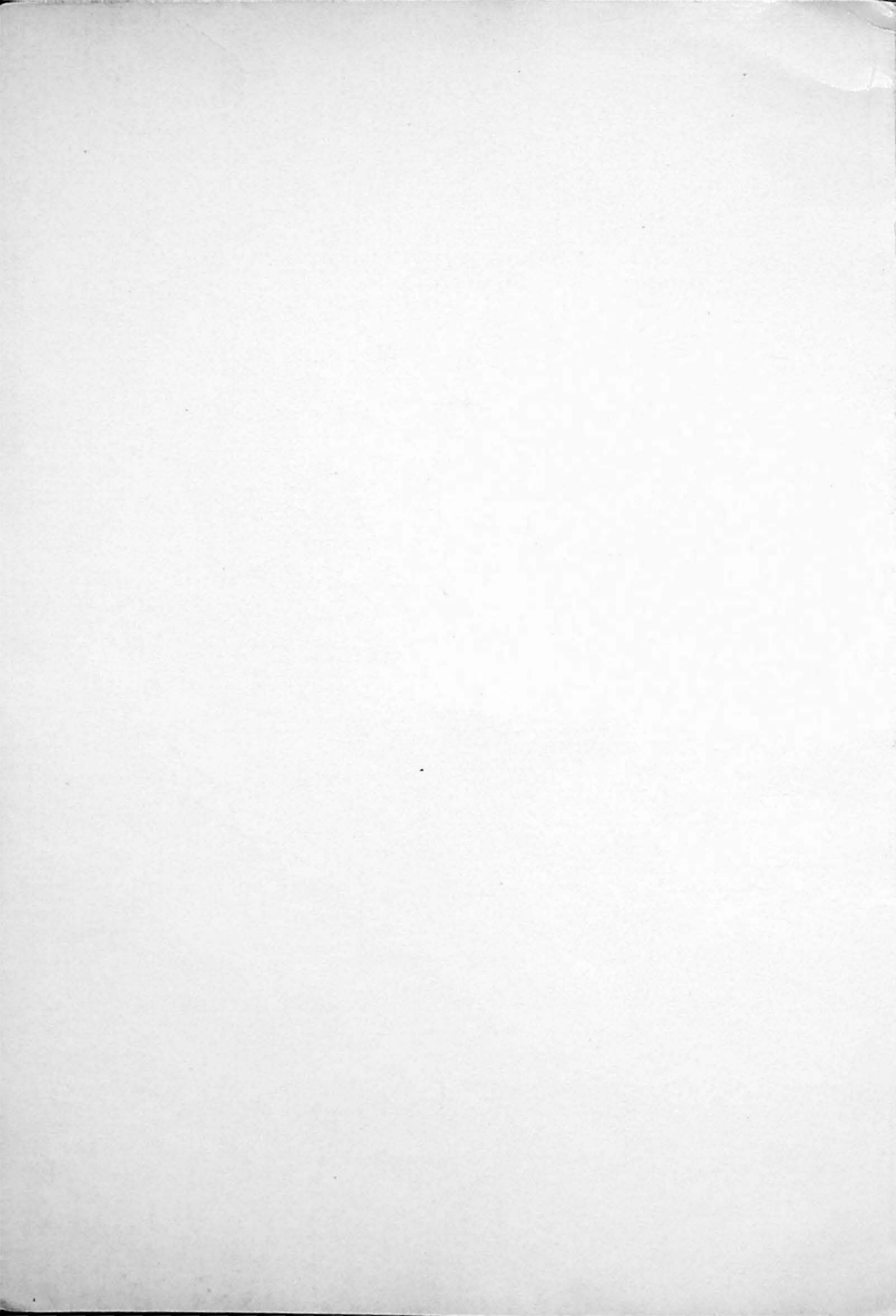


MILWAUKEE MILLING MACHINES

HILL, CLARKE & CO., Inc.
Distributors

BOSTON — NEW YORK — PHILADELPHIA

KEARNEY & TRECKER CO.
MILWAUKEE, WIS. U.S.A.



CATALOGUE 17

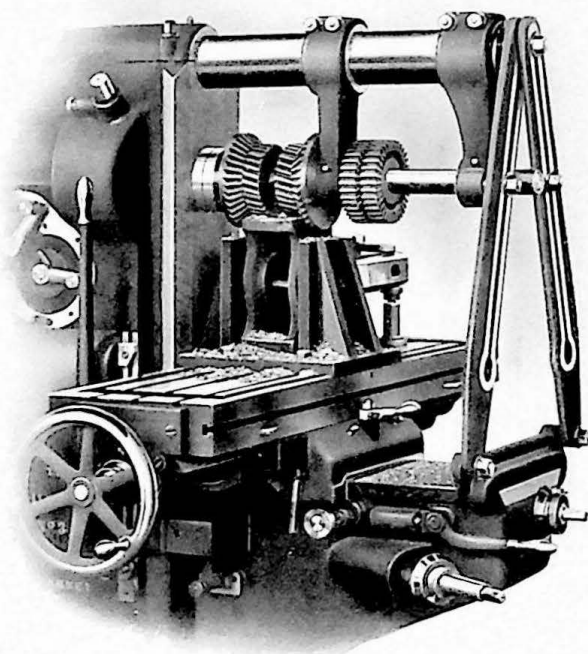
MILWAUKEE
MILLING
MACHINES

CABLE
ADDRESS

TRECKER
MILWAUKEE

WESTERN UNION
LIEBERS CODE

Manufactured By
KEARNEY & TRECKER CO.
MILWAUKEE, WIS. U.S.A.



GANG MILLING CROSS HEAD
(Outer cutters for second operation)

INTRODUCTION

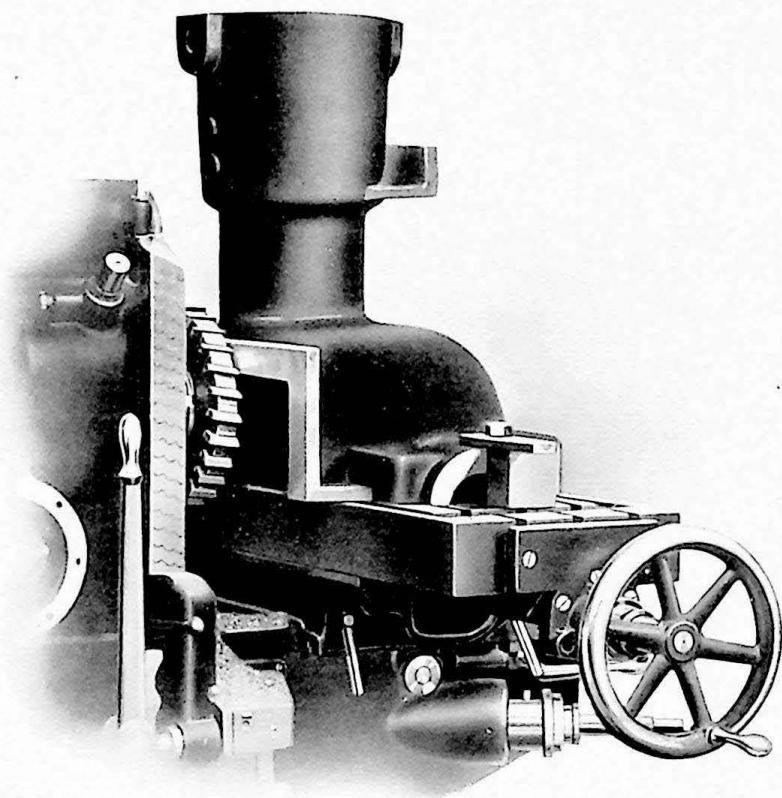
IN 1898, when Milwaukee Milling Machines were in contemplation, we were advised by a then prominent firm of dealers to imitate, as nearly as possible, a machine that was enjoying considerable popularity at that time.

We held to the belief that imitation is an indication of weakness and that a firm, seeking success in a large sense, must possess originality.

When our first machine appeared, it had the box section knee, closed on top, quick change gear feed, back gears completely covered and other improvements that gave it an immediate standing on the market, overtaking our capacity from the start. We soon followed these with other improvements including a heavy vertical spindle attachment in which all tools would interchange with the horizontal spindle. This was at first said to be unnecessary because older concerns had never made one that way.

The subject of milling has been our constant study, not only in our own factory but in those of others as well—profitting by the experience of thoughtful men in many and various lines. Thus we have advanced, step by step, eliminating in due time the cone pulley and in place of continuing to manufacture that type, as long as anyone could be found who would buy, we are today and have been for some years, the only exclusive manufacturers of the constant speed drive milling machine.

Joseph Jefferson, the actor, said that the greatest satisfaction to one of his profession did not come from overwhelming and immediate success but rather from steady, uninterrupted advancement in his art. It is for this we strive, not in quantity but in quality, of workmanship and design.



FACE MILLING TRACTION ENGINE CYLINDER

TO CORRESPONDENTS

When considering the purchase of a milling machine for some specific purpose and our advice is desired with reference to the best method of milling or an estimate of output, we will be greatly helped and our opinion will be of more value if we are in possession of the fullest information. Please follow as nearly as possible the following suggestions.

First:—Send complete drawings of the part showing all views—mark the surfaces to be milled and state how much metal is to be removed. If no complete drawing is to be had, send sketch giving the general dimensions, as well as the surface to be milled; or send a rough and a finished piece.

Second:—In how large lots are the parts made and how often are these lots put through?

Third:—What kind of material—is it hard or soft?

Fourth:—How is the work being done—what is the output by this method—is the finish and accuracy satisfactory?

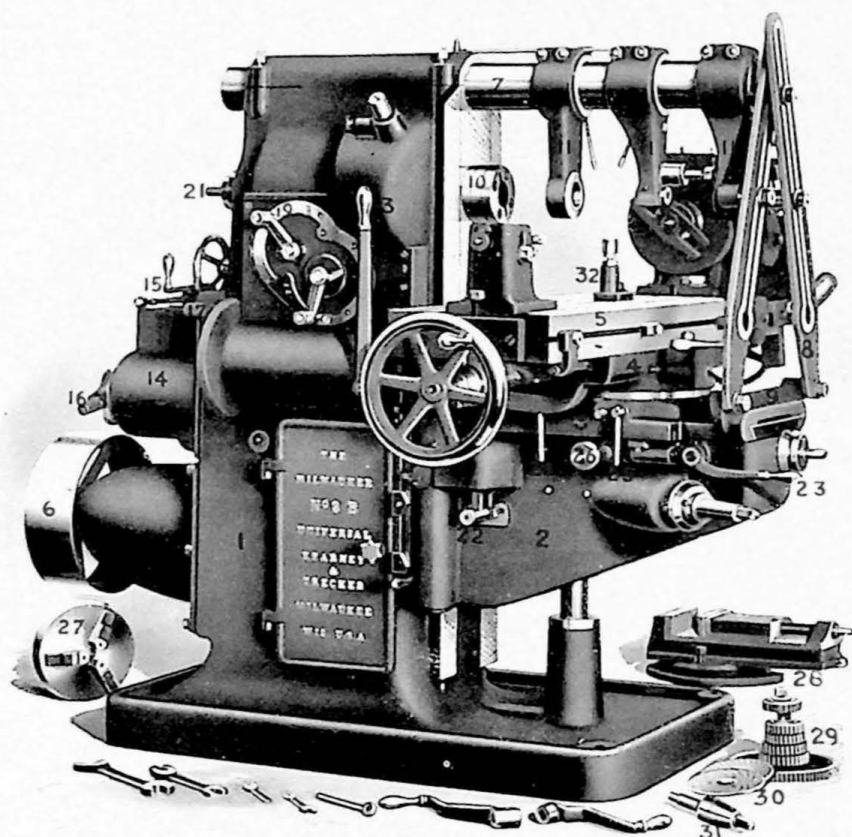
Fifth:—What are the finish and accuracy requirements?

Sixth:—Have you milling cutters for the work? If so, let us know their diameter, size of hole, kind of steel and if they are strong or delicate.

Seventh:—Have you suitable means for chucking the work for milling?

Eighth:—Is the piece in question one of a series of sizes? If so, what position in the series does it occupy?

Ninth:—Is this piece fairly representative of the general run of the work?



UNIVERSAL MILLING MACHINE

Front view

- | | |
|-----------------------|----------------------------------|
| 1—Column | 17—Speed segment lever |
| 2—Knee | 18—Speed lever |
| 3—Saddle | 19—Sleeve gear lever |
| 4—Swivel carriage | 20—Column plate |
| 5—Table | 21—Arbor rod |
| 6—Driving pulley | 22—Feed interlocking lever |
| 7—Over-arm | 23—Cross and vertical trip lever |
| 8—Arm braces | 24—Knee clamp levers |
| 9—Knee clamp | 25—Saddle clamp levers |
| 10—Spindle | 26—Cross feed trip |
| 11—Arbor supports | 27—Universal chuck |
| 12—Spindle lock | 28—Swivel vise |
| 13—Starting lever | 29—Change gears |
| 14—Feed box | 30—Index plates |
| 15—Feed handles | 31—Quick return shaft |
| 16—Feed segment lever | 32—Center rest |

MILLING MACHINE DESIGN

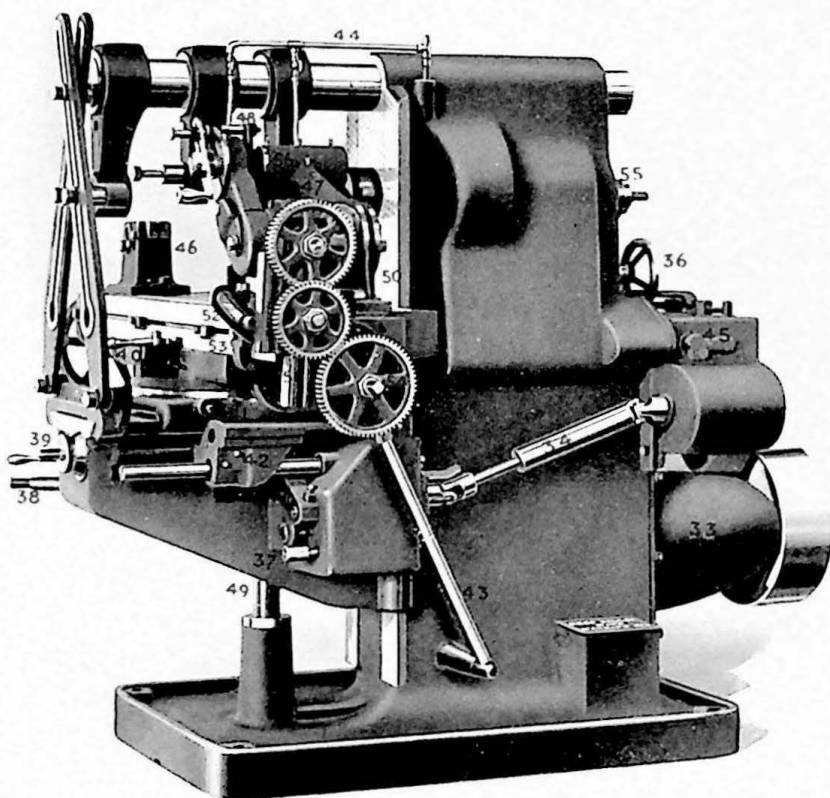
There are in every piece of engineering work certain essential elements upon which success or failure depends in the greatest degree; and the designer competent to be trusted with important work is he who understands what these elements are and has a thorough knowledge of the functions they must perform.

It is the object of this brief treatise to call attention to the problems confronting the designer of the knee type milling machine and point out how these problems have been met in the machines catalogued in these pages, in the hope that our solution of the problems will meet with the approval of the reader to the end that he will become a user of our product.

Removing Metal The milling cutter with its numerous teeth, one or more of which are always in the cut, has proven itself to be the most economical instrument for removing metal on any kind of a surface; and where forms are to be reproduced or interchangeable standards maintained it is a commercial necessity.

Rigidity The successful milling machine is the one that has ample power to revolve the cutter at the most productive surface speed, regardless of its diameter—easily adjusted and with ample means to feed the work against the cutter be the cut heavy or light, at a rate suited to the nature of the cut and the material being operated upon. But above all, the successful milling machine must possess sufficient rigidity, proper proportion and adjustment between the bearing surfaces to enable it to maintain the same alignment between the cutter and the work, when subjected to the severest strains, as existed when the work was set up and the cut not started. The machine that fails in this, no matter how meritorious its other features, fails to produce accurate or interchangeable work within the narrow limits prescribed by modern practice in many lines.

The question of rigidity was first considered in our designs—let it be the first to be considered here.



UNIVERSAL MILLING MACHINE

Rear view

- | | |
|----------------------------|-----------------------------------|
| 33—Pulley bracket | 45—Spindle reverse lever |
| 34—Universal feed shaft | 46—Elevating tail stock |
| 35—Machine oil reservoir | 47—Universal spiral dividing head |
| 36—Spindle hand wheel | 48—Index plate lock |
| 37—Feed reverse | 49—Telescopic elevating screw |
| 38—Elevating shaft | 50—Knee slide |
| 39—Cross feed screw | 51—Change gear bracket |
| 40—Table feed lever | 52—Change gear bracket brace |
| 41—Swivel carriage clamp | 53—Table feed limit trip |
| 42—Cross feed bracket | 54—Table screw |
| 43—Cutter lubricant return | 55—Spindle take-up nut |
| 44—Cutter lubricant supply | 56—Worm adjusting screw |

Distortion Taking note of the typical job of milling shown on page 2, it will be seen that the tendency is to spring the work downward and to the left as the table advances and of course, with equal force the tendency is to spring the cutters in the opposite direction. The fact that the work stands high above the top of the table gives it long leverage on that member. This force, with its tendency to distort the machine, is transmitted from the table through the saddle and knee to the column, the cutters meanwhile through the spindle and over-arm tend to augment this distortion in the opposite direction.

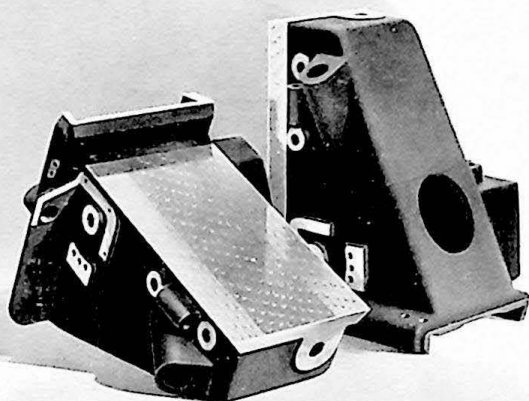
Foundations To withstand these strains, the column is cast in one piece with strong internal ribs and is a box section of increasing depth as it extends downward to the pan shaped base—this being given sufficient height from the floor to allow heavy ribs to be used and render masonry foundations unnecessary where the floor is strong enough to carry the load.

The openings in the column are as few and small as may be, consistent with ready accessibility of the parts contained within and these openings are all closed with well fitted plates or brackets screwed and doweled in place so that the finished column is a box section in fact, oil tight and entirely closed.

Knee Slide The knee slide is of extra width and depth and extends upward to the over-arm, giving rigid support to that member and at the same time surrounds the spindle box, giving additional metal at a point where it is most needed.

The upward extension of the knee slide serves an additional useful purpose in that it furnishes a neat and efficient means for securing attachments to the frame, these being designed as part of the machine and have the appearance and effect of not being attachments as ordinarily understood.

Thickness of metal is proportioned to secure strength and stiffness and in no case is any added simply to secure weight for selling purposes.



BOX KNEE WITH CLOSED TOP

Next in importance to the column is the knee which is, **Knee** in fact, a bracket that must carry the saddle, table and work mounted upon it and at the same time withstand the downward thrust and the torsional strains set up by the work feeding against the cutters. This torsional strain is very greatly increased where the work stands high above the table as it often must do.

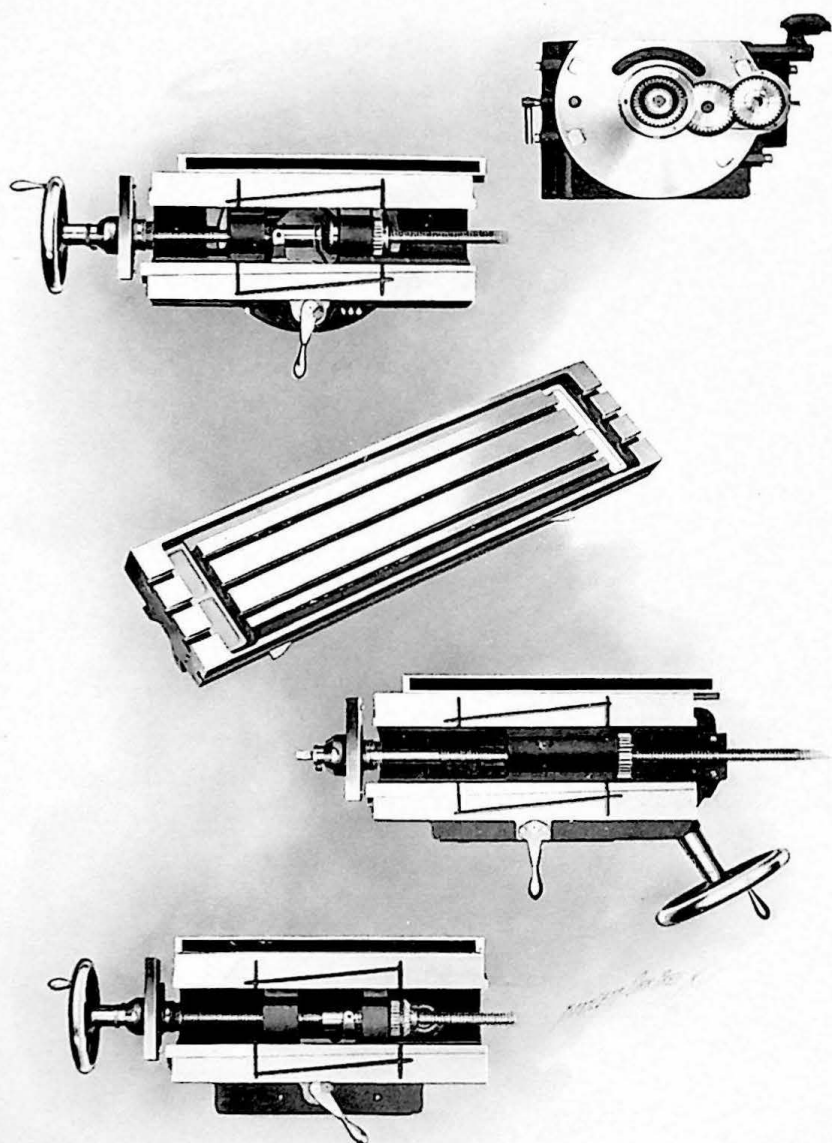
The box section form of knee, with its bearing on the column above the top plate of the knee or saddle slide, withstands distortion better than any other form, this being determined by numerous tests and experiments in order to secure the best possible design for this important member.

The top plate of the knee is made wide to give **Closed Top** the saddle a firm foundation and is cast solid without any holes whatever so as to avoid the inevitable closing of the usual slotted top when the saddle clamps are set tight or the cutting strains come upon it.

This item of the box knee, closed on top, is not a trivial matter. Frequently cuts—and severe ones must be taken with the table drawn out far from the column; especially is this true on universal machines cutting spirals when the saddle must be run out to prevent the table striking the ways on the column. Then it is that the operator would like to exchange the slotted top knee for the other kind. We regard this as the most important improvement in this type of milling machines in many years. Of what use is high power for the spindle or convenience and strength for the feed if the foundations of the machines are unable to take advantage of these to the full.

The over-arm is a solid steel bar, accurately parallel with the spindle, to which the arbor supports are clamped by the most efficient means.

The arm braces form a tie between the arm and the **Braces** knee and help to prevent their springing in opposite directions. These braces are constructed with special regard



TABLE, SWIVEL CARRIAGE AND SADDLES

to convenience, there being no single piece too heavy for easy handling by one man.

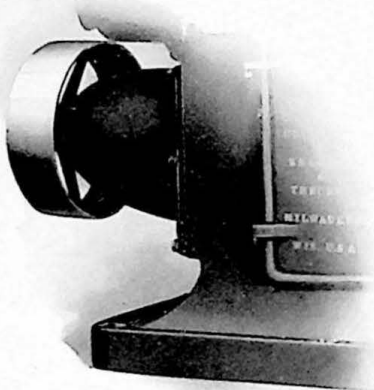
On the opposite page are shown the parts in which occurs the chief difference between the Universal,¹ Plain and Manufacturing types of Milling Machines. These parts are not less important in their contribution to the stiffness, accuracy and maintained alignment of the machines than the members previously mentioned. Broad bearing surfaces, hand scraped to perfect fit, narrow guides in proportion to length, taper gibs carefully fitted, adjustable endwise by screw at both ends and backed up by solid metal in place of riding on screw points.

The work table projects beyond the bearings and protects them from dirt and chips.

Oiling The large covered oil hole in the front of the table conveys lubricant to the bearings where it is distributed by the channels shown and those in the bottom of the table, to every part of the bearing and guide surfaces.

In the Universal machines, the saddle, fitted to the top of the knee and adjustable to and from the column on it, has circular top with a centering ring and four bolts extending into a Tee slot in the swivel carriage, holding these two parts securely together at any angle. The swiveling of the table through the means mentioned is for the purpose of cutting spirals, gashing worm gears and work of this character incident to the tool room and general shop.

Low Saddles The Plain and Manufacturing saddles are cast in one piece and the table can travel only at right angles to the cutter arbor. The last two types of machines are preferable for all classes of straight milling, due to the fact that the top of the table is closer to the top of the knee, consequently there is less torsional strain upon it. This distance is as low in the Universal machines as it can be and make the saddle and swivel carriage of sufficient strength to perform successfully the duties imposed upon them.



STANDARD DRIVE



RIGHT ANGLE DRIVE



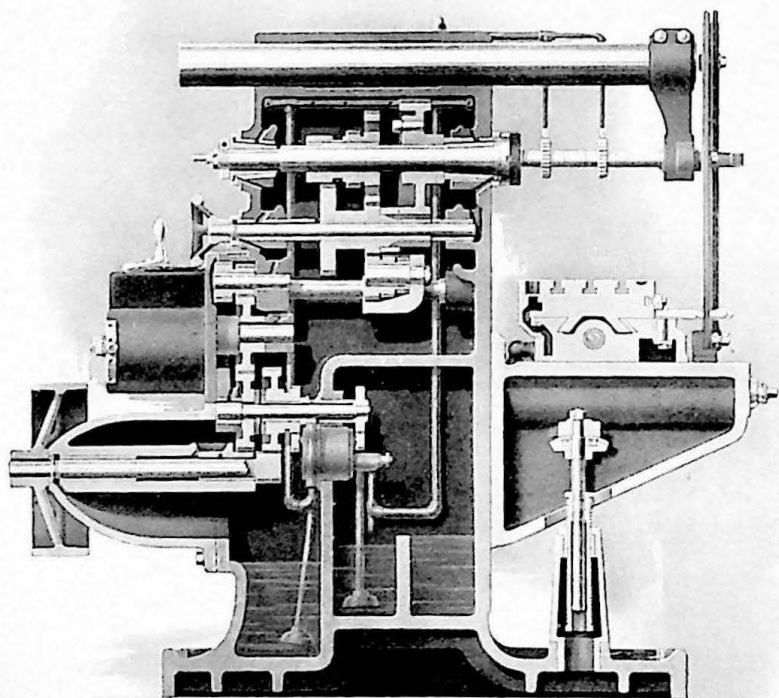
ELECTRIC DRIVE

Drive Given a machine with sufficient stiffness to withstand severe service without losing its alignment; the next important thing is the drive. In our design we have eliminated the cone pulley and ceased entirely the manufacture of this type of machine, confining ourselves to the "constant speed drive" on account of its superiority as a means of driving milling cutters of varying diameters.

Name This type of machine is called by various names such as "Heavy Duty"—"High Power"—"Single Pulley" and "Constant Speed Drive". We believe that the last is the only one that is fairly descriptive as any machine of any type, no matter how weak, can be called by the first two as they are terms referring to no fixed standard. A single pulley machine may be so designed as to require a countershaft with two or more speeds and thus introduce some of the faults of the cone pulley.

The constant speed drive as made by us requires no countershaft or overhead belts and the pull at the periphery of the cutter is the same at any given surface speed regardless of its diameter while in any variable speed drive the power diminishes, due to the slower belt speed, as the size of the cutter is increased and at a time when it should be at a maximum.

Unit System We have three styles of drive brackets manufactured as interchangeable units to suit the convenience of any shop to which we seek entry. Unless otherwise specified the machines are furnished with pulley shaft parallel with the spindle. If convenience of location requires the machine to set at right angle to the line shaft, the brackets with their pulleys are interchanged when the drive is through a pair of miter gears running in oil. When electric drive is in order, a bracket is furnished, made adjustable to receive any standard make of motor and carrying inside the machine a pair of reducing gears to which the motor is connected. These three systems of drive can be interchanged with each other at any time without special preparation or changes in the machine.



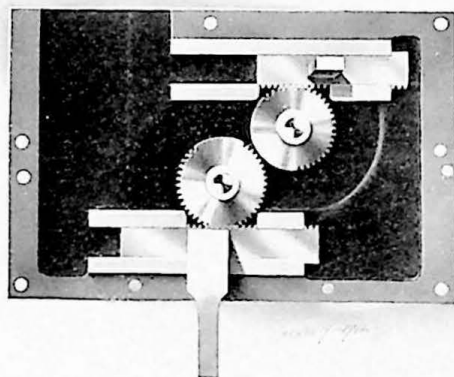
FLOODED LUBRICATION

Drive shafts and gears are made of steel, case **Lubrication** hardened to prevent wear and increase strength and stiffness. To render them practically indestructible, they are flooded with streams of oil that is pumped with a simple spur geared pump from the reservoir in the base, and to the rear of the machine, and distributed to all gears and bearings by means of a perforated pipe at the top. After flowing into the pockets arranged to supply the spindle bearings it overflows and cascades downward, overflowing each pocket and sending a steady stream through each bearing. Where oil grooves are in ordinary construction left closed at the ends to retain the oil these are left open to let it flow and carry with it anything that would under other circumstances cause trouble.

The pinion on the pulley shaft engages with a **Jaw Clutches** sliding clutch gear turning idle on the shaft and connected with the starting lever. The opposite clutch gear on the same shaft is engaged when the machine is started. This gear drives the transmission gear at the back of the feed box. Jaw clutches are used by reason of their great simplicity and the fact that no adjustment is ever necessary and, as they revolve at a comparatively low and constant speed, no harmful shock occurs when they are engaged. The gear on the feed box drives the main drive shaft which in turn, through a sliding gear on it, drives the three step tumbler by means of which the speed is varied in the following manner.

The hand wheel shaft below the spindle **Speed Variation** carries two gears of different diameter and the tumbler is arranged so that each one of its three steps can be engaged with each of these two gears, giving six speed changes. These are multiplied by 3 through the sliding sleeve gear on the spindle which is made to engage with the main spindle drive gear or either of the two gears on the hand wheel shaft.

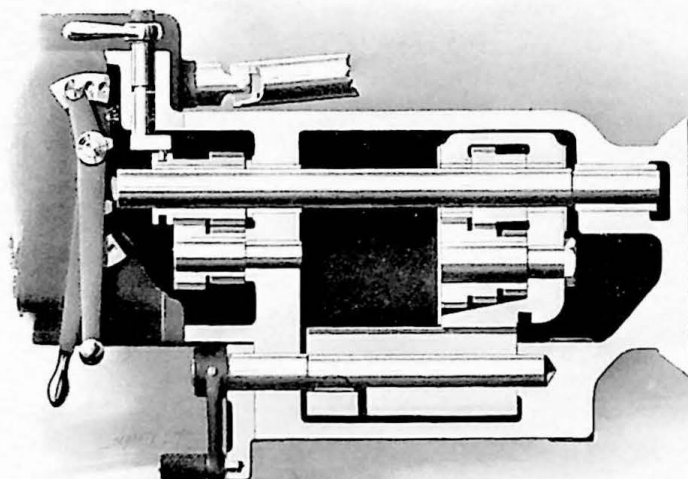
Thus are eighteen changes obtained in geometrical **Ratio** progression by means that are simple and strong. The ratio used is 1.225 and any speed multiplied by this ratio gives the next higher speed.



COLUMN PLATE—INSIDE



SPEED INDEX PLATE



TUMBLER SUPPORT AND SPINDLE REVERSE

**Tumbler
Support**

The lower view on the opposite page is a horizontal section through the three step tumbler gear. This gear revolves on a hardened steel stud firmly planted in a swinging frame that is securely supported on both sides of the tumbler; on one side by the driving shaft which is made far larger than is actually required and on the other by the teeth of the long pinion meshing into gear teeth cut in a segment of the frame and by means of which it is made to engage with the gears above. It will readily be seen that this frame supported on both sides gives a much more rigid bearing for the tumbler than if it were supported on one side only and allowed to overhang.

**Spindle
Reverse**

This view also shows how reverse for the spindle is effected. The sliding gear on the drive shaft engages, for right hand rotation, with the gear on the feed box which also engages the smallest step of the reversing idler. When the sliding gear is in mesh with the large step of the idler it is out of mesh with the main drive gear and the spindle runs left hand.

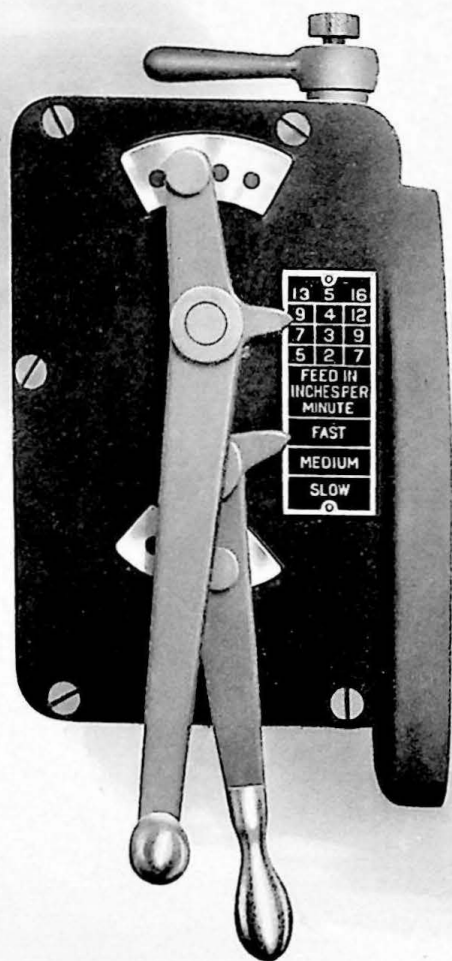
The spindle is made of forged crucible steel, runs in bronze bearings, both of which are taper and have means for compensation for wear. These bearings are liberal in size and the oiling so abundant that loss of alignment will not take place in a generation.

Flanged

The front end of the spindle is flanged and has a key to drive the arbor drive collar, face mills or attachment drive gears, these being held in place by four screws. The objection to the threaded spindle for millers of great power is that the tools will stick if the pitch is slight and unscrew when the machine is reversed if the thread is steep enough to prevent sticking.

Lock

Means are provided to lock the spindle when tightening arbor nuts. The locking plunger is cut as an internal gear of the same pitch diameter as the main spindle gear so that when the two are engaged the teeth fit in all their curve throughout a wide arc, one being an exact reverse of the other, and the spindle is held perfectly secure. The starting lever is automatically locked out when the spindle is held fast.



FEED BOX—TOP VIEW

Going back to our first proposition, we wish to repeat that the first requisite in the design of the successful milling machine is rigidity.

The second in order of importance is a drive that can force the largest cutter the machine will take made from the latest product of the steel makers art.

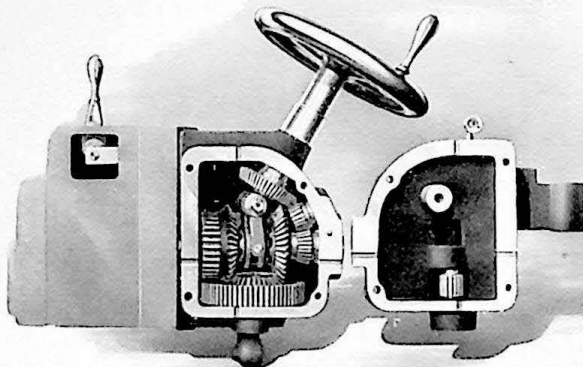
Feed Variation The third feature to be considered is the feed. This is driven from the constant speed gear on the feed box, previously mentioned as part of the drive train, and the amount of power going into it automatically depends on the conditions and requirements of the cut. Twelve changes are provided by mechanism in the feed box similar to that shown for the drive and in a similar way it is flooded with oil from the same source. These changes are also in geometrical progression, the ratio being approximately 1.35. The slowest is $\frac{1}{2}$ " and the fastest 16" per minute, without reference to the speed of the spindle.

Fewer changes of speed are required where this system of feed drive is used as it provides finer feeds for small cutters at high rotative speeds and coarser feeds for large cutters at low rotative speeds than can possibly be obtained by any system of feed driven from the spindle, regardless of how many changes are used.

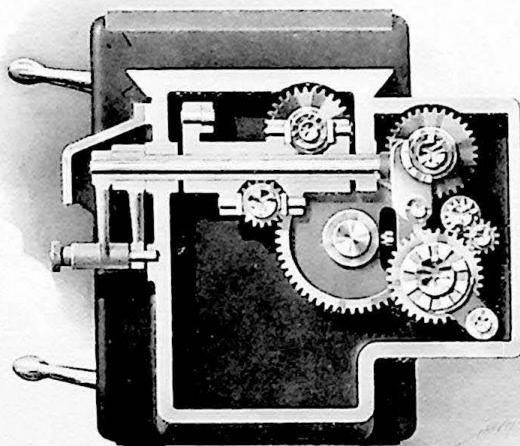
This power is carried from the feed box forward by a universal joint shaft with all its parts made of steel. The center block is square and forms an oil reservoir to keep the parts thoroughly lubricated.

This shaft forms a convenient, smooth running and durable connection to the gearing in the saddle of the Manufacturing—(Style A) machines and to the knee of the Universal and Plain (Style B) machines.

The cut on page 12 shows how the feed screws are driven—note how close together the clutches and nuts are located to avoid torsion through the long screw. The thrust on the table bracket is taken up by ball bearings to increase the smoothness and efficiency.



FEED REVERSE—MANUFACTURING MILLERS



FEED INTERLOCKING DEVICE
PLAIN AND UNIVERSAL MILLERS

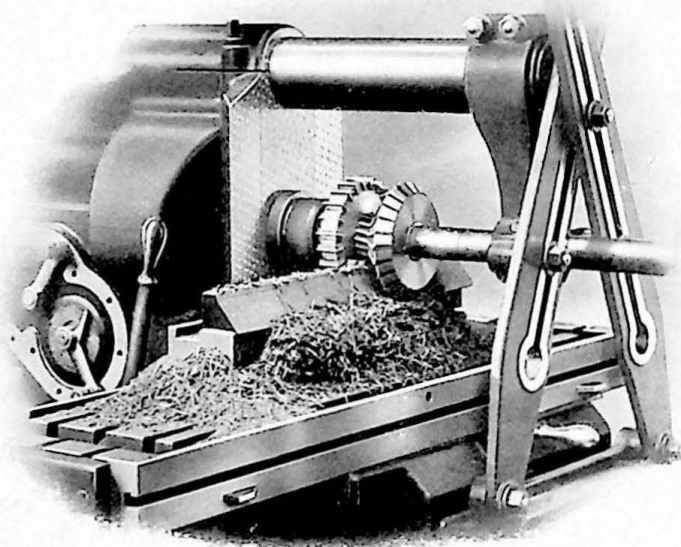
The feed reverse in the Manufacturing type (style A) is carried in the saddle as these machines have power feed to the table only. These gears project into the pan shaped bottom which is kept filled with oil.

Three Feeds All Universal and Plain machines (Style B) have power vertical, cross and table feeds and these are arranged so that no two can be engaged at the same time. The sectional view of the knee on the bottom of the opposite page shows how this is accomplished.

The shaft in the upper right hand corner is for the table feed and the clutch on this shaft is engaged only when the plunger at the left is in the central position at which time the double rocker arm controlling the cross and vertical feeds is locked by this plunger. In order to throw in either of the other feeds, this plunger must be set to one side of the lever through which it passes and this disengages the table feed clutch and makes possible the engagement of one only of the other feeds according to which way the plunger is moved, the knee being plainly marked to show which feed will be engaged.

Adds to Life of Cutters Owing to the large increase in the use of steel, either rolled, forged or cast, in mechanical construction, we provide all machines with a pump and thorough system of lubrication for the cutters, claiming that this adds 40% to their productive capacity, prolongs their life and increases the interval between sharpenings. We call especial attention to the careful provision that is made for the return of the lubricant from the table to the reservoir in the base of the machine.

It is not possible within the narrow limits of the foregoing to do more than point out the main features of milling machine design but convenience in operation is also of vital importance. A rigid machine with strong drive and powerful feed will take fast and heavy cuts but maximum results can only be obtained where careful consideration has been given to the location and arrangement of operating handles, enabling the operator to keep the cutters at work with the least possible delay between cuts.

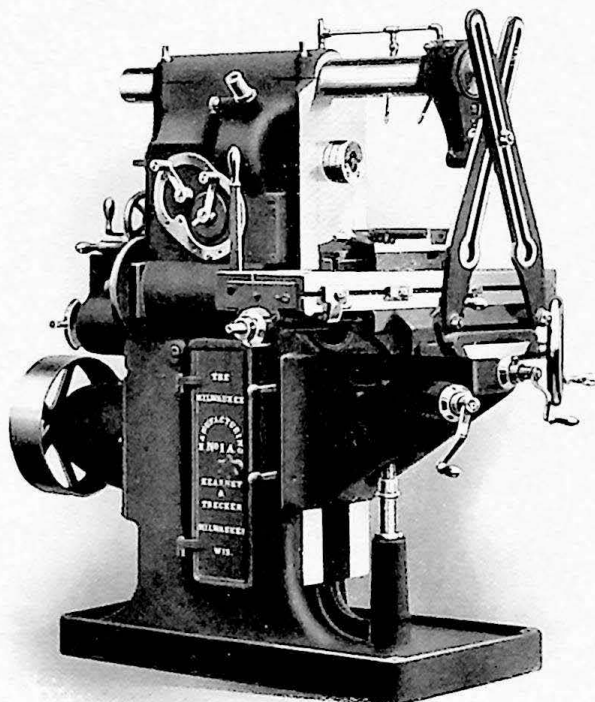


MILLING KNEE GIB

DIMENSIONS OF MILWAUKEE MANUFACTURING MILLERS

(Number of machine cannot be used as a basis of
comparison with other makes.)

No. of Machine	1-A	2-A
Table feed—automatic.....	25"	30"
Cross adjustment.....	7"	10"
Vertical adjustment.....	18"	19"
Working surface of table.....	38 $\frac{3}{8}$ "x9 $\frac{1}{2}$ "	47" x 12"
Center of spindle to over-arm.....	5 $\frac{5}{8}$ "	6 $\frac{7}{8}$ "
B. & S. taper hole in spindle.....	No. 10	No. 11
Width of vise jaws.....	6 $\frac{1}{4}$ "	7 $\frac{1}{4}$ "
Depth of vise jaws.....	1 $\frac{1}{2}$ "	2"
Vise opens without steel jaws.....	5 $\frac{1}{8}$ "	6 $\frac{1}{4}$ "
Number of speed changes.....	18	18
Range of speed (R.P.M.).....	15 to 354	15 to 360
Number of feed changes.....	12	12
Range of feed (in inches per minute).....	$\frac{1}{2}$ to 16	$\frac{1}{2}$ to 16
Diameter of driving pulley.....	14"	16"
Width of driving belt.....	4"	4 $\frac{1}{2}$ "
Speed of driving pulley (R.P.M.).....	250	300
H. P. of motor for electric drive.....	3	5
Net weight in pounds.....	2600	3800
Shipping weight (domestic).....	2900	4200
Shipping weight (foreign).....	3000	4600
Number of boxes (foreign).....	1	2
Cubic Feet (foreign).....	70	105
Code Word.....	Enforce	Endeavor



No. 1A MANUFACTURING MILLING MACHINE

Pat. Oct. 23rd, 1906. Others Pending.

Range

Table.....	25"
Cross.....	7"
Vertical.....	18"
Code Word.....	ENFORCE

NO. 1A MANUFACTURING MILLING MACHINE

Drive:—Constant speed. Belt direct to line shaft. No countershaft or overhead belts.

Pulley:—14" diameter for 4" double belt, runs 250 R.P.M.

Spindle:—Forged crucible steel, running in bronze bearings, adjustable for wear. Flanged front end with positive drive for arbors and face mills, No. 10 B. & S. taper hole. Through hole, $\frac{3}{4}$ " diameter with draw-in and discharge rod for arbors.

Spindle Speeds:—Eighteen changes in geometrical progression from 15 to 354 R.P.M. Ratio of gearing, 17 to 1.

Feed:—Positive and driven from constant speed shaft. Range, $\frac{1}{2}$ " to 16" per minute.

Motor Recommended:—Constant speed, 3 H. P. Must be capable of carrying 50% overload for one hour.

Over-Arm:—Solid steel, accurately parallel with spindle. Distance from under side of arm to center of spindle, $5\frac{5}{8}$ ".

Arbor Support:—One, bushed with bronze, for Style A Arbor.

Table:—Has a working surface of $38\frac{3}{8}$ " x $9\frac{1}{2}$ ". Has two T slots $1\frac{1}{16}$ " wide, oil grooves and screened pockets connecting with telescopic tubing for cutter lubricant return.

Lubrication:—Automatic flooding of all gears and bearings from reservoir in the base.

Cutter Lubrication:—Pump supplied with each machine. Improved means furnished for returning lubricant to reservoir.

Tools Recommended:—See pages 64 and 65.

Vise:—Jaws are $6\frac{1}{4}$ " wide, $1\frac{1}{2}$ " deep. Opens with steel jaws, $4\frac{1}{8}$ ", without steel jaws, $5\frac{1}{8}$ ".

Equipment:—Vise and all necessary wrenches.

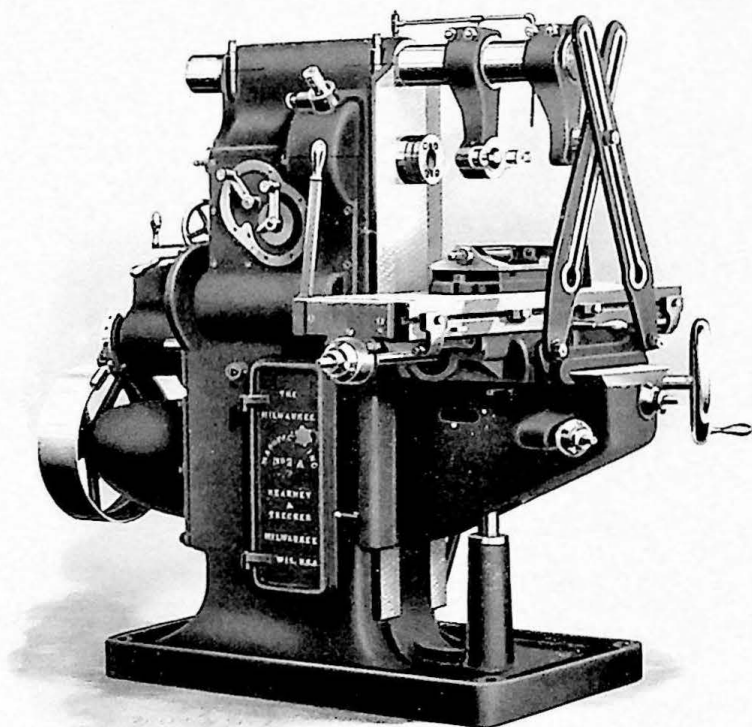
Net Weight:—(in pounds) 2600

Shipping Weight:—(domestic) 2900

Shipping Weight:—(foreign). 3000

Number of Boxes:—(foreign) 1

Cubic Feet:—(foreign) 70



No. 2A MANUFACTURING MILLING MACHINE

Pat. Oct. 23rd, 1906. Others Pending.

Range

Table.....30"
 Cross.....10"
 Vertical.....19"

Code Word.....ENDEAVOR

NO. 2A MANUFACTURING MILLING MACHINE

Drive:—Constant speed. Belt direct to line shaft. No countershaft or overhead belts.

Pulley:—16" diameter for $4\frac{1}{2}$ " double belt, runs 300 R.P.M.

Spindle:—Forged crucible steel, running in bronze bearings, adjustable for wear. Flanged front end with positive drive for arbors and face mills, No. 11 B. & S. taper hole. Through hole, 1" diameter with draw-in and discharge rod for arbors.

Spindle Speeds:—Eighteen changes in geometrical progression from 15 to 360 R.P.M. Ratio of gearing, 20 to 1.

Feed:—Positive and driven from constant speed shaft. Range, $\frac{1}{2}$ " to 16" per minute.

Motor Recommended:—Constant speed, 5 H. P. Must be capable of carrying 50% overload for one hour.

Over-Arm:—Solid steel, accurately parallel with spindle. Distance from under side of arm to center of spindle, $6\frac{7}{8}$ ".

Arbor Supports:—Two, bushed with bronze, one each for Style A and B arbors.

Table:—Has a working surface of $47'' \times 12''$. Has three T slots $\frac{1}{16}$ " wide, oil grooves and screened pockets connecting with telescopic tubing for cutter lubricant return.

Lubrication:—Automatic flooding of all gears and bearings from reservoir in the base.

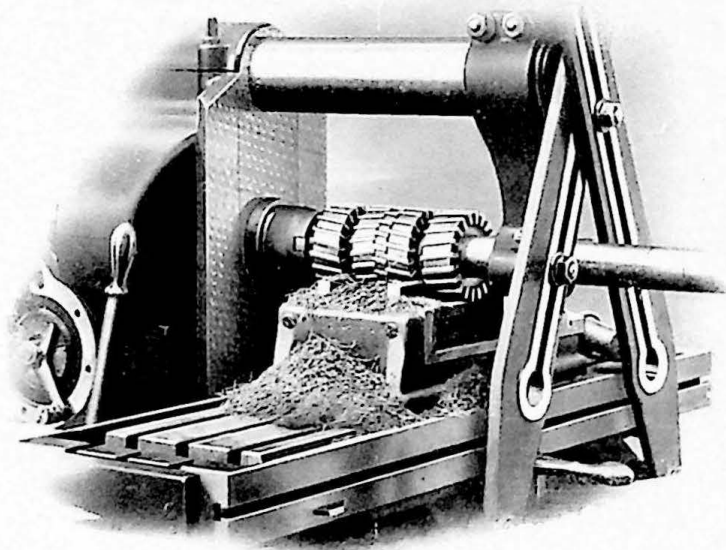
Cutter Lubrication:—Pump supplied with each machine. Improved means furnished for returning lubricant to reservoir.

Tools Recommended:—See pages 66 and 67.

Vise:—Jaws are $7\frac{1}{4}$ " wide, 2" deep. Opens with steel jaws, $5\frac{1}{4}$ ", without steel jaws, $6\frac{1}{4}$ ".

Equipment:—Vise and all necessary wrenches.

Net Weight: —(in pounds)	3800
Shipping Weight: —(domestic)	4200
Shipping Weight: —(foreign)	4600
Number of Boxes: —(foreign)	2
Cubic Feet: —(foreign)	105

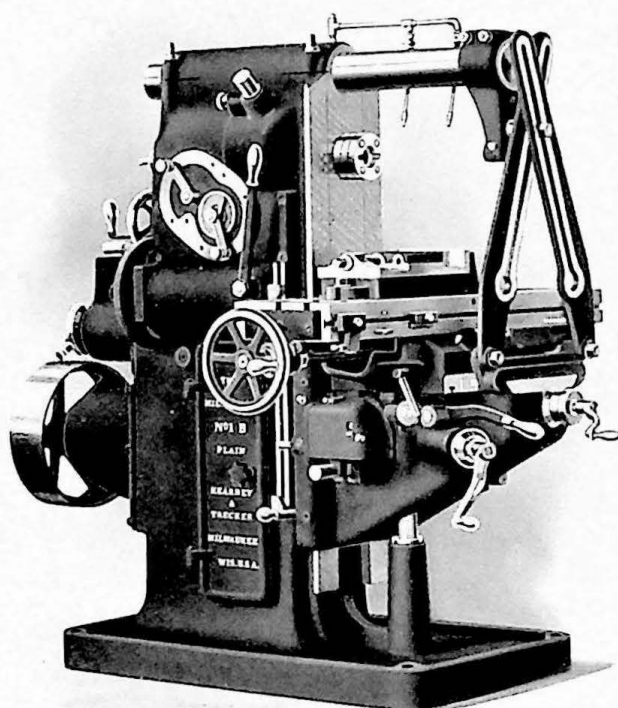


MILLING VISE JAW

DIMENSIONS OF MILWAUKEE PLAIN MILLERS

(Number of machine cannot be used as a basis of
comparison with other makes.)

No. of Machine	1-B	2-B	3-B
Table feed—automatic.....	24"	30"	36"
Cross feed—automatic.....	8"	10"	12"
Vertical feed—automatic.....	18"	19"	20"
Working surface of table.....	38 $\frac{3}{8}$ " x 9 $\frac{1}{2}$ "	47" x 12"	54" x 14"
Center of spindle to over-arm.....	5 $\frac{5}{8}$ "	6 $\frac{7}{8}$ "	7 $\frac{3}{4}$ "
B. & S. taper hole in spindle.....	No. 10	No. 11	No. 12
Width of vise jaws.....	6 $\frac{1}{4}$ "	7 $\frac{1}{4}$ "	8 $\frac{1}{4}$ "
Depth of vise jaws.....	1 $\frac{1}{2}$ "	2"	2 $\frac{1}{4}$ "
Vise opens without steel jaws.....	5 $\frac{1}{8}$ "	6 $\frac{1}{4}$ "	7 $\frac{1}{4}$ "
Number of speed changes.....	18	18	18
Range of speed (R.P.M.).....	15 to 354	15 to 360	13 to 320
Number of feed changes.....	12	12	12
Range of feed (in inches per minute)...	$\frac{1}{2}$ to 16	$\frac{1}{2}$ to 16	$\frac{1}{2}$ to 16
Diameter of driving pulley.....	14"	16"	16"
Width of driving belt.....	4"	4 $\frac{1}{2}$ "	5"
Speed of driving pulley (R.P.M.).....	250	300	350
H. P. of motor for electric drive.....	3	5	7 $\frac{1}{2}$
Net weight in pounds.....	2700	3900	5500
Shipping weight (domestic).....	3000	4400	6200
Shipping weight (foreign).....	3300	4800	6500
Number of boxes (foreign).....	1	2	2
Cubic Feet (foreign).....	70	107	132
Code Word.....	Ensign	Envoy	Energy



No. 1B PLAIN MILLING MACHINE

Pat. Oct. 23rd, 1906. Others Pending.

Automatic Feeds

Table.....	24"
Cross.....	8"
Vertical.....	18"
Code Word.....	ENSIGN

NO. 2B PLAIN MILLING MACHINE

Drive:—Constant speed. Belt direct to line shaft. No countershaