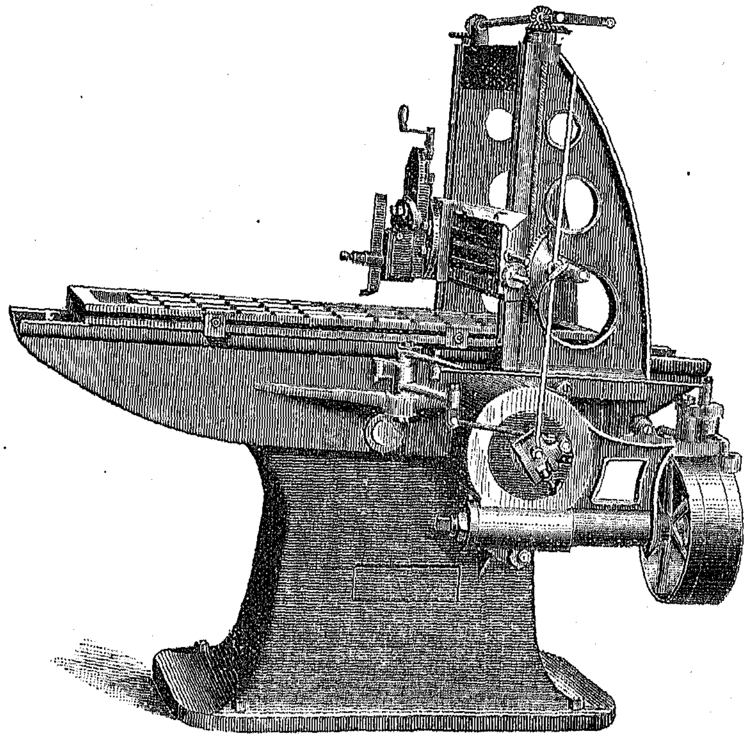

Fig. 237.

lathes are parallel to it. Hence the planers of this type are wasteful of room in a crowded shop. To counteract this difficulty the first transmission from the pulleys has been made by bevel-wheels, the other gearing being the

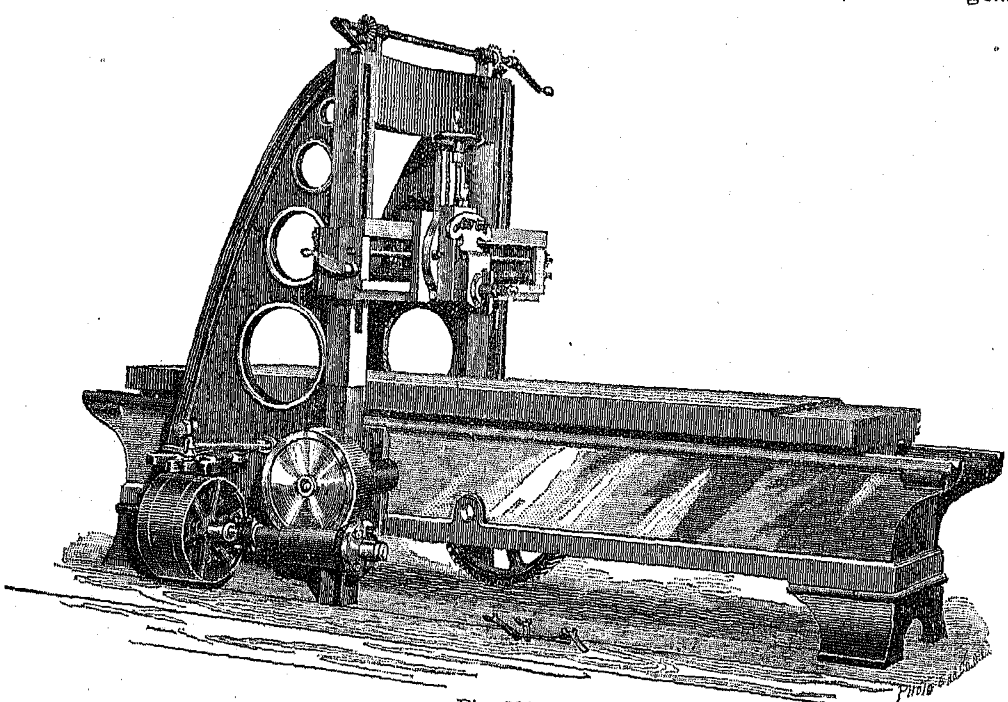

Fig. 238.

same (Fig. 236). This brings the planers parallel to the lathes. Another arrangement uses a worm and wheel at the first corner (Figs. 237 and 238). In still another the rack is driven by a worm of four threads, which has been called a "spiral pinion", and gears the worm-shaft to the belt-wheels parallel to the bed by a pair of bevel-gears of great difference of diameter (Fig. 239). This arrangement is inferior to the one just preceding, in that

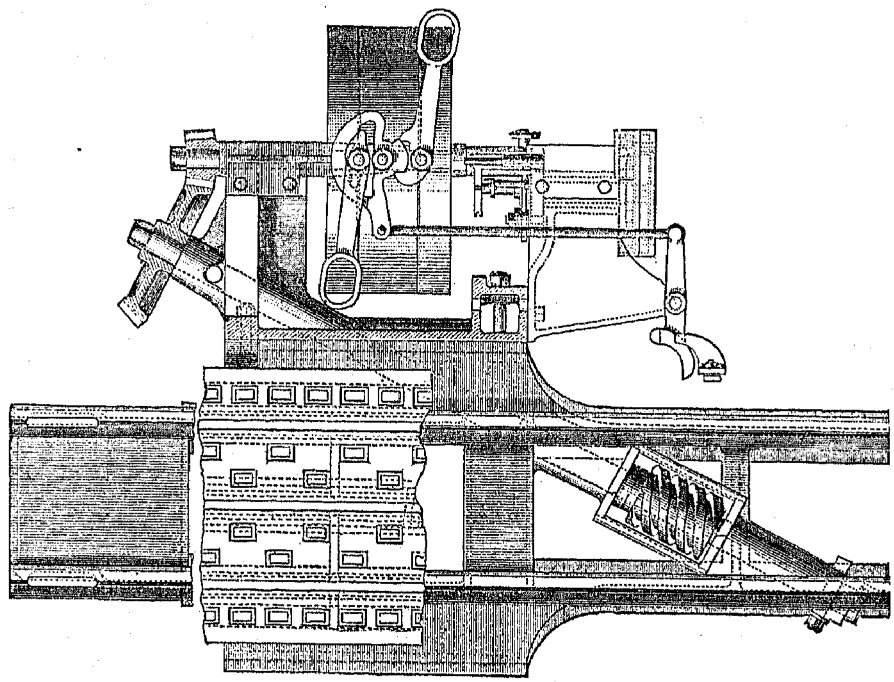

Fig. 239.

the rapid reduction of speed due to the worm takes place after the toothed gears, instead of before. The slower the gears revolve the less noise, chatter, and wear. To accomplish the quick return on the inoperative stroke of the table with two belts is comparatively simple. The usual ratio of quick return is about as one is to two; the return is twice as fast as the cutting traverse. Upon the counter-shaft above the tool are two pulleys whose

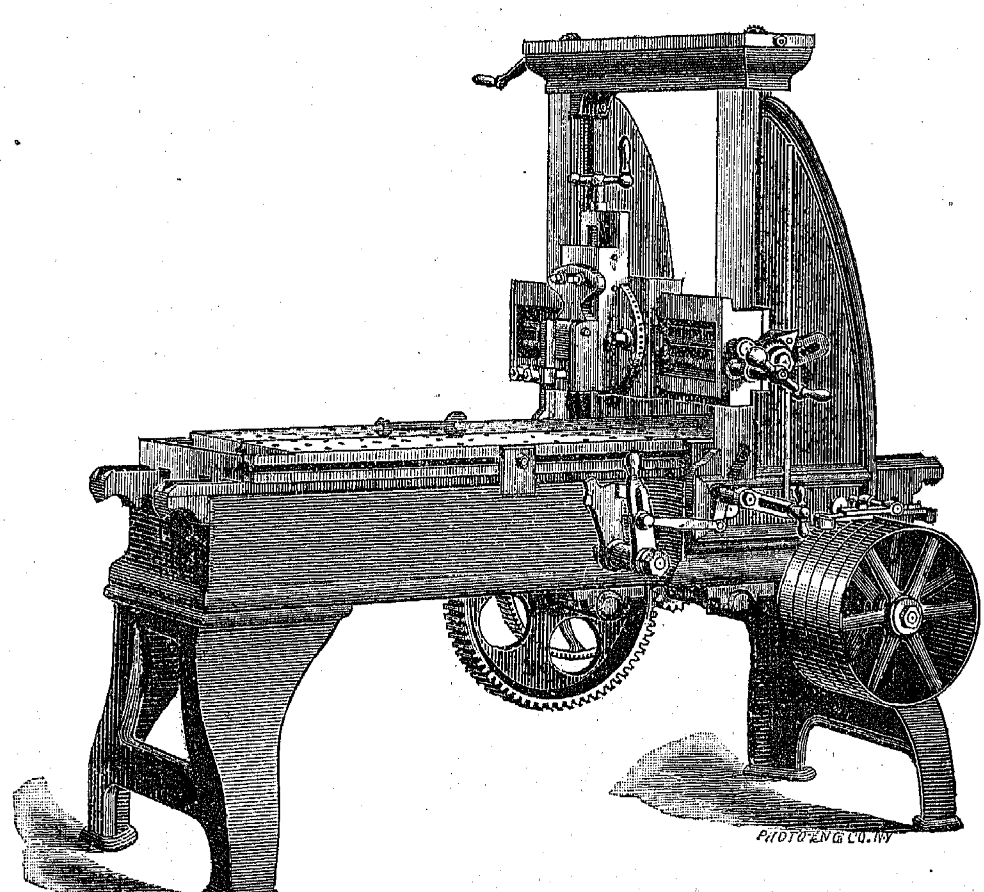

Fig. 240.

diameters are as one is to two. From the smaller one comes the belt for the forward stroke to the pulleys on the machine, while from the larger comes the belt for the return. This belt is crossed or open, according as the other is open or crossed, as determined by the shafting of the shop. The pulleys on the machine are of the same diameter usually. Where both belts are shifted at once, as in some of the smaller planers (Fig. 240), there must be five of them, the two outside and the middle one being loose. This has the advantage that the tool may be stopped without arresting the counter-shaft. On the other hand, the motion of the belt-shifters must be greater. When one belt is shifted upon the loose pulley before the other is shifted upon the fast pulley, as in the newer and better practice, but three pulleys are needed. A wide fast pulley turns between two narrower loose ones. The shifters prevent both belts from getting at once on the driving-pulley, and the shrieking of the belts as they slip in arresting the motion of the train is, to a great measure, avoided. One design has pulleys of different diameters on the machine, by which system four will be required, the two inner pulleys being loose. The system of two belts has an advantage over that using but one belt, in that the train of gearing under the machine is made simpler. Where but one belt is used, the outer wheel will be on a shaft connected to the rack-pinion by a train of gears consisting of an even number of wheels, with large reduction of velocity. The inner wheel will turn loose on the first shaft, and will be connected to the rack-pinion by a train with less reduction of speed and containing an odd number of wheels. When, therefore, there is an odd or an even number of shafts between the belt and the rack the one belt will move the table forward or backward. A loose pulley must separate the other two; therefore the tool may be arrested without stopping the counter-shaft. But the shifting-motion must be ample. Sometimes, to prevent very wide shifting of wide belts on larger tools on this system, two narrow belts were used, four pulleys were required, and each belt was shifted over only one-half the width of the wider belt which would have been required. One form of planer was made in which the reversal and quick return was effected by using external spur-gear from the inner wheel and internal gear from the outer. The internal gear moved the table in the opposite direction from that due to the external, and the speed was changed by the ratio of diameters.

For shifting the two belts in that system at once simple eyes or forks embracing the belts are secured to the rod which receives the cross-motion. For shifting them in succession a variety of devices are in use.

Fig. 239 illustrates one system in plan. There must be a separate shifter for each belt. These are pivoted near the end which is farthest from the belt-eye, in order that a small motion of the shifter-lever may move the belt over a larger distance. The link from the lever, which is moved by the dogs on the table, is attached to a lever vibrating horizontally around a fulcrum-pin. This lever has a tooth shaped on one side, which engages in a space formed in the side of one shifter. This tooth is so shaped as to move the shifter, and after escaping the corner of the space to lock the arm from moving. On the other side of the fulcrum is milled out an internal tooth or hollow cam, which acts upon tooth-like projections upon the other shifter. These profiles are so located with reference to each other that on both forward and backward stroke the belt which has just been in action shall be shifted first upon the loose pulley. Otherwise, large belt-motion would be required.

