MILLING MACHINES

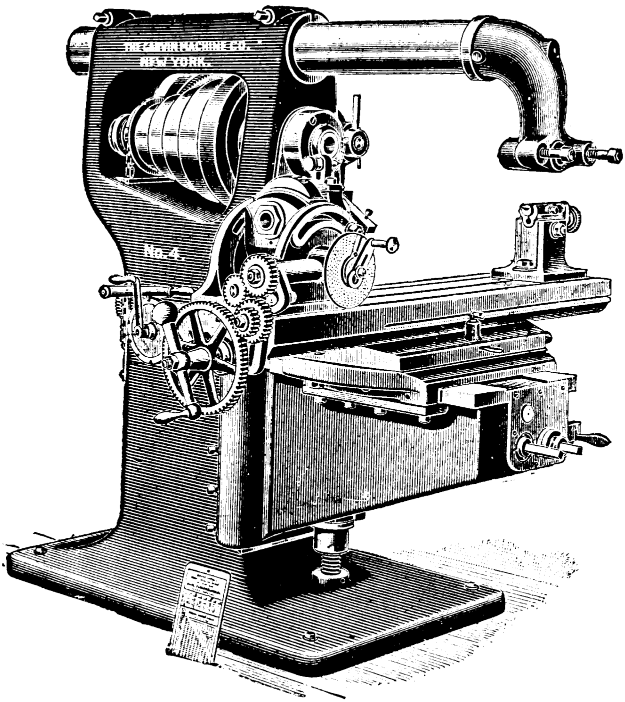


Fig. 178.

MILLING MACHINES.

A milling machine is a power machine-tool for shaping metal by means of a cylindrical cutter or serrated spindle.

No special tool has come more rapidly to the front in recent years than the milling machine; by its use a large variety of work which was formerly done by the planer, shaper, and by hand, is now performed on various types of these tools.

A milling machine has been defined as "a whole machine shop in itself"; it has a movable table, to which the work is fixed and on which it is brought to the cutter; it is fitted with index-plates and other appliances for securing accuracy in the work executed.

Milling is nearly identical with grinding; the former is a cutting and the latter an abrading process; the milling machine resembles in its action a high type of emery-grinder; the rotating cutter in the grinder being, however, of emery, while in the milling machine it is a steel cutter, the latter producing plain, curved or special formed surfaces on the material operated upon.

Metal may be cut away by a rotary milling cutter at from four to ten times the speed at which it can be cut in a shaping or planing machine.

A "universal milling machine" is shown in fig. 178; this is capable of cutting spirals on either taper or parallel work, being provided with an index head arranged with suitable gearing or feed motion to rotate the work while it is travelling beneath the cutter; hence, when these two feed motions act simultaneously, the path of the work beneath the cutter is a spiral, and the action of the revolving cutter in the work is therefore similarly spiral; grooves may be cut or spiral projections left on the work according to the shape of the cutter employed.

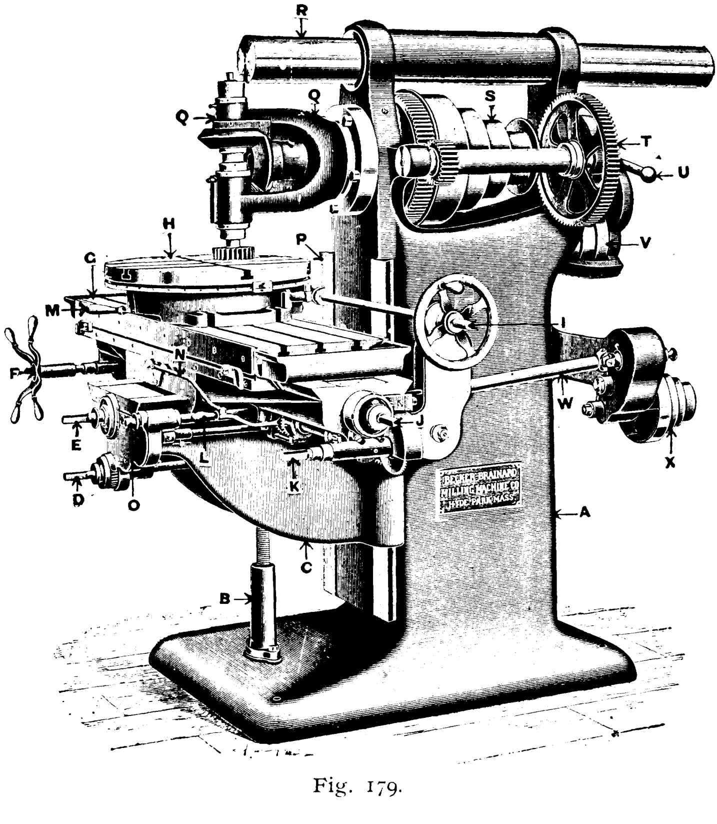


Fig. 179.

Fig. 179 shows a plain horizontal milling machine, fitted with a vertical head and rotary cutter.

PARTS OF MILLING MACHINE.

Following is a description of the principal parts of this machine tool and their use:

A is the standard on which is attached all the main parts of the machine.

B is called the horn, and contains the elevating screw for raising the knee, *C*, which is adjustable vertically on the slide, *P*.

D is the spindle with micrometer attachment for operating the elevating screw of the knee, *C*. This is also connected with the power feed spindle, *W*, through connecting spindle *O*.

E is the horizontal adjustment for the saddle, which, in turn, supports the table, *G*. This is also connected in the same manner as *D*.

F is the hand-wheel shown connected with the quick-return longitudinal movement of the table. This handle can also be used on the spindle, *K*, which also operates a quick-return movement connected with the table.

G is the table, which is shown with oil grooves on each side and oil pockets on each end. On each end of the table on the side, and shown connected by the T-slot running longitudinally with the table, is a dog, which, by engaging with the locking lever, *R*, in the center of the saddle, this, in turn, being connected by the rod, *N*, with the lever, *L*, throws the power feed off when the machine is in motion. This power feed is connected to the longitudinal and transverse motions of the table.

H is the rotary table which is shown bolted to the regular platen of the machine and connected with the power feed by the spindle, *I*. This, in turn, is connected by gearing, which is shown encased, with the spindle, *J*, which, in turn, is connected with power-feed spindle, *W*.

M is the lever connected with the interior mechanism of the rotary table for tightening the same when the table is to remain in a fixed position.

O is a spindle on which is the pull gear for connecting the cross or vertical feed with the power-feed spindle, *W*.

Q is the vertical attachment.

R is the overhanging arm, on which is used, at times, the outboard bearing for supporting the end of horizontal spindle. *S* is the driving cone on main spindle of machine.

T is the back-geared sleeve, and gears which are thrown in connection with the spindle by the lever, *U*.

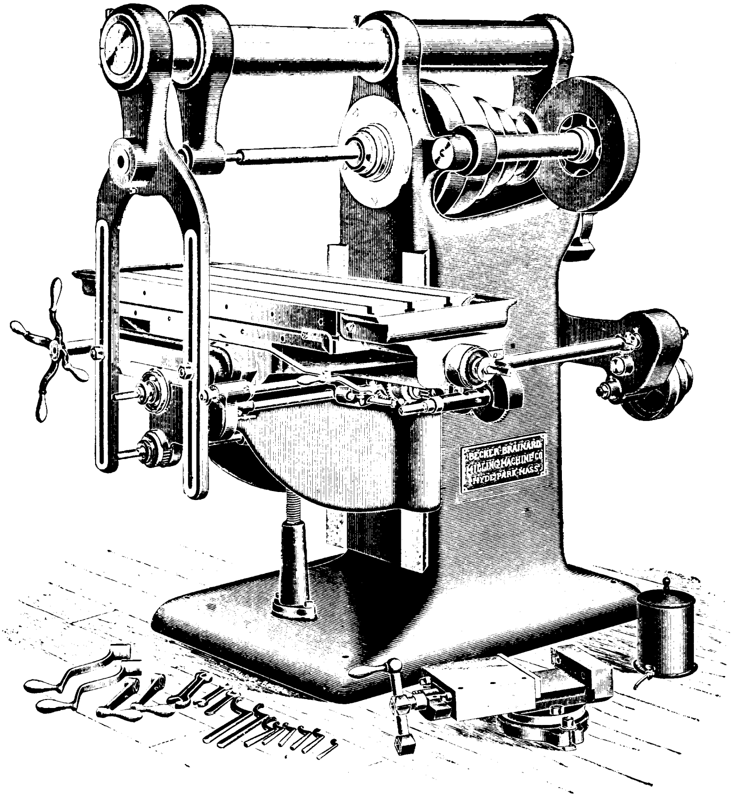


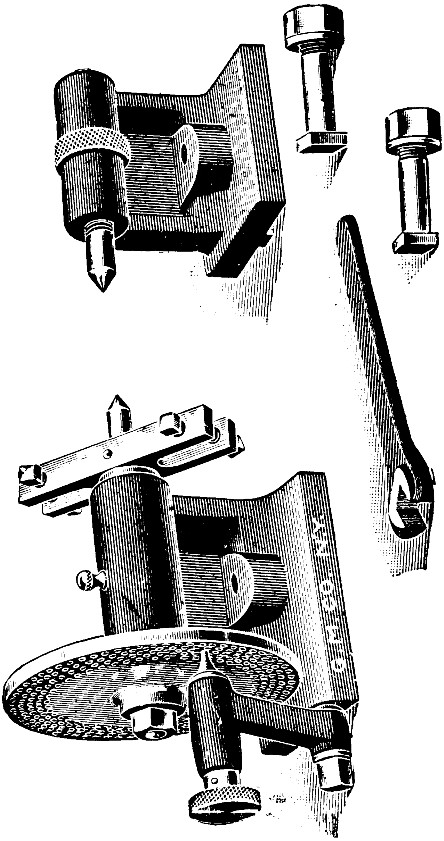
Fig. 180.

V is the feed cone connected by gearing with the end of the main spindle.

X is the feed-driving cone, which is connected by a belt with cone *V*. This cone drives the complete feed mechanism of the machine.

Fig. 180 shows a milling machine of the simplest design, with horizontal cutter; it is a similar machine to the one illustrated in fig. 179, without the vertical head.

Fig. 181 shows a dividing head and tail stock for a milling machine; the index plate has five rows of



Fig, 181.

holes drilled in circles of 48, 56, 60, 66 and 72; the spindle can be solidly bound for taking heavy cuts, thus relieving the index pin from strain.

Fig. 182 shows a dividing head and tail stock. In this example the dial is moved by a worm and gear which turns and at the same time holds the head-stock spindle, thus relieving the index pin and the dial of strain, and

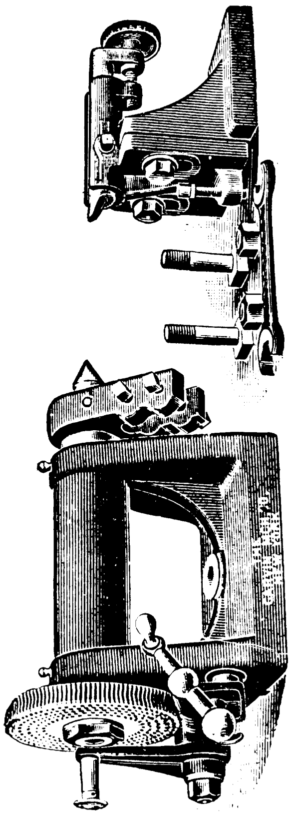


Fig. 182.

also the attendant wear and loss of accuracy; the worm can be dropped out of gear when it is desirable to turn the dial by hand; the tail-stock spindle has a vertical adjustment for taper work, as shown in the illustration.

Fig 183 shows a regular vise, mounted on a graduated base, and held by a beveled friction disk and bound at any angle.

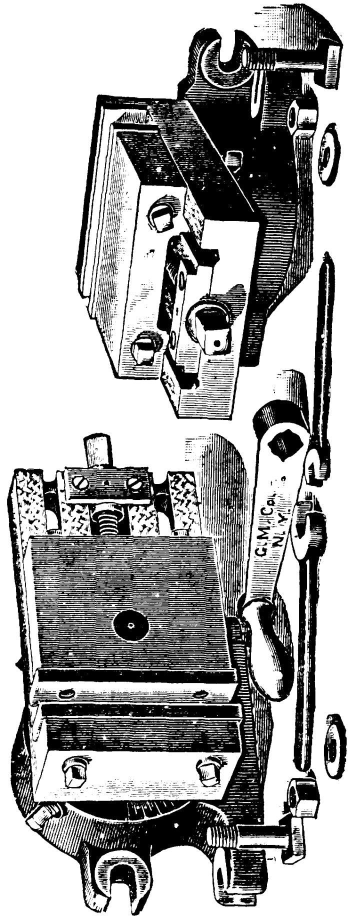


Fig. 186.

The base is provided with two clamping surfaces, so that the vise can be mounted horizontally or vertically, and clamped at any angle in either position.

The Feed Mechanism is a special feature of the Garvin Milling Machine

As shown by the illustration, fig. 184, the Change-Gear Box is set into the column and driven by a chain from the spindle. The Feed-Box is movable vertically and provided with an adjusting-screw, so that any slack in the chain can be taken up at once. A slip-friction

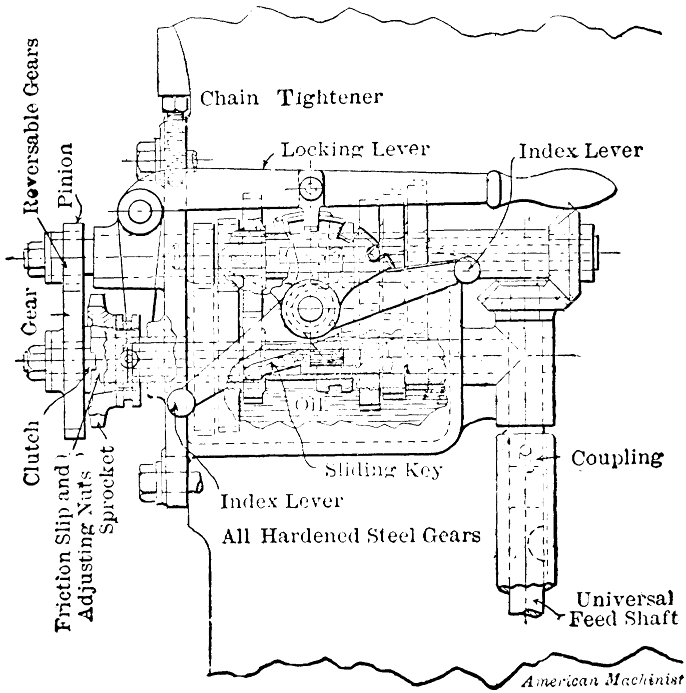


Fig. 184.

device is set in the feed-box sprocket, so that if any unusual strain is put on the machine, the frictional resistance will be overcome and prevent breakage.

Two double cones of gears are employed, which arrangement gives a larger number, and greater range, of feeds than is possible with a single cone. Nine direct changes are obtained, and by reversing the two outside gears, eighteen changes are obtained, ranging from $\frac{1}{270}''$ to $\frac{1}{4}''$ per revolution of spindle.

The change-gears in the box are all hardened steel and run in a bath of oil. Gears are connected to the shaft by means of two sliding spring-keys, as shown, which require no waiting for keyways to come in line. Each index lever is connected to a sliding key, and when each lever is moved the key is changed from one set of gears to another.

The numbers on the index table represent numbers of revolutions of spindle per inch travel of table. Feeds marked "pinion" mean that the outside pinion must be attached to the upper shaft, and feeds marked "gear" mean that the large outside gear should be attached to the upper shaft to obtain the indicated feed-speed. Supposing that a feed of $\frac{1}{100}''$ is required; examine table and see that combination 2—5 gives this feed; first lift the locking lever, and then bring No. 2 on the outside lever around to the setting point; then No. 5 on the inside lever is brought to the setting point. The locking-lever is now pushed down into place, thereby locking the index levers in place, when the connection will be made for this feed. These feeds are all positive.

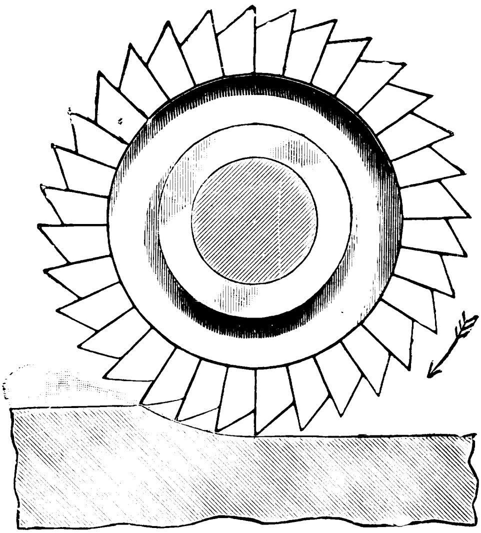


Fig. 185.

Fig. 185 represents a side view of a face or straddle mill in operation; the direction of the motion of the tool is shown by the arrow—the movement of the work being from the left hand to the tool.

MILLING OPERATIONS.

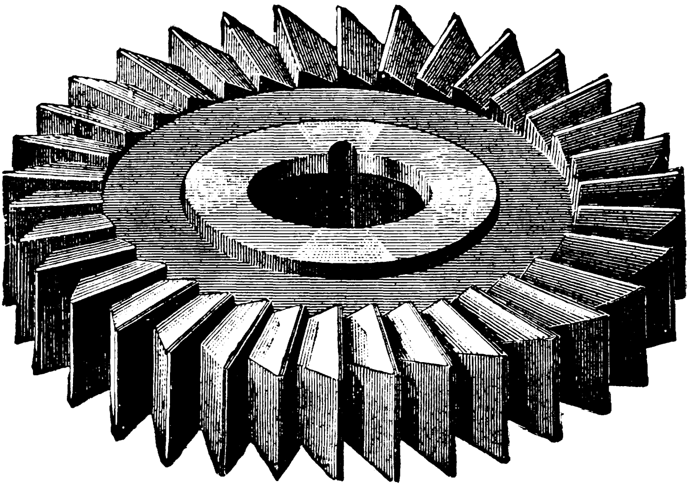


Fig. 186.

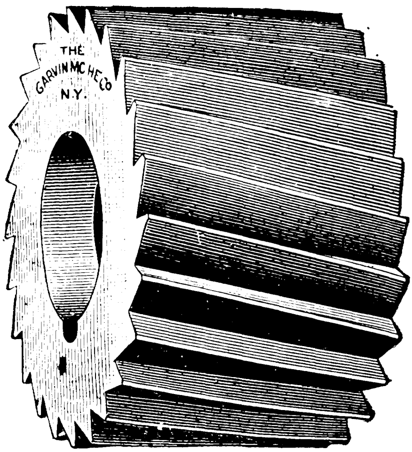


Fig. 187.

SPEED FOR MILLING CUTTERS.

The face mill shown in fig. 185 is a form in general use; it has straight teeth arranged at equal distances on its "face," parallel to its axis, and radial teeth on one side, as shown in fig. 186. When two of these mills are arranged in pairs, or when a single mill has teeth on its face and on two sides, it is called a "straddle" mill.

Should a mill have a wide "face," the teeth are cut spirally, as shown in fig. 187; wide, straight teeth would not maintain a uniform cut on entering or leaving the work; with spiral teeth the cut begins at one end of the tooth; the cut being started, the cutting is uniform, producing smooth work, also avoiding a sudden shock when entering or leaving the cut.

The face-mill cutter is provided with a center hole, which fits on an arbor, and is provided with a keyway, shown in the illustration; the end of the arbor fitting into a conical seat, is securely held in the machine spindle, permitting the arbor to revolve in either direction, without becoming released; the mill can be reversed on the arbor, and the feed of the work can be changed, which, it is plain, could not be done if the mill was on an arbor that screwed upon the driving spindle of the machine.

The proper rotating speed of the cutters is essential to the economical production of work done by milling machines. The following rules and table will be found of value.

RULE.—*Divide the required speed per minute in inches, by the circumference of the cutter in inches, and the result is the number of revolutions per minute of the cutter.*

MILLING OPERATIONS.

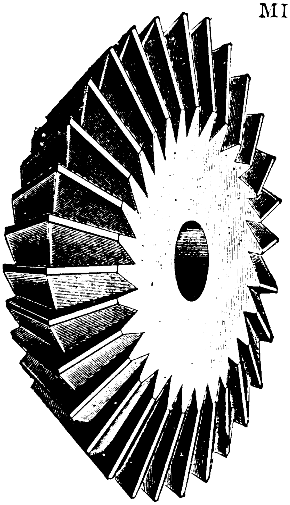


Fig. 188.
Angle or Spiral Cutter.

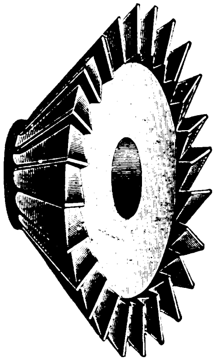


Fig. 189.
Angle or Spiral Cutter.

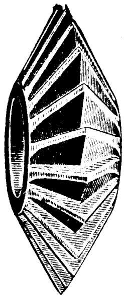


Fig. 190.
Double Angle Cutter.

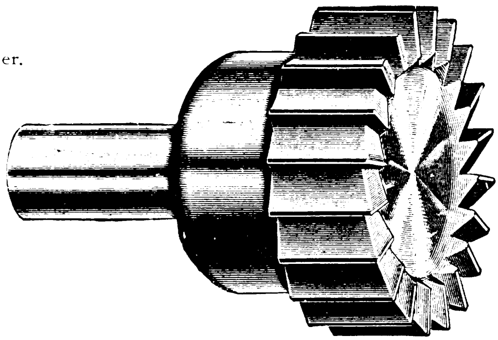


Fig. 191.
Face Milling Cutter.

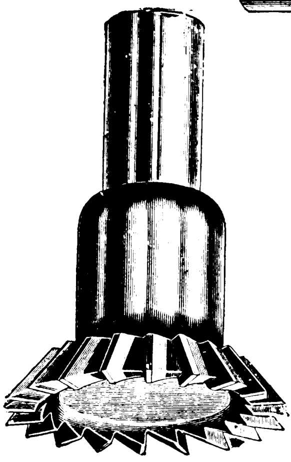


Fig. 192.
Angle or Spiral Cutter.

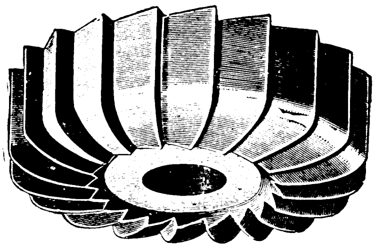


Fig. 193.
Face Milling Cutter.

SPEEDS FOR MILLING CUTTERS.

EXAMPLE FOR FIGURING CUTTER SPEEDS.—If a milling cutter is 3 inches in diameter, and it is required to cut wrought iron at a peripheral speed of 40 feet per minute, how many revolutions per minute must the cutter make? Now,

$$\frac{40 \times 12''}{3'' \times 3.1416} = \frac{480 \text{ inches}}{9.4248'' \text{ circum.}} = 51 \text{ revols., nearly. Ans.}$$

RULE.—*Multiply the circumference of the cutter in inches by the number of revolutions of the cutter per minute, divide by 12, the result is the cutting speed per minute in feet.*

If a milling cutter of 4 inches diameter makes 60 revolutions per minute, what is its peripheral cutting speed in feet per minute?

$$\frac{4 \times 3.1416 \times 60}{12} = 63 \text{ feet per minute, nearly. Ans.}$$

SPEEDS FOR MILLING CUTTERS

	Brass	Cast Iron	Machine Steel	Tool Steel Annealed
Ft. per min...	80 to 120	40 to 60	35 to 45	25 to 35

The speed of the cutters varies considerably with the kind of material to be operated upon, and is another case where the workman will be called upon to use his own judgment. The table shown above may be taken as a guide.

MILLING OPERATIONS.

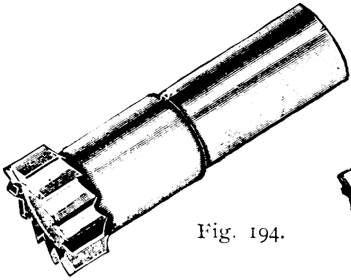


Fig. 194.

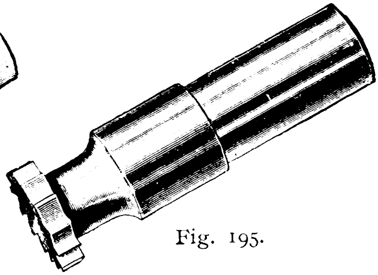


Fig. 195.

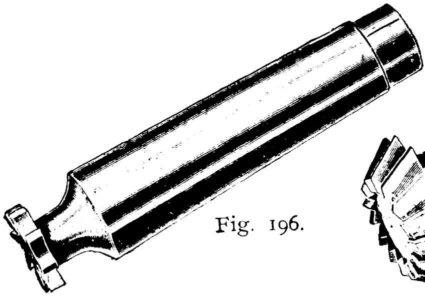


Fig. 196.

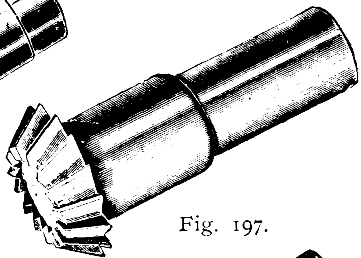


Fig. 197.

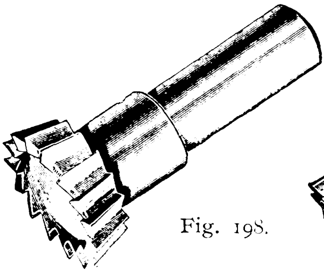


Fig. 198.

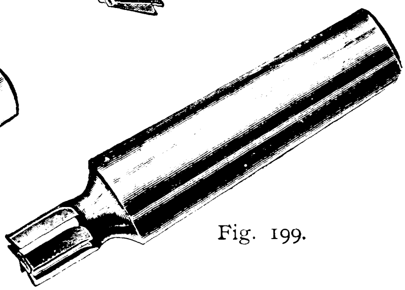


Fig. 199.

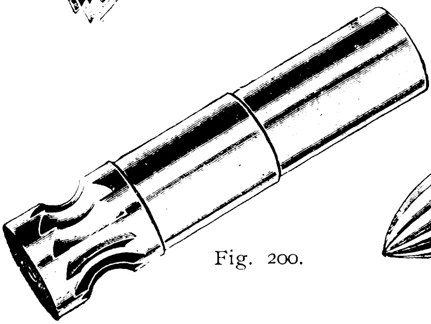


Fig. 200.

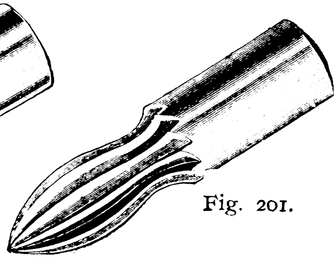


Fig. 201.

SPEEDS FOR MILLING CUTTERS.

It is more satisfactory to run milling cutters up to nearly the maximum speed, with comparatively light feed, than to reduce the speed of cutter, and overfeed the work.

A second table is added to the one printed on page 189; this gives the speeds for roughing and finishing, and also the traverse feed.

TABLE SHOWING AVERAGE MILLING SPEEDS, VIZ., THE PERIPHERY SPEED OF CUTTER (IN FEET) PER MINUTE.

	Steel	Wrought Iron	Cast Iron	Gun Metal	Brass
Roughing cut......	30	40	60	80	120
Finishing Cut......	40	55	75	100	140
Feed per min., ins..	¼″ to ½″	¾″ to 2″	½″ to 1½″	1¼ to 2″	2½

Where there is no great depth of material to cut away, these feeds may be taken as the maximum figures.

On page 188 are illustrated a variety of milling cutters or "mills."

Figs. 188 and 189 are angle mills used in cutting spiral grooves.

Fig. 190 is a double angle cutter.

Figs. 191 and 193 are face milling cutters.

Fig. 192 is an angle or spiral cutter.

On page 190: figs. 194–196 are T-slot cutters, figs. 197 and 198 are bevel mills, fig. 199 is an end mill or shank cutter, figs. 200 and 201 are surface mills or form cutters.

MILLING OPERATIONS.

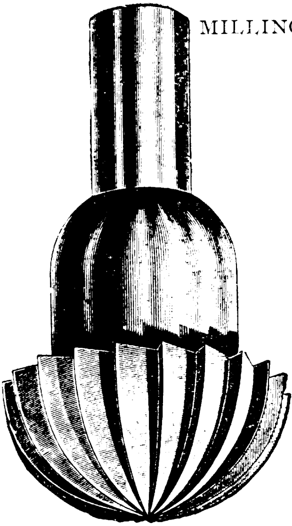


Fig. 202.

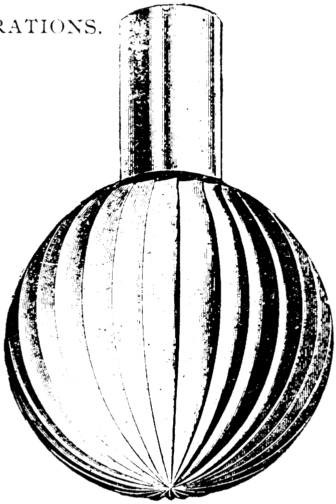


Fig. 203.

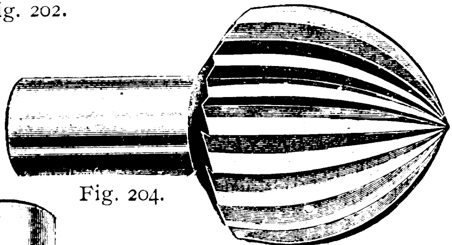


Fig. 204.

Rose or Groove Cutters.

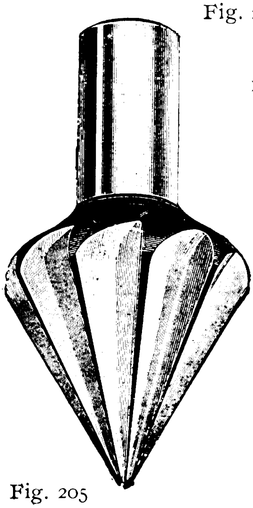


Fig. 205

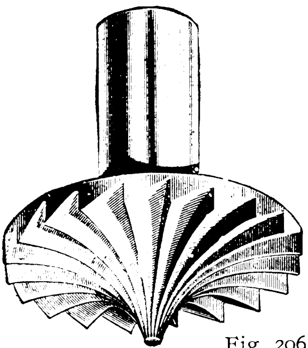


Fig. 206.

Counter Bore Mills.

MILLS AND CUTTERS.

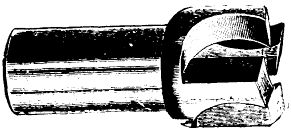


Fig. 207.

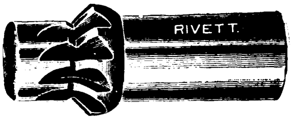


Fig. 208.

Fig. 209

Fig. 210.

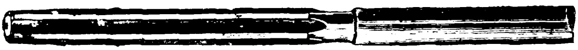


Fig. 211.

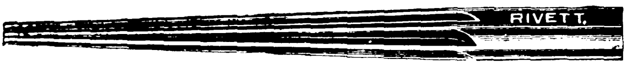


Fig. 212.

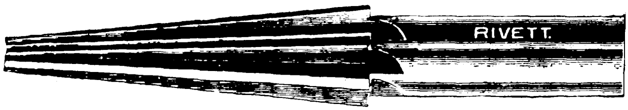


Fig. 213.

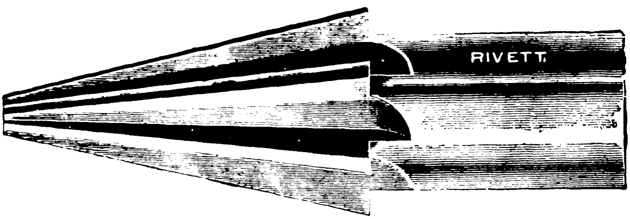


Fig. 214.

MILLING OPERATIONS.

Figs. 202–204 are rose mills or groove cutters.

Figs. 205 and 206 are counter-bore mills, or irregular cutters.

On page 193: fig. 207 is a special surface cutter, fig. 208 is a hollow end mill.

Fig. 209 is a center reamer.

Fig. 210 is a counter-bore mill.

Fig. 211 is a parallel reamer.

Figs. 212–214 are taper reamers.

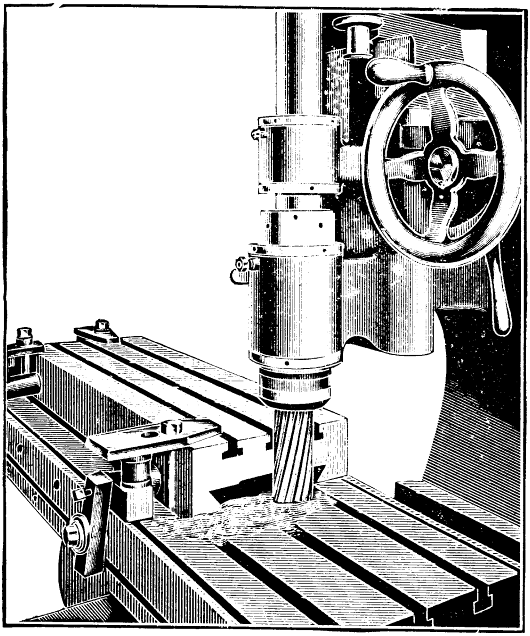


Fig. 215.

Fig. 215 exhibits a side cutter in operation, finishing the end of a milling machine table; formerly this work was done in a planing machine, which required to be very large, in order to permit the casting to pass between the housings.

MILLING OPERATIONS.

Fig. 216 illustrates a rose mill (see fig. 203) operating on the periphery of a circular casting, cutting a groove; this class of work can be done very much faster on a mill-

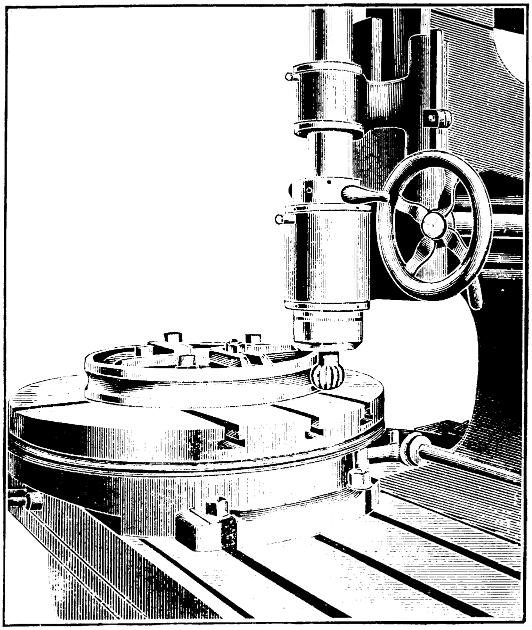


Fig. 216.

ing machine than it could be accomplished in a lathe; in addition, the shape of the recess is secured without a possibility of an error on the part of the operator, by the use of the rose mill.

MILLING OPERATIONS.

Fig. 217 illustrates a bevel or angle mill in operation, finishing a cone or bevel surface on a circular casting; this cutter bevels the internal face of a corresponding ring, in-

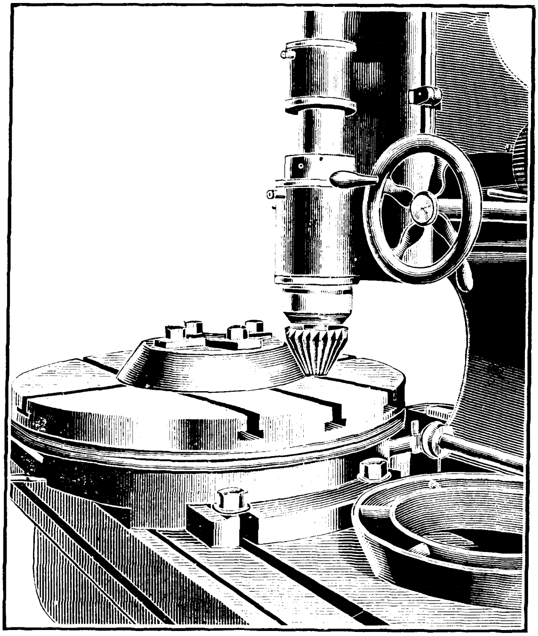


Fig. 217.

suring accuracy of fit between the two faces; this mill is largely used for economically finishing valves and many forms of similar work.

MILLING OPERATIONS.

Fig. 218 shows an angle mill in operation, finishing the parallel vees on the inside of a sliding-head casting; both the vees can be finished at one setting; the slides can

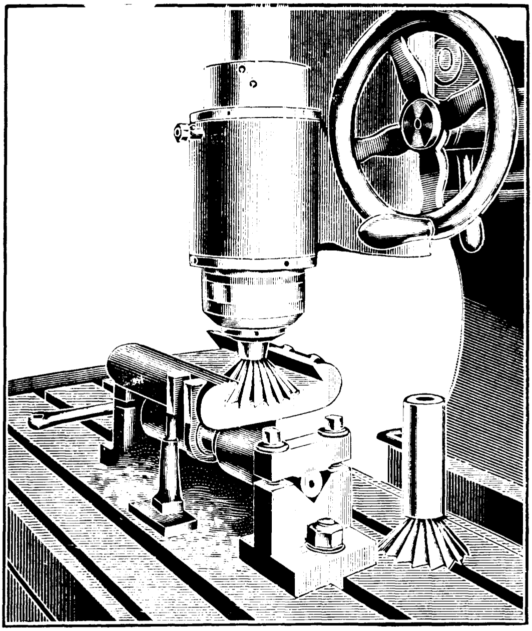


Fig. 218.

be made to match in duplication, or duplicate work, in less time in the milling machine than the same work could be done in a planer. For the four last illustrations credit is due to the Becker-Brainard Milling Machine Co.

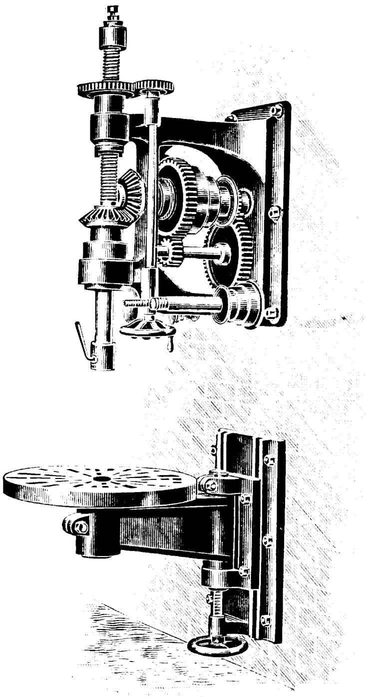


Fig. 219.