Another device is shown by Fig. 241. It depends on the principle of crank-motion that the piston moves most rapidly when the crank is at right angles to the axis of the rod. The two shifters are connected by links to pins on a horizontal wrist-plate which are on radii about 90° apart. The wrist-plate receives a partial rotation from the shifter-dogs, and always stops so that the pin connected to the belt which is driving shall stop with its radius perpendicular to the link to the shifter of that belt. By this expedient, for any angular motion of the wrist, the driving-belt will be shifted farthest at first, and may be off the fast pulley before the other is moved on.

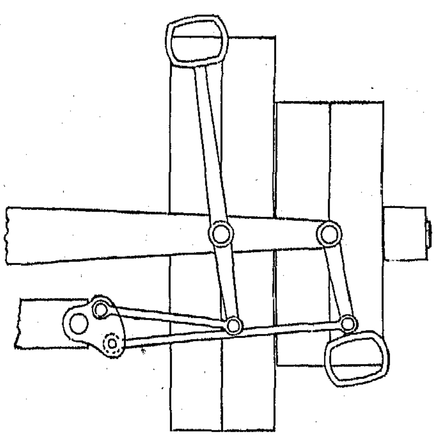

Fig. 241.

Another device has a vertical pin upon the tail of each shifter, which is moved by a groove in the lever from the shifting-dog. This groove is so designed that the pins shall be moved successively upon each reciprocation of the lever (Fig. 245).

In another design a slide receives a motion greater than that required to move the shifters. Truncated pyramids on each side of the slide engage with the double rocking tails of the shifters. The excess of motion of the slide causes the motion of the shifters to be successive, and the upper bases of the projections lock the tails of the latter. In another device the sliding-plate from the dogs has two inclined grooves in it, which operate pins on the shifters.

The planer shown in Fig. 242 adopts a principle different from any of the foregoing. There are two pulleys loose on the spindle. The middle wheel is a double-friction clutch, which may be engaged with either wheel by a slight longitudinal motion, so that the arbor will be turned either by the open or the crossed belt and at the suitable speed. The clutch is moved by a pin on a sleeve upon which turns the inner belt-wheel. This pin receives its motion from a slot cut diagonally in a short sleeve. This sleeve is rotated on its axis by the table dogs, which rotation causes the pin to slide up or down the incline and to throw the clutch in one direction or in the other. This arrangement causes the reversal to be very quiet and instantaneous.

To insure that the shifting devices shall receive equal motion on both strokes of the table the two dogs are often made to strike the levers at different points. The table has less momentum on the cutting-stroke than on the return, since it is moving more slowly. Hence the dog for the motion on this stroke is often made longer, so

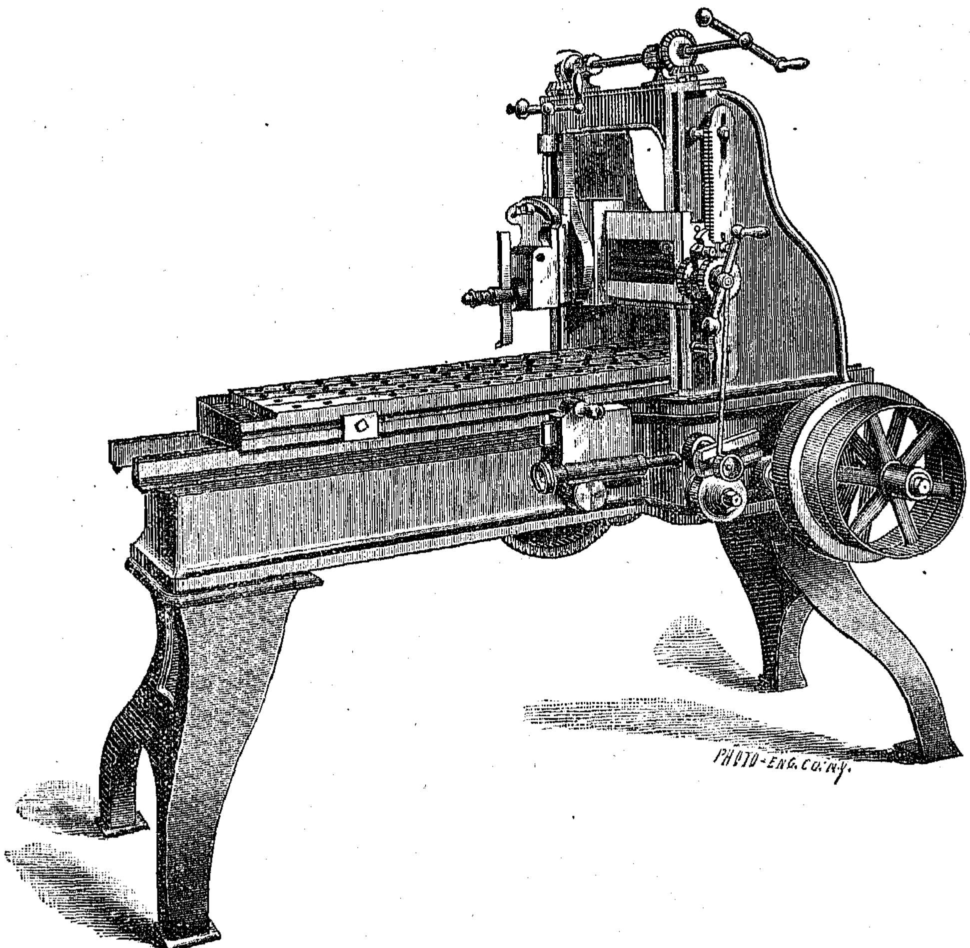

Fig. 242.

as to strike the shifting-lever nearer the center of motion. This will give the same ultimate motion as when the shorter dog of the return traverse moves a greater distance nearer the end. The end of the lever which is moved by the dogs is often arranged with a spring latch-gear, so that the latch may be sprung out of the path of the dog and permit the table to traverse farther than the limit for which the dogs are set (Figs. 237 and 243).

Without this convenience it is necessary to unscrew the dogs when the operator wishes to examine the work in front of the cross-head and tool and to set them anew when the cuts are to be resumed. The shifting-levers have usually a handle for their convenient manipulation by hand.

To obtain the single reciprocating motion required for the feed-motions in all directions is a simple problem. It is solved in two general ways. The motion is either taken directly from the levers which are moved by the table-dogs, or else it is taken from the train of driving-gears by a frictional device. This latter system is perhaps more general than the other, but it may be questioned whether it is preferred for any very cogent reason on small tools. The shifting-dogs and levers should be stout enough for their own duty, to be able to withstand the slight extra strains for feeding. The feed has only to overcome the friction of parts, since there is no cutting strain on the tool when the feed is given, and therefore the shifting-motion may be multiplied, if desirable, to have a capacity for a coarse feed for finishing. When the feed is taken from the train one of the arbors (usually the second) is prolonged outside the bed. Upon this arbor is secured a cast-iron disk, and a second disk compresses a loose washer of leather against it with any desired pressure. This pressure is made adjustable by a screw and nut. The second disk is loose on the arbor, and carries on its face the slotted crank, from whose pin the reciprocating link passes to the ratchet-gear. This loose disk is caused to revolve by friction of the leather, between stops, which permit the crank to make one-half of a revolution at each change of direction in the motion of the train. This also insures that the feed shall be given before the cut begins, and any desired power of feed may be secured by the frictional compression of the leather. The disadvantage of this form lies in the slipping of the disks while the movable one is held against the stops. This consumes a little power, and wears the disks.

Another form (Fig. 245) uses the friction due to compression of a wrought-iron split ring on the periphery of a disk. The ring is split, and is compressed by adjustable springs on the outside. An elliptical pin is fitted in the

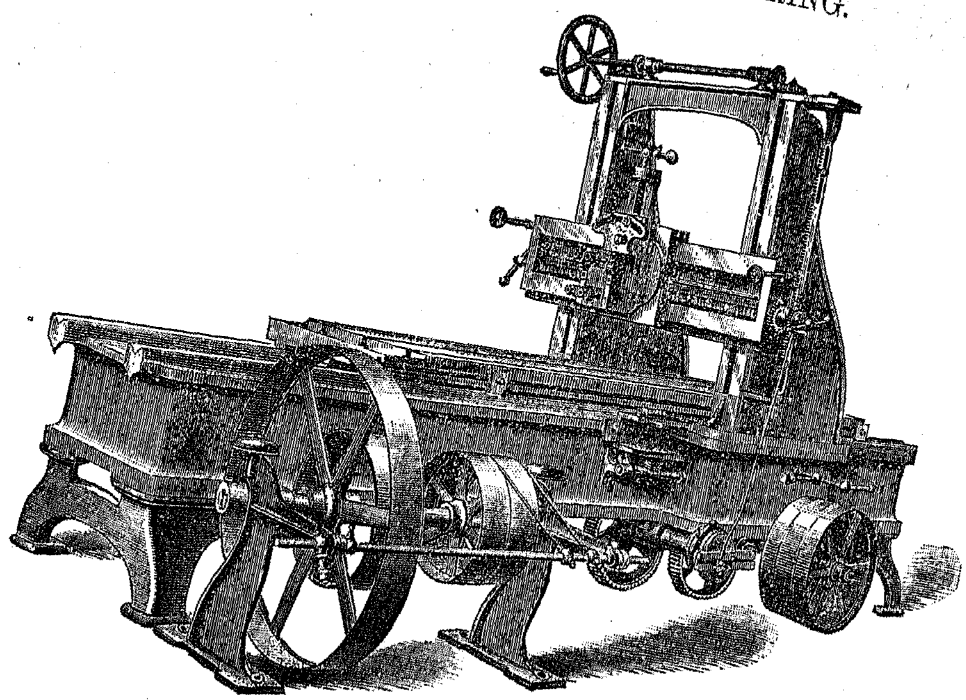

Fig. 243.

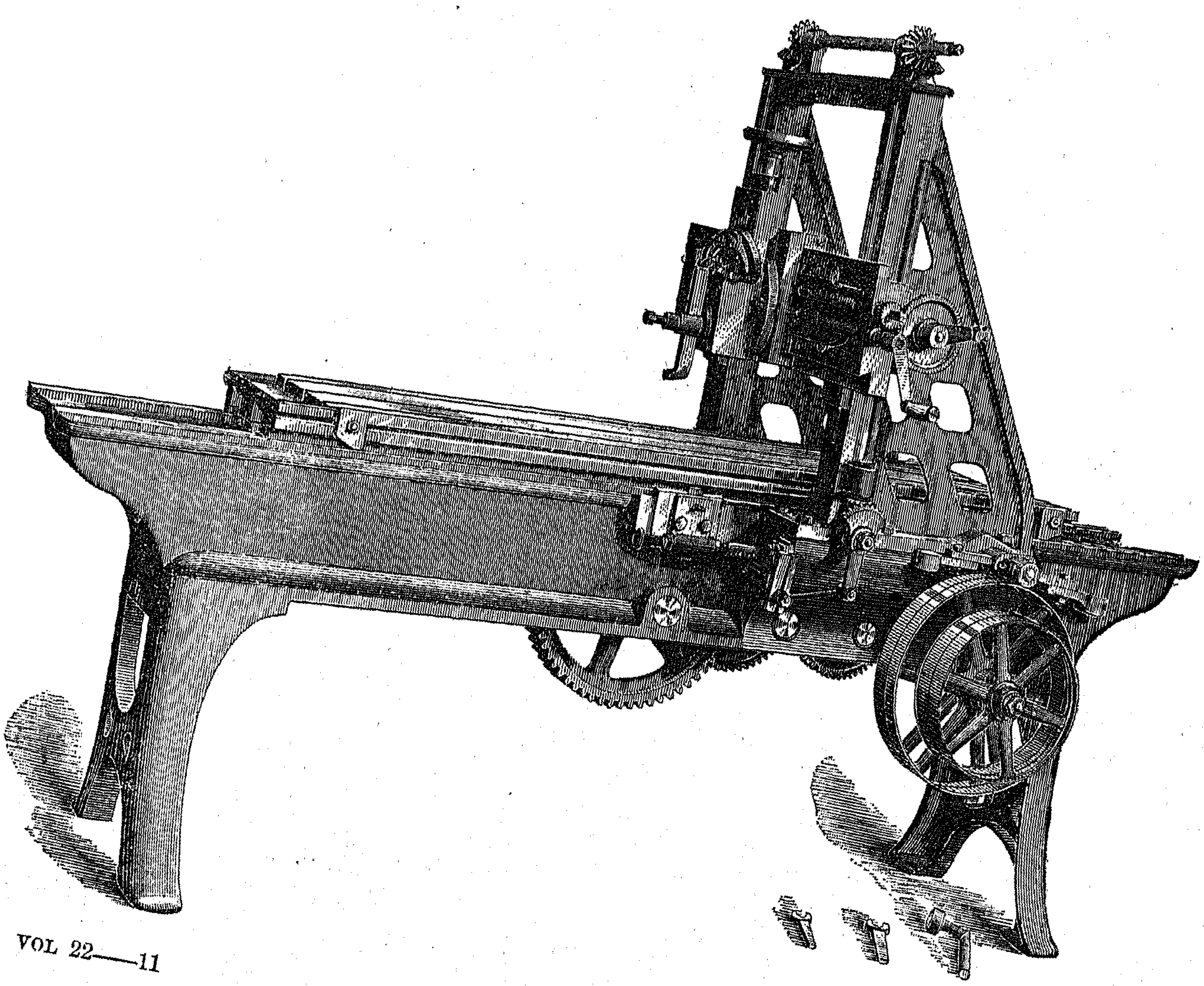

Fig. 244.

split of the ring, which is of such dimensions that the long diameter shall be sufficient to open the split and release the ring. The short diameter of the pin is enough less to permit the ring to close and establish the friction when the former is turned less than one-half around. It will be sufficient to cause the stops to turn this pin partially when the feed is made. The friction will be in a great measure released as soon as the stops are reached. A similar type is shown by Fig. 233. The friction will be engaged by the spring of the ring, when a stop no longer opposes it.

The device of Fig. 246 uses friction only to engage the pawls at each change of motion. A positive motion of the crank-disk is kept up by the ratchet-wheel until the pawl is disengaged by a positive stop. The ratchet-wheel is revolved by a pinion on the front end of the pulley-shaft.

In the planer shown in Fig. 236 the feed-motion is positive from the train, without the necessity of friction devices. A pinion on the second arbor of the train turns a half-wheel. The pinion and wheel may be toothed, or

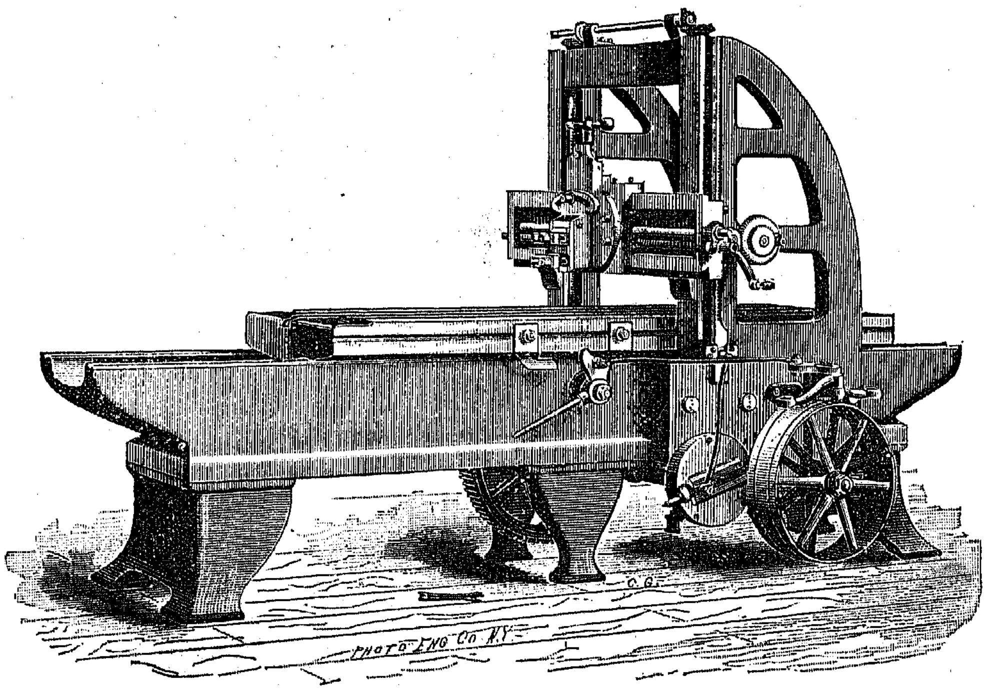

Fig. 245.

in newer practice are made of **V**-friction faces. The semicircle of the wheel is counter-weighted, to preserve its equilibrium. The face of the pinion is broader than that of the wheel. The last three-fourths of an inch of the face of the latter at the two ends of the semicircumference is arranged so as to be effective at the *beginning* of the half revolution, but inoperative at the end. This is accomplished by making this last fraction of the face at each end to be the end of a dog, which swings from a stud on the plate of the wheel and abuts in one direction against a stop. When the pinion on the train reverses, the dog engages with it, and by pulling against the stop the face is drawn into gear. At the end of the half revolution the dog clicks idly over the pinion, until its

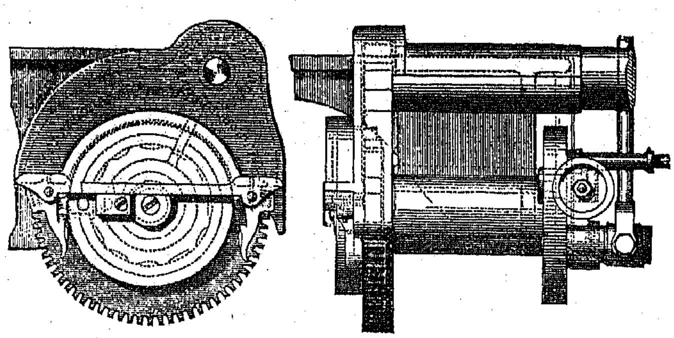

Fig. 246.

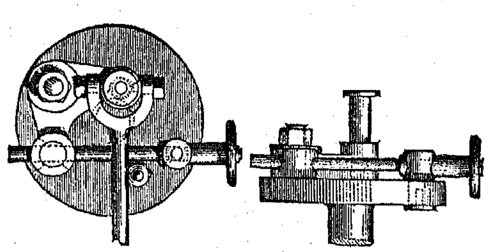

Fig. 247.

direction changes. With friction faces this clicking is noiseless. For the adjustment of the amount of the feed, while the tool is in motion, the pin on the wrist-plate is either clamped by a hand-nut or else is upon a screw. By turning this screw the pin traverses in the slot, and by it may be held at any distance from the center.

A very ingenious device for this object is illustrated by Fig. 247. The milled head on the post will move the upper end of the pivoted bell-crank, by which the pin of the vertical link will be moved and clamped nearer or farther from the center of the motion of the disk.

Were the tool held rigidly at the slide-rest, the return of the work under it would scrape the cutting-edge from behind and dull it. Hence all tools, both light and heavy, have the tool secured to a swinging apron, hinged on a conical pin between cheeks on the slide. This permits the tool to swing outward upon the return of the work, and where the tool and apron are light this arrangement is sufficient. On larger machines, with heavy cutter and

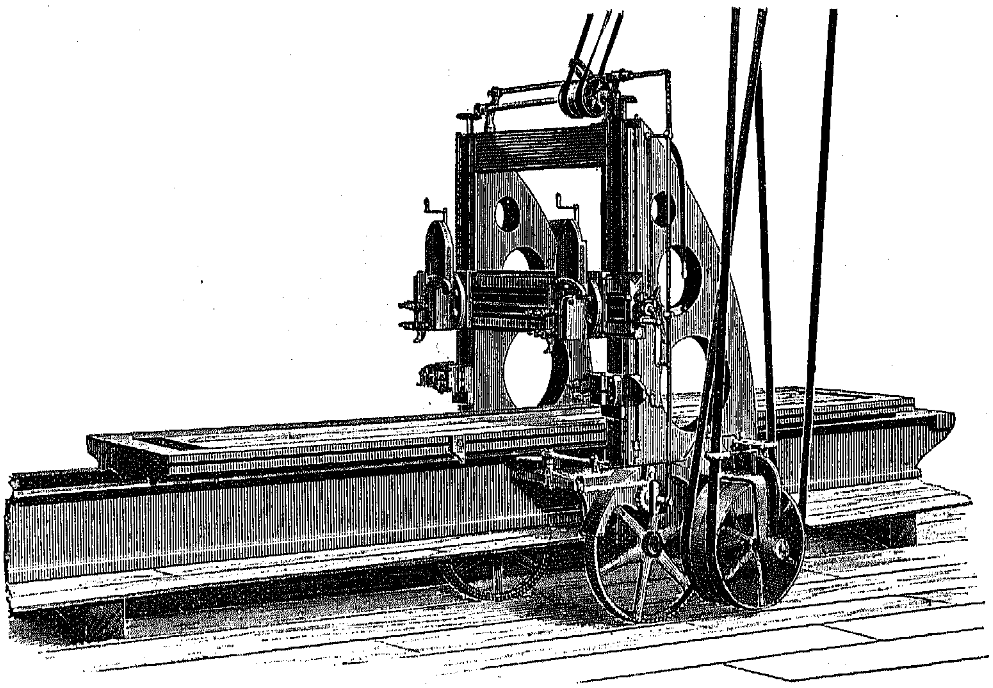

Fig. 248.

apron, the weight of the combination will be sufficient to press the edge with a grinding pressure against the work. It becomes necessary, therefore, to lift the apron and the tool by positive means. There are several methods of

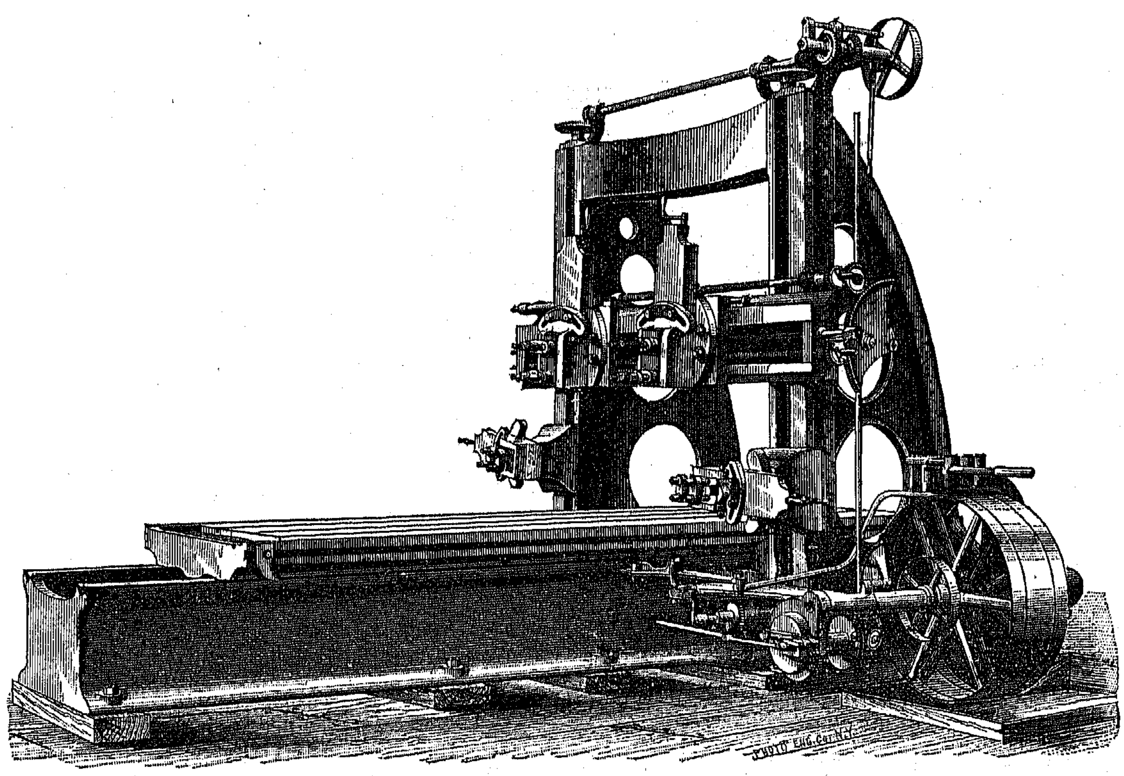

Fig. 249.

effecting this, but all use a cord over pulleys pulled by the feed-levers and kept taut by a weight. The feed-lever pulls on the cord and turns a spiral washer under the apron. The rise of the inclined plane against a twin washer in the bottom of the apron throws the tool forward and up. When the feed-lever reverses, the weight rotates the washer back into its first position. A second arrangement makes the cord lift a knee-lever against the apron by the rotation of a disk or washer with eccentric hole. Still another has a cam on the end of a vertically-oscillating lever. All accomplish the purpose about equally well.

Planers of very large size will have two slide-rests on the cross-head, and an extra rest upon one or both of the uprights (Figs. 248 and 249). An extra feed-rod will probably be required for the second rest on the cross-head, but the rests on the uprights are usually arranged for hand-feed only. These larger tools, being designed for work of great weight from which a heavy chip is to be taken at each cut, usually move more slowly than the lighter tools, and have more wheels in the train which drives the table. The feed also has to be powerful, and the cross-head and rests must be located by power.

Fig. 249 shows the device for lifting and lowering the cross-head by two bevel-wheels, which may be clutched to the shaft of the overhanging belt-wheel to produce motion in either direction. These larger tools are usually built with the rack with **V**-teeth. In these longer trains of gears there is more chance for back-lash in the teeth, which produces, with the elasticity of the belt, a disagreeable intermittance of the motion of the table, which is fatal to the exactness of some work. The design of Fig. 249 drives the table through one pair of gears and the worm which meshes into the rack. The smoothness of the worm-motion is noticeable, and the obliquity of the passage of the worm-shaft through the bed-casting prevents the weakening of the bed by its being cut open to admit of the

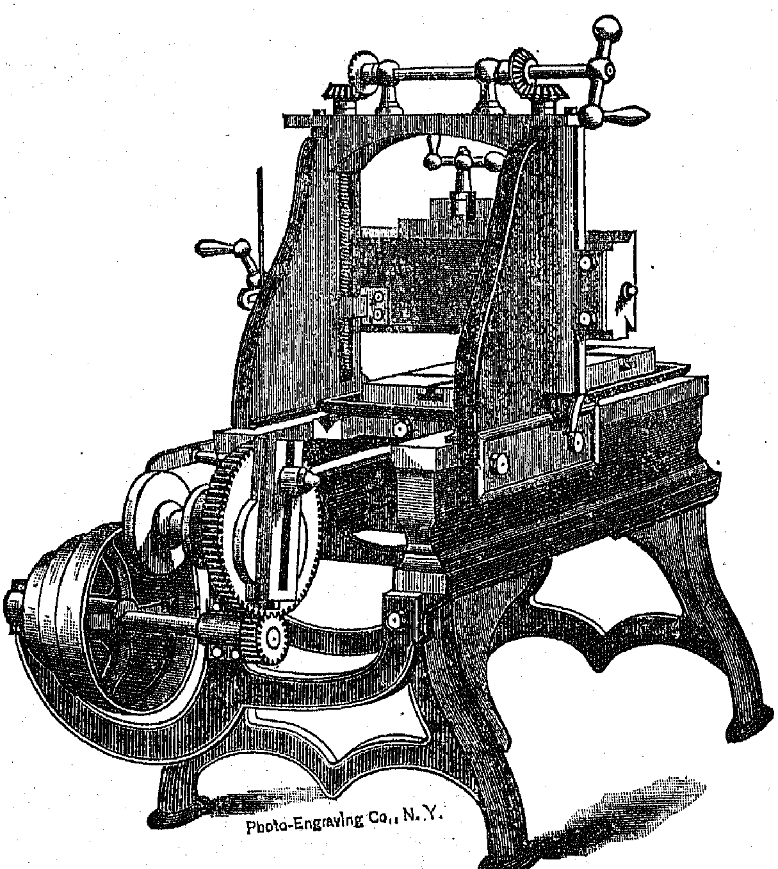

Fig. 250.

gear-train arbors. The rack-teeth are straight, but inclined at about 5° to prevent a tendency to sidewise motion. The thrust of the worm-shaft under the cut is borne by a step-bearing in the rear side of the bed, and that of the quick-return motion by hardened steel collars. The other features are common to the smaller designs of the same builders.

For small work, where the speed may be increased, a great deal of work can be satisfactorily done upon crank-planers. The bed stands high upon legs, and instead of being driven by screw or rack, it is reciprocated by a slotted crank on the cone-pulley shaft. The stroke is adjusted for length by the position of the crank-pin, and for speed by the cone-pulleys. This adjustment of speed is made necessary by the fact that without it the table would move over its travel in the same time, whether the stroke were long or short. This would make the cutting-speed to vary between too wide limits.

The crank is either of the ordinary form, or else of the Whitworth quick-return type, which is employed for shapers (Fig. 250). This latter device results in a saving of time. The tool is usually fed by power for horizontal traverse only, from a groove in a cam-plate. The design of Fig. 251, however, presents all the conveniences of the larger tools. The connecting-rod eye is held in a slot in the under side of the table in these tools, its position being adjustable by a screw in front.

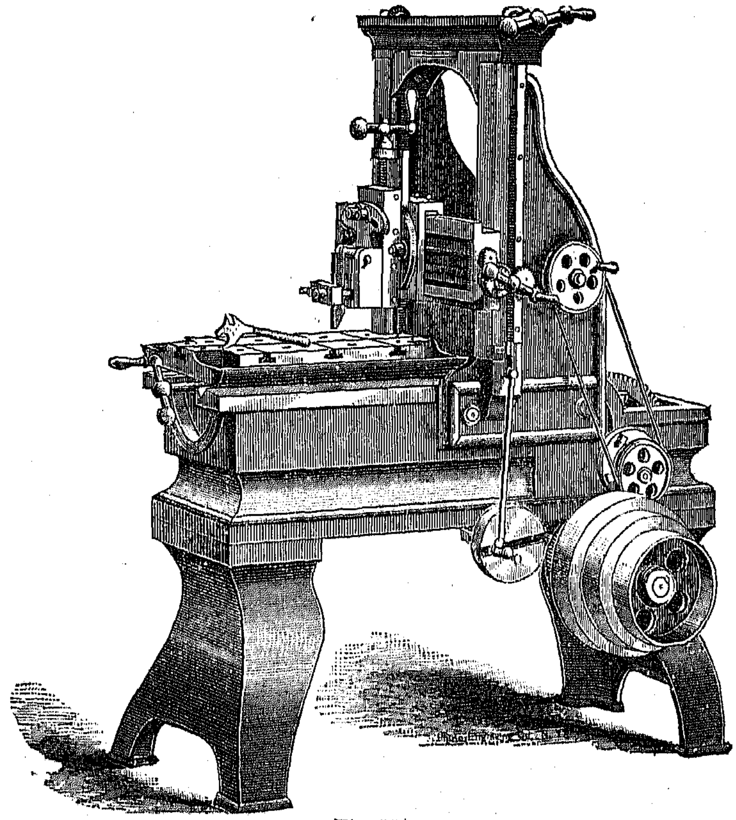

Fig. 251.

This class of machine is much used for brass work and the like, presenting some advantages over the ordinary type of planer, or the shaper, which it much resembles.

§ 27.

SPECIAL FORMS OF PLANER.

To save at least one-third of the time of planing operations as usually done, planers have been devised with two cross-heads. These are held upon two sets of uprights, which may be bolted in T-slots on the side of the bed. Both may be made adjustable (Fig. 252), or only one (Fig. 253). The former shows a novel device for feeding the

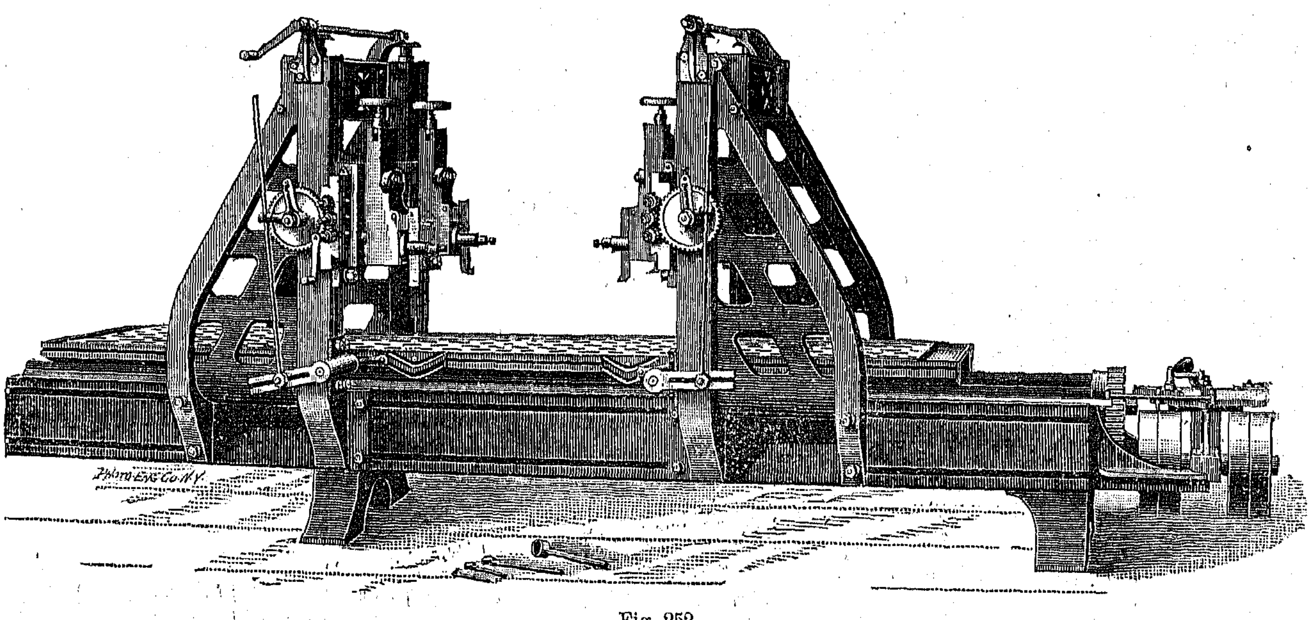

Fig. 252.

slides, and the two designs differ in the method of applying the principle of the screw for driving the bed. Each is driven by two belts. These tools are especially adapted for planing the stubs of engine-work or for other short surfaces upon long work. At least two articles can be finished at each end at once.

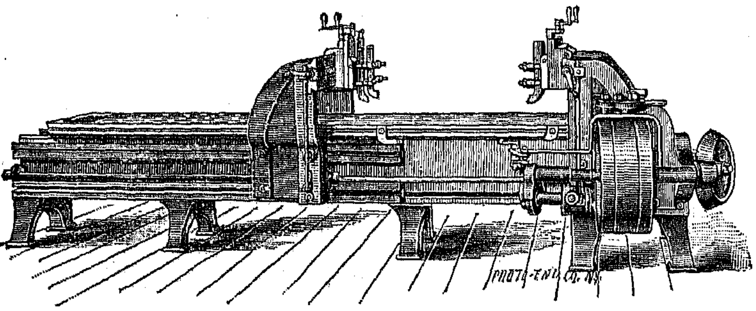

Fig. 253.

Figs. 254 and 255 show two types of machine for edge-planing of boiler- or ship-plate for calking. If not so treated the calking edge must be produced by hand-chipping, which is costly, and will not be so exact. The plate is held stationary by the long vise-jaw in Fig. 254, the two screws at the ends being worked together by the hand-

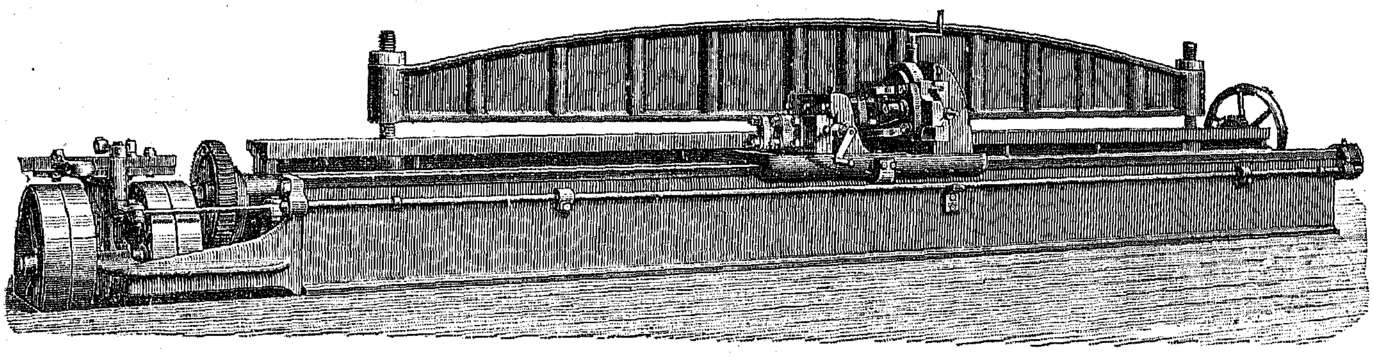

Fig. 254.

gear at the right. Bosses for set-screws are provided in the movable jaw, in case ship-plates are to be beveled after being curved. The other design clamps all work by the set-screws. The tool-carriage is fed by a long screw from open and crossed belts. It is intended to carry at least two tools, and sometimes three. Where two are used one cuts on one stroke and the other on the return. Where three are used, two cut on the forward stroke and the third makes a finishing cut upon the return. This latter has a stop provided, so that when the holes are arranged at first to be parallel with the future edge, all holes shall be at the same distance from that edge. These tools will plane plates 14 or 15 feet in length.

For special purposes attachments may be applied to any pattern of planer. One builder of large engines has applied a boring and facing attachment to his largest planer. By this means engine frames may be planed for the guides and trued at the cylinder ends with one chucking to the table. Locomotive-shops have applied false tops to the tables for planing the links of the reversing and cut-off gear on the Stephenson system. The link has a curvature due to the radius of the eccentric-rod. The link may be clamped to a vise which swings around a center in a line at right angles to the path of the tool, and at the proper distance from the center line of the slot. In another and simpler device a slotted bar bolts to the rear of the cross-head. It projects horizontally at an angle, and a slide on top of a post fits the slot in the bar, and gives the proper rotating motion to the false top.

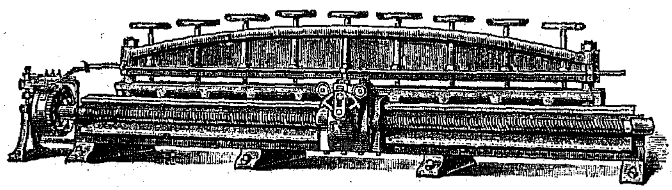

Fig. 255.

The frames and table of planers are often used for the foundation of other machines working with rotary cutters, to which allusion will be made in the sequel. For some special work on locomotive-frames an unique planer has been made, with one upright at the working side as usual, but having the other end of the cross-head carried by an arched frame. This frame is made of open cast iron, in somewhat the form of an arch. The abutments are at the ends of the bed, so that wide work may overhang the table of a smaller planer at the farther side. There are but three or four of them in use.

§ 28.

SHAPERS.

The term shaper is applied to a tool in which the planer principle is inverted. The work is held and the tool traverses across it while feeding-motion is imparted to either or both. The tool is held at the end of a long slide, which receives a reciprocating motion usually from a connecting-rod and crank. This slide is guided by a track or shears, to which it is gibbed, and is made long to resist the increased strain when working on a long stroke with considerable overhang. The tool has a quick return in most cases, either by the Whitworth gear by two elliptical wheels or by two belts from wheels of different diameters.

The principle of the Whitworth gear is shown by Fig. 256. A gear-wheel, S, is driven by the small pinion. The crank-body P does not have the same center as S, but is eccentric to the latter. Its center is C. The center of S is made large enough for the center C to pass through it, as shown by the dotted line. The crank P is not connected to the face of S, but may slide upon it as it is compelled by their mutual eccentricity. The rotation of S, however, compels that of P by the pin in the face of the former which plays in and out in a slot in the tail of the latter. Hence, when the pin is farthest from the center C, the slide connected to R will move most slowly with

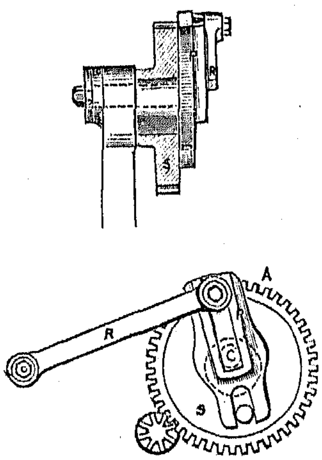

Fig. 256.

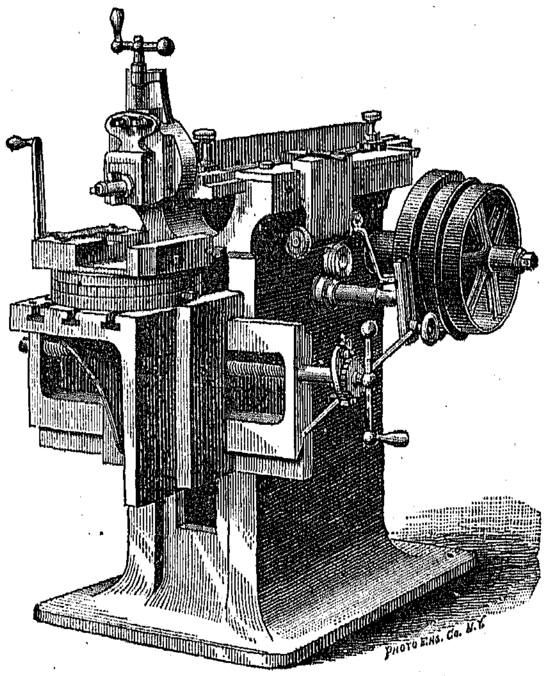

Fig. 257.

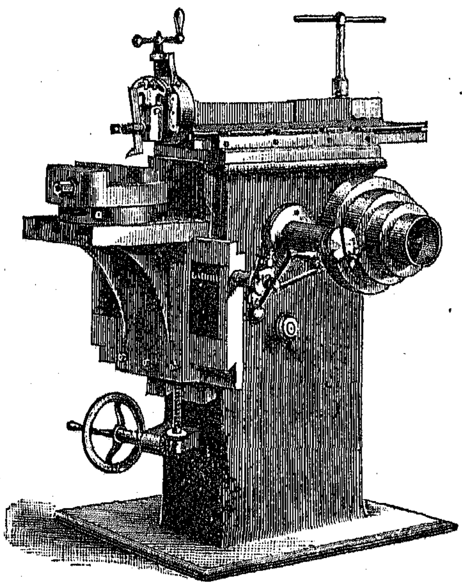

Fig. 258.

the greatest power. When the pin is nearest C the crank will turn most quickly, but with least force for the return stroke. The variation of stroke is accomplished by the slot in the crank-arm. To compensate for the higher speed of long cuts the small pinion is driven from cone-pulleys. In the elliptical-gear arrangement the wheels are horizontal, and turn around their two foci. The quick return will be effected when the long radius of the driver turns the short radius of the gear which carries the crank-pin.

The shaper shown in Fig. 257 has the tool-slide driven by a pinion which meshes into a rack upon its under side. The pinion is driven from either of two belt-wheels driven by open and crossed belts, to either of which it may be clutched by a double-friction cone, precisely as in the planer built by the same makers. This makes the tool the most direct inversion of the planer, and permits the length of stroke to be varied without stopping the machine. The position of the slide relative to the crank is made variable in the other forms by a long slot in the side of it. The pin for the free end of the connecting-rod may be clamped to any part of the slot.

The shaper appears in two forms, the pillar-shaper (Figs. 258 and 259), and the traveling-head shaper (Fig. 260). The pillar-shaper has the power-feed to the work given horizontally only. Vertical or angular feed is given by hand. The whole front has a vertical adjustment by screw and hand-wheel. In another form (Fig. 261), the slide is arranged vertically to secure stiffness from depth in the overhang. The table in this tool is made with a vertical face, to which work may also be bolted. The fly-wheel is preferred by some builders, in order to equalize the active and inactive strokes.

The older form of horizontal shaper belongs to the pillar class.

The shaper with traveling head is built for the larger services. The cone-pulley shaft is splined, and the head which carries the tool-slide carries also the driving-gear and crank. The whole head is fed by a screw along ways on the top of the frame (Fig. 260). The feed is by a pawl and levers, and it is so arranged that the feed shall always be given at the beginning of a cut, and not at the end or in the middle. There are two tables, to which an object may be clamped vertically or horizontally, or to which any vise or centers may be applied. There is also a mandrel

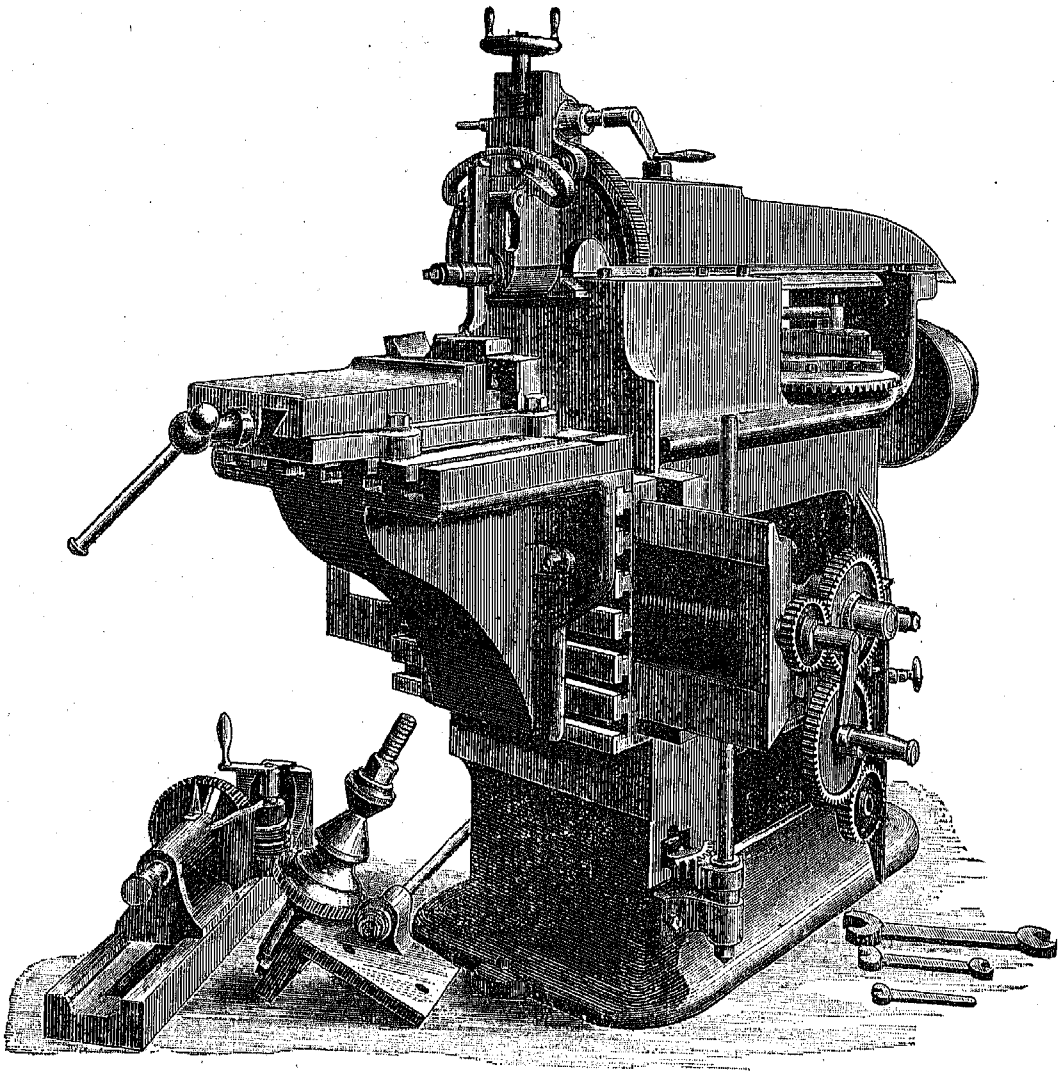

Fig. 259.

with cones for cylindrical work. The tables have a vertical feed-motion, and the tool may be fed vertically or at an angle, or may have a circular feed for concave or convex surfaces. The tool-feeds are given by hand.

Fig. 262 illustrates a similar tool, where the circular, vertical, or angular feed may be effected automatically. The stops give motion to the rod which is connected to a ratchet on the feed-screw by universal joints. The saddle, or head in this tool has quick hand-wheel traverse by the rack on the inside of its track. One of the tables is arranged to have a swivel top, interchangeable with the vise and centers. Fig. 263 shows a tool with similar capacities. Sometimes shapers are made with two heads upon one bed-plate to operate on both ends at once of long work, such as engine-rods and the like. These are called double-shaping machines.

Shaping-machines are especially applicable for small work, or for the finishing of small areas on large work. They are also adapted for finishing the curved surfaces of cranks or of levers with bosses upon them. They will also work rapidly on polygonal work, held in the centers. They do a variety of work which the planer could only do with less economy of time, and with less ease of management, beside requiring more power.

The fundamental principle of the shaper is often resorted to for work which is relatively very large as compared with the tools which are to operate on it. The work is bolted fast to the floor-plate or a bed-plate, and a tool is made to slide in front of the work and receives the proper feeds by hand. The tool may be held on a planer-bed which reciprocates at the side of a heavy casting.

A tool specially adapted for this class of work consists of two parallel rails which form the bed. Between them is a pit, in which may be laid the large work. The insides of the rails are fitted with inclined lugs and brackets, so that the work may be held and adjusted parallel to the shears on top of the rails. On the upper side of these

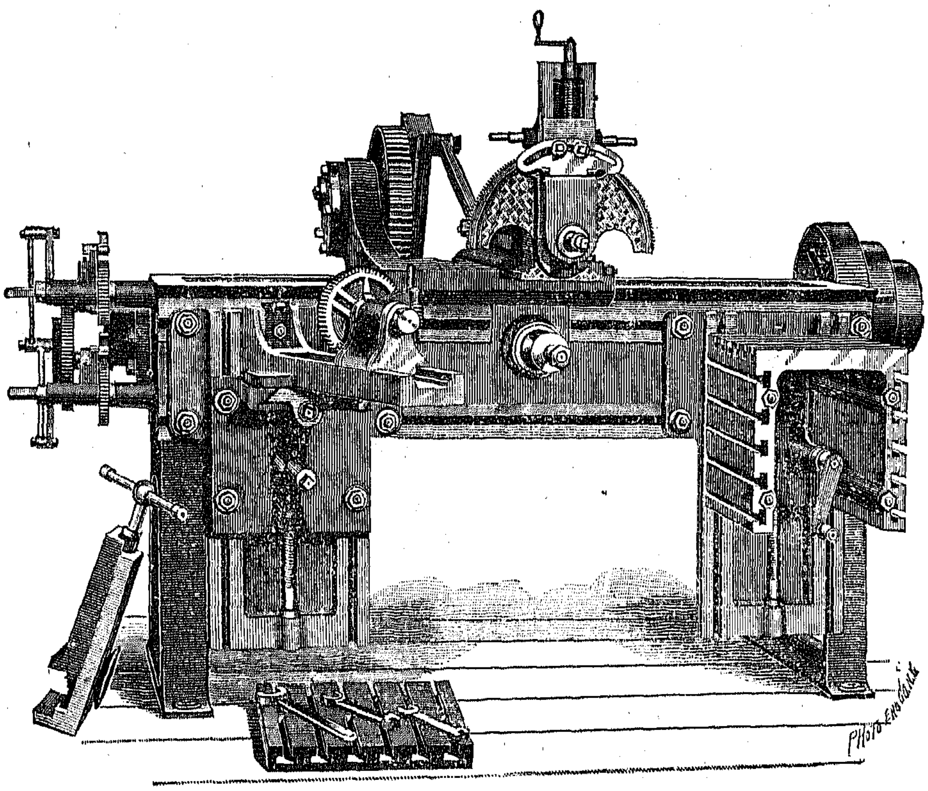

Fig. 260.

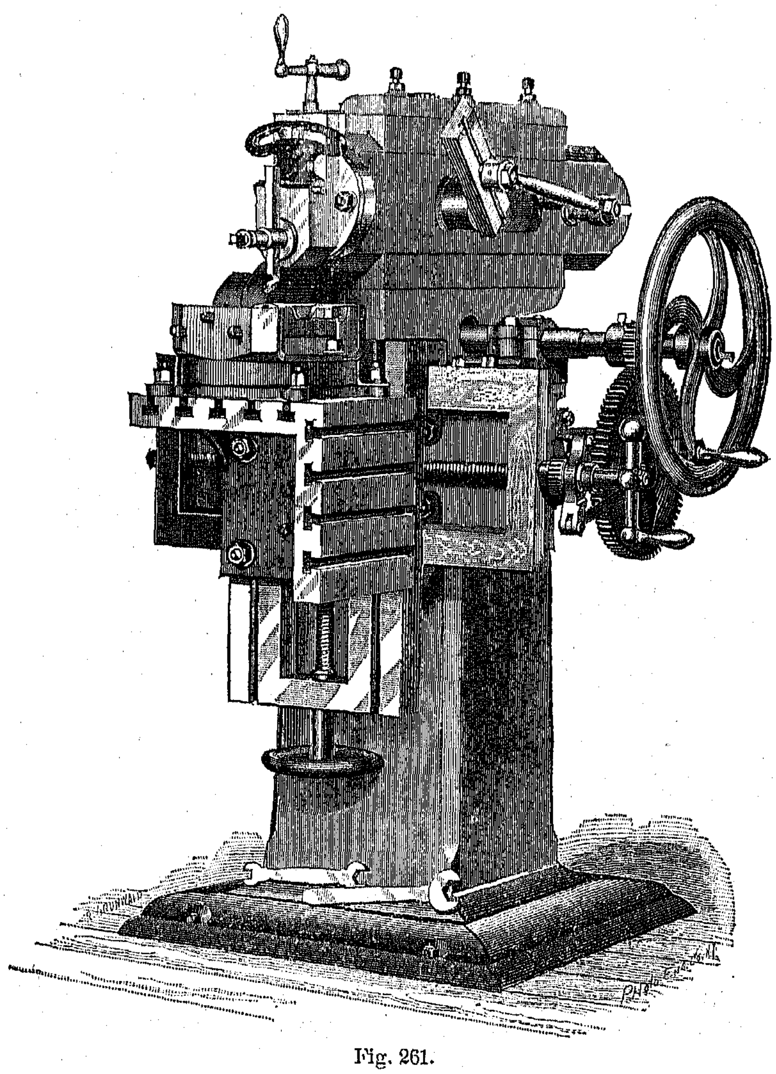

Fig. 261.

rails slides a stiff cross-rail spanning the pit and carrying shears and a saddle for holding tools. The cross-rail receives longitudinal motion along the rails by two screws between the shears of the primary rails driven by bevel-

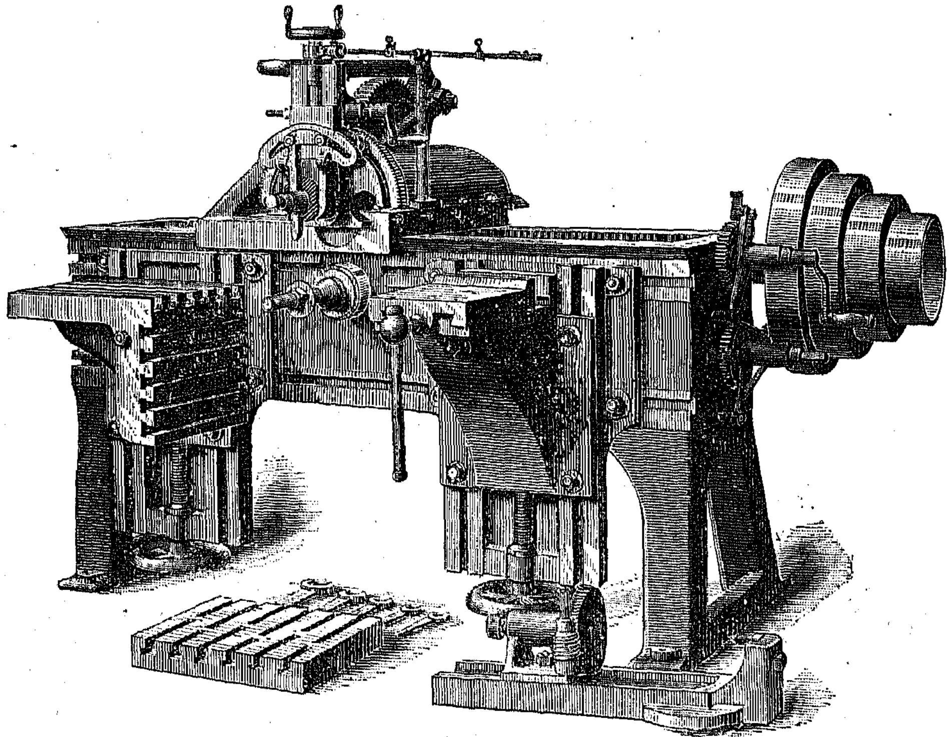

Fig. 262.

gear from the driving-shaft at the head. A very ingenious and simple form of holder keeps the horizontal screws from sagging, as the cross-rail nuts recede from the center, and so prevents jumping at the cut. This tool is particularly adapted for work upon heavy engine bed-plates.

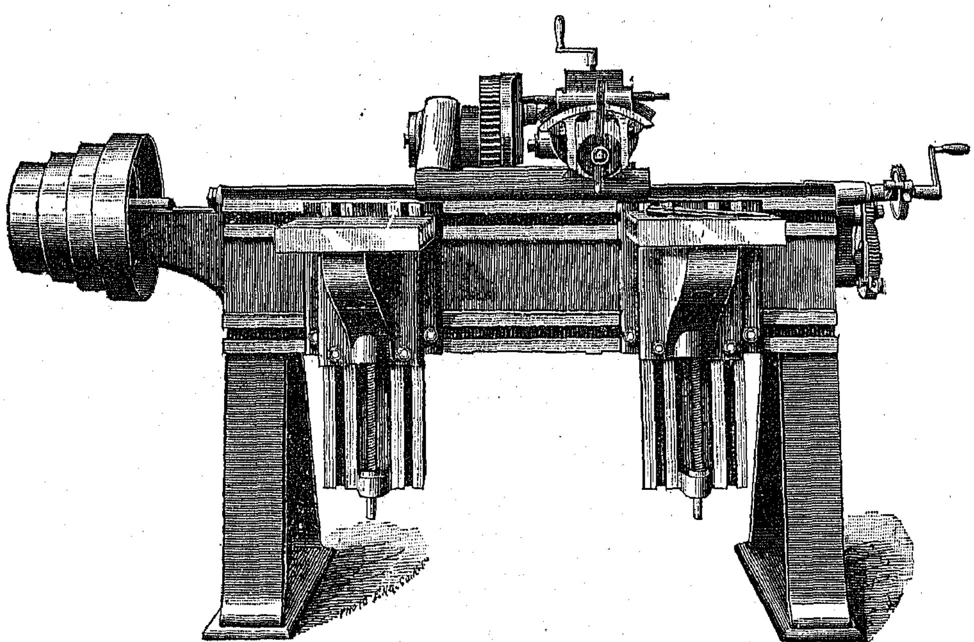

Fig. 263.

§ 29.

SLOTTERS.

The term slotting-machine is applied to a shaper with a vertical cutting-stroke. They are so often applied to the cutting of key-ways and similar vertical slots that their name has come from that one function.

The tool-slide is guided by the dovetail slides in front of the machine. In two designs these guides are adjustable, and may be brought down nearer the table to prevent any spring from the long overhang (Figs. 264 and 265). The reciprocation is derived from a slotted crank or wrist-plate, to which a quick-return motion is imparted by elliptical gear (Fig. 269) or by the Whitworth device. The slide-pin is adjustable in a slot, in which it may be clamped by a nut, or it may be carried upon a screw (Fig. 266). The tool illustrated has a convenient method for turning the adjusting-screw. The strain on the tool is in the direction of its length, consequently it needs to be clamped very firmly against the slide. This is accomplished in the smaller tools by means of two heavy set-screws. Not infrequently the cutting-edge is a simple "bit," carried in a large holder, which gives ample hold for the tool-screws. To avoid the dragging of the tool-point on the up-stroke, which its spring under the strain of the cut is certain to cause, the bit may be hinged in its slot in the holder, and fall away from the work when lifted. A

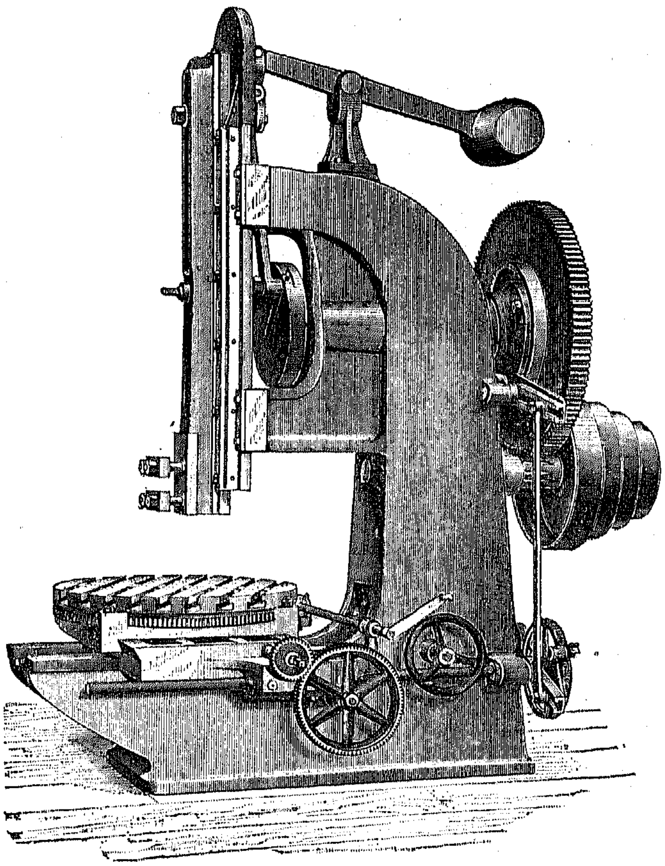

Fig. 264.

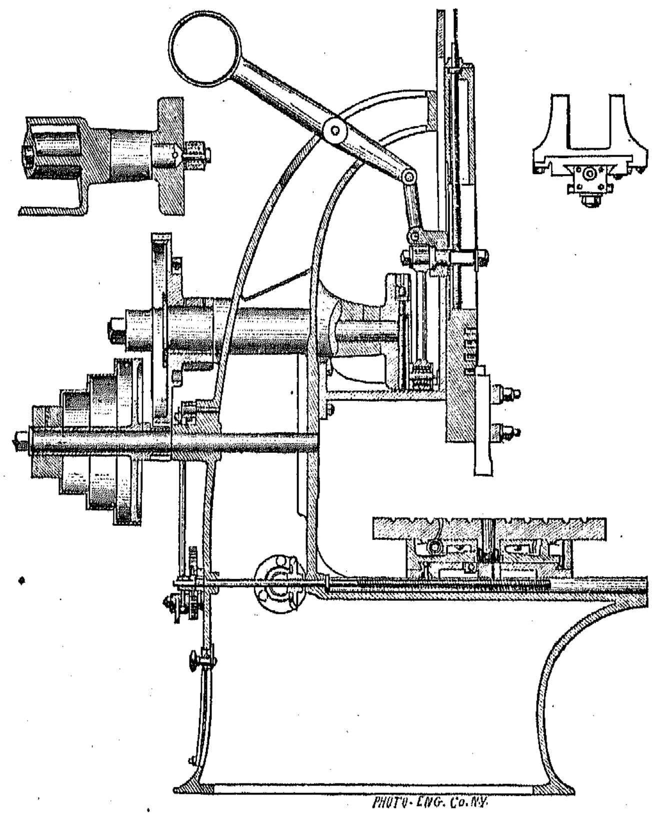

Fig. 265.

spring forces the bit against the shoulder when it is released from its work (Fig. 267). For larger work an apron may be bolted to the end of the slide, acting similarly with the larger tool (Fig. 268). In the tool shown in Fig. 269 an especial device for the relief of the tool is one of the features. On the inoperative stroke of the feed-levers a motion is given to a screw of steep pitch which backs off the work from the tool-point. When the tool is up, this steep motion is restored and the feed is given in addition by the reverse motion of the levers. In this tool, and in that shown by Fig. 264, the adjustment for the slide-pin is made by the hand-crank on the squared arbor in front. A pair of bevel-wheels turns the screw on which the pin is borne. The quick return is effected by elliptical gear.

The slotter tables have three motions. They move forward and backward, to the right and left, and in addition will turn around a center by a tangent-screw combination. To prevent undesired rotation the circular top of the table may be clamped to the upper traversing slide by grooves in its periphery. The feed is given by a slotted lever, worked by a grooved cam on the crank-shaft. This gives motion to a dog-lever, which may turn slip-gears loose or with splines on the various arbors, which work the tables by screws. The tool-slide is counterpoised by a weighted lever connected to it by a link.

Some of the larger slotting-machines are driven by a rack upon one side of the slide. This rack is either with straight teeth, or the teeth may be made of the V-shape for smoothness. The designs of this latter class have the pinion for the rack driven by a worm on the belt-wheel shaft. There are pulleys of different diameters on it for the quick return, with open and crossed belts shifted separately. The stroke is controlled by dogs in a slot of the slide. Some of the older and larger slotters attain the quick return from one belt. This is shifted from a pulley fast to a shaft which carries a small bevel-wheel, to a pulley on a sleeve turning on the first shaft, which carries an equal bevel-wheel, facing the other way. These bevel-wheels turn others of different diameters on the first shaft of the pinion-train, and thus operate to reverse and to cause the quick return, when the belt is shifted by the motion of the tool-slide.

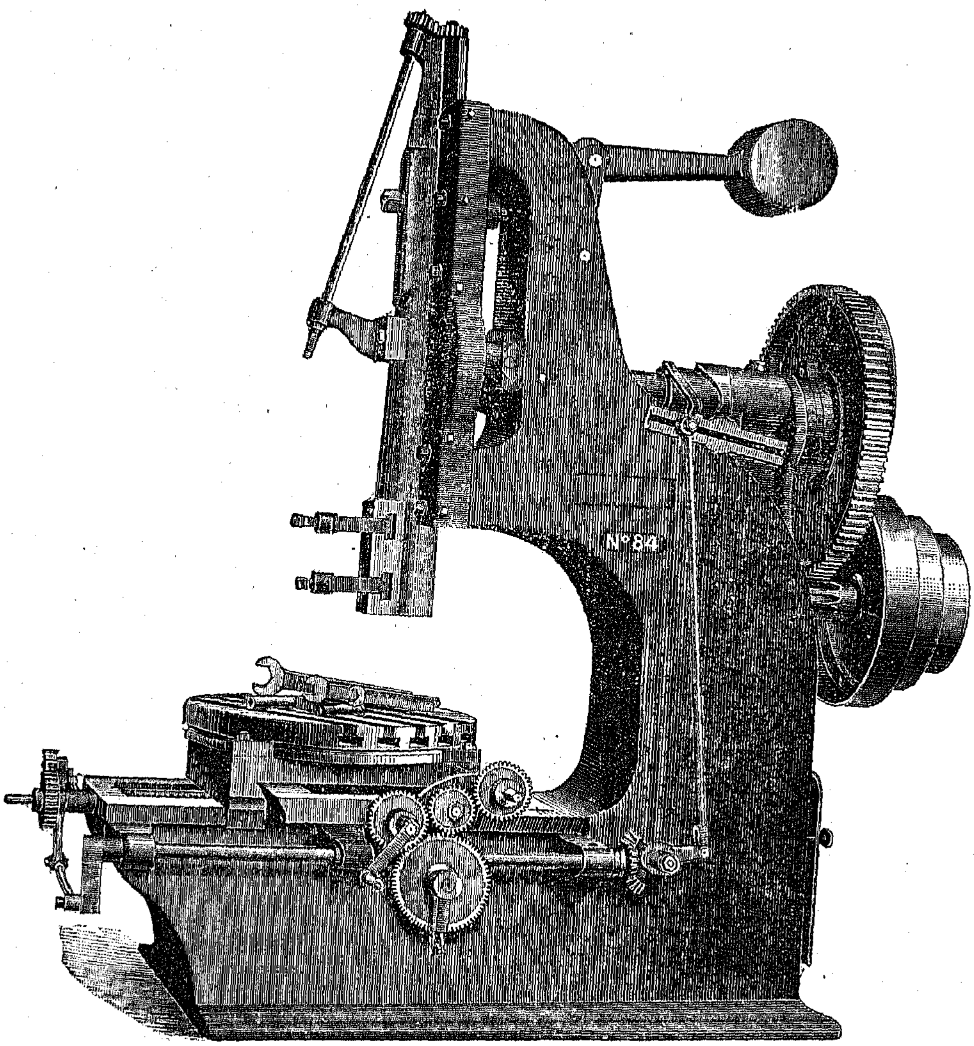

Fig. 266.

For the very largest slotters, a screw of steep pitch moves the tool-slide. On a tool of this class for the heaviest work, the piece is chucked to a heavy floor-plate, and the upright which carries and guides the holder

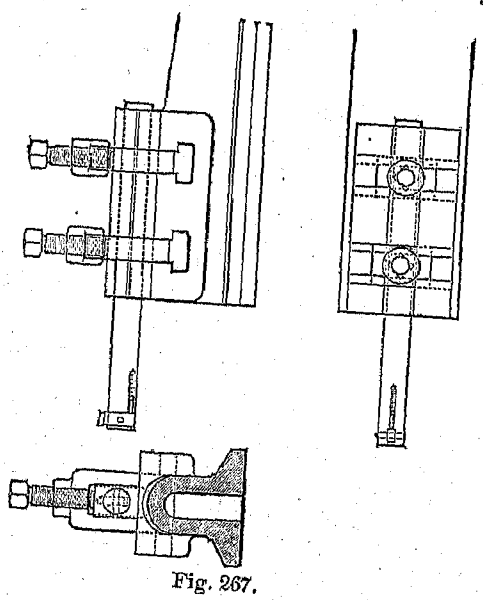

Fig. 267.

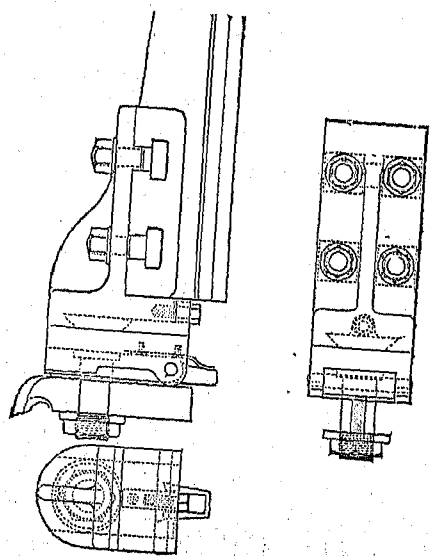

Fig. 268.

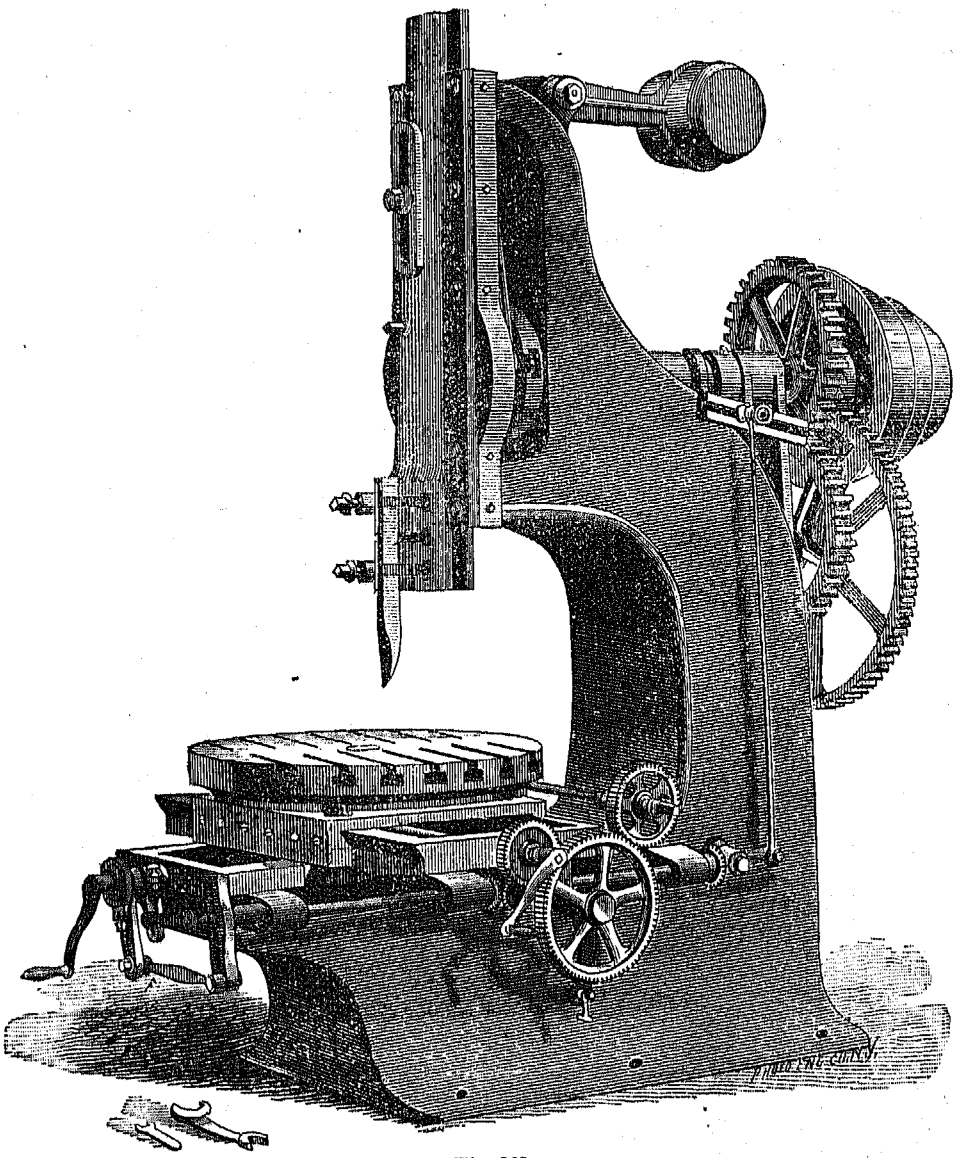

Fig. 269.

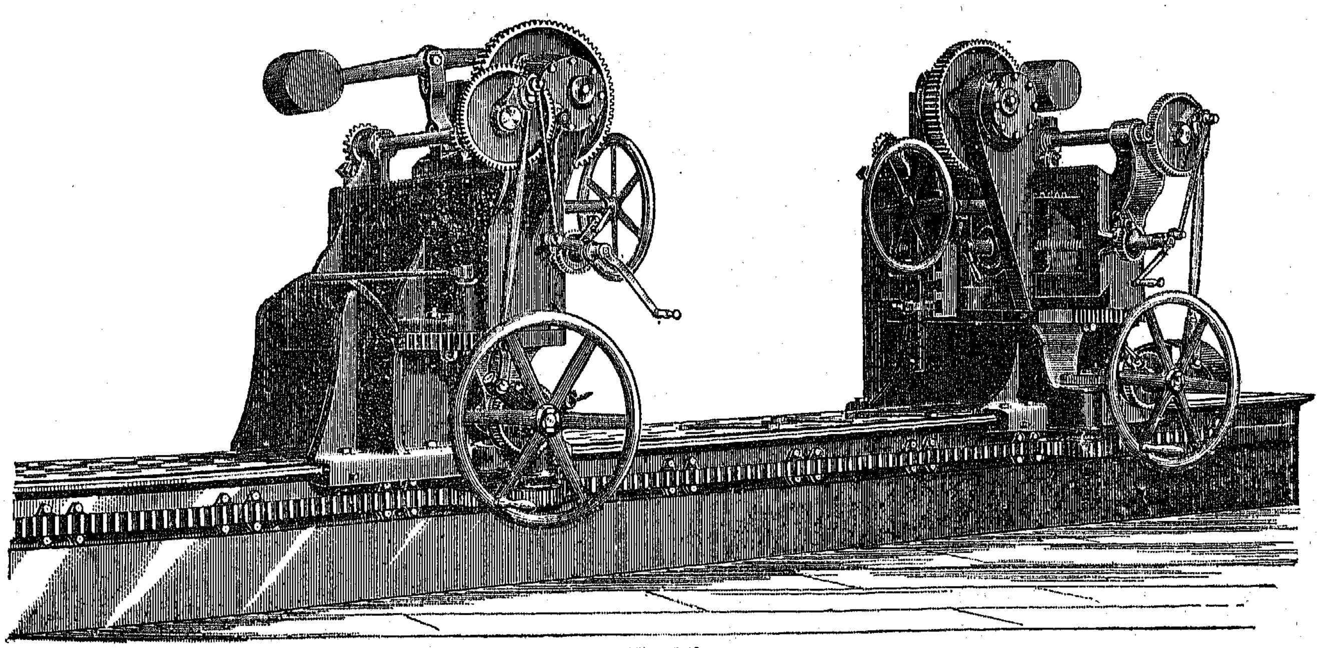

Fig. 270.

slides in front of it as fed by a screw. The quick return is given by two belts to a geared splined shaft in the bed below the upright which drives the cutting-screw. The shifting is effected by dogs on a horizontal slotted disk, and the feed is controlled by shields which may admit any desired engagement of ratchet-dogs in either direction. Some heavy slotters, self-contained, have been built with two heavy pillars bolted to the bed-plate which carries the compound table. These pillars are at the two ends of the bed, and support a heavy entablature upon which the train of driving-gear is carried. When these tools are used for heavy profiling, the cutter is pivoted in the holder between cheeks. The long tail of the cutter acts as the spring of the smaller holder previously shown, to permit release on the up-stroke, and to bring the cutter to the shoulder of the holder for the cut.

Fig. 270 illustrates a special form of slotter for dressing the welded frames of locomotive-engines. The two heads face each other, and are driven and operated separately from the splined shafts at the rear. The slide is borne upon the cross-rail, and has automatic feed across the table, while the entire head may receive longitudinal

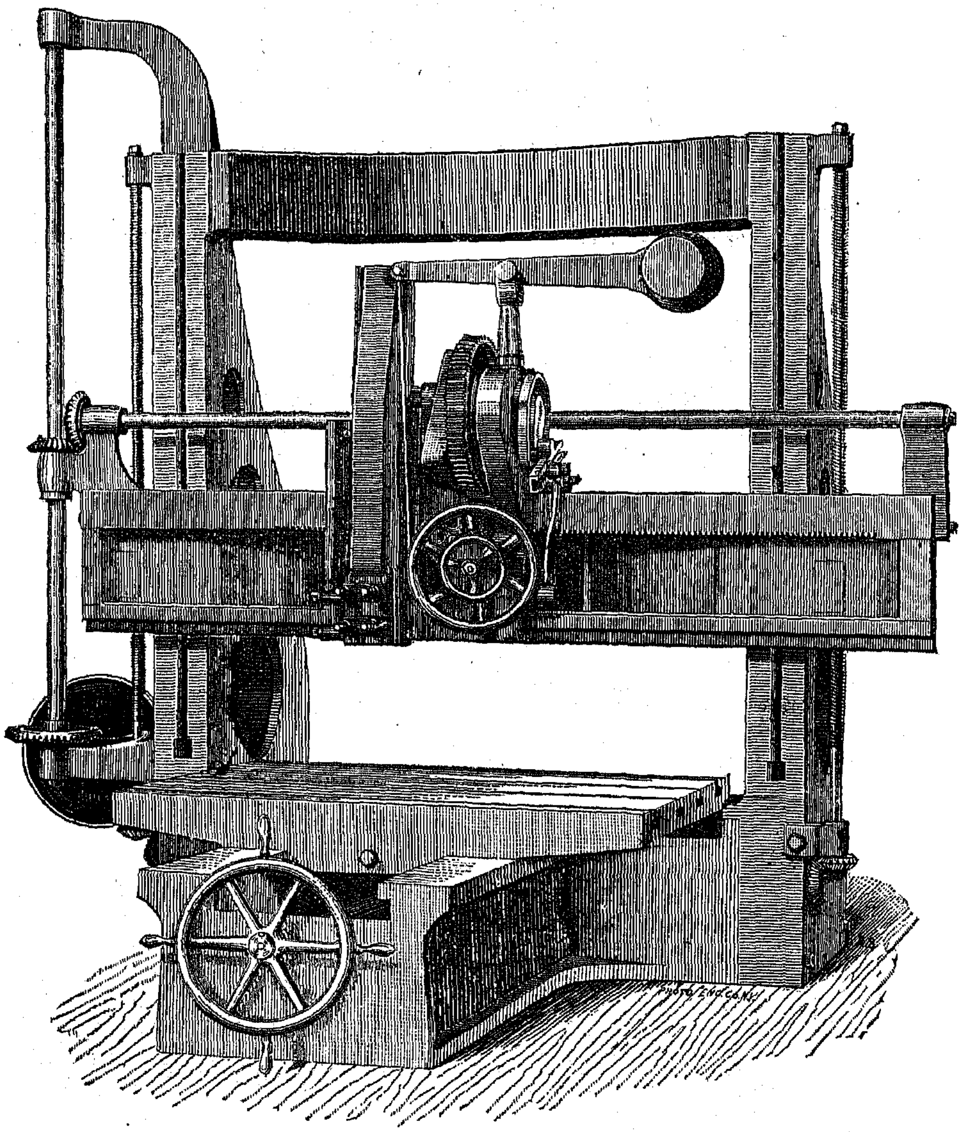

Fig. 271.

feed. The feed-cam is made adjustable upon the gear-wheel which turns the slide-crank to bring the feed in any desired relation to the end of the stroke. For slotting the jaws for the boxes of the driving-wheel axles the heads have an angular adjustment by a pinion and sector, so as to cut obliquely to the line at 90° with the axis of the bed. The saddle has a rapid motion by hand-wheel and rack.

Fig. 271 shows another form of plain traveling-head slotter. The slotting-machine is especially adapted for profiling of heavy work, especially where the profile is much broken. The work may be secured to the table with ease, since gravity assists in holding it there. The table also opposes a direct resistance to the cut, so that the strain of holding the work does not come upon the chucking devices with increasing leverage as the dressing progresses. Large cranks and similar work could be as easily dressed into shape upon no other tool, and for cutting off and cutting up scrap for reforging it serves an admirable purpose.

Fig. 272 shows a tool upon the dividing line between the slotters and the milling-machines. It is for cutting key-seats and similar work. The cutter reciprocates with a quick-return motion from the crank and slotted lever.

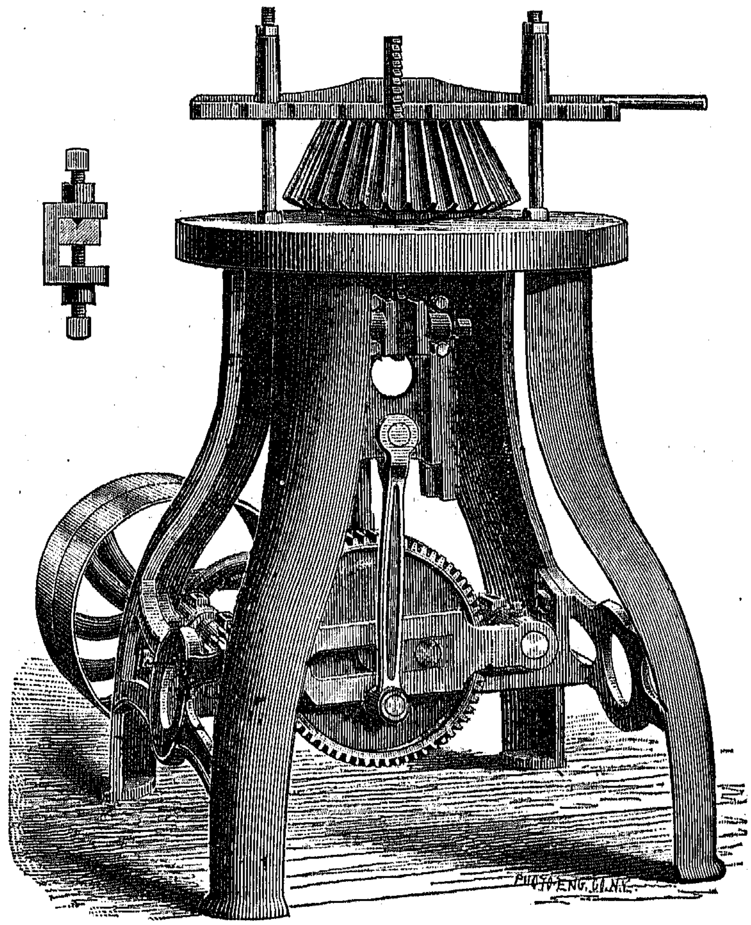

Fig. 272.

The cutting is done by the teeth on the point of a bar which resembles a developed milling-cutter. It can, of course, pass through a hole of quite small diameter.

§ 30.

D.—MILLING-MACHINES.

The term milling-machine may be applied generally to all metal-working tools operating with serrated rotary cutters. Where the cutter is very thin, the machine becomes a metal saw; where especially adapted for one operation, it is often known by a special name; but it still retains enough fundamental features to justify its classification with the typical machine.

The use of the milling-machine is attended with certain conspicuous advantages. These are the result of the revolving cutter, and the resulting elimination of spring in the tool. A great saving of time results from the continuous action of the cutters. There is no return or inactive stroke as in the reciprocating tools. The cutting-edges are very near to their points of support. Therefore exactness of dimensions may be insured and uniformity in duplication of irregular shapes. Again, the cutting-edges of the rotary cutter compel an outline of the work whose form accords with that of the cutter. Hence, if a pattern of cutter be fixed upon by a skilled mechanic, the reproduction of duplicate forms can be intrusted to a less skilled operative. Provided only the cutters are maintained in shape, and the work is properly chucked, the machine can be worked to stop-gauges without the repeated application of standards. For these reasons, the milling-machine in its various forms has become an essential in the manufacture of exact machinery. Operators become easily accustomed to working to a thousandth of an inch, and for fire-arm, electric, and sewing-machine work they have revolutionized the practice of earlier days.

One of the earliest forms of milling-machine for gun-work is illustrated by Figs. 273 and 274. In both the machines shown great improvements have been made over the original machine as made many years ago. The driving-spindle rises and falls in the uprights, controlled either by two screws geared (Fig. 273) or by one screw, equalized between the two boxes by a cross-head and stiff plungers (Fig. 274). Lost motion is prevented by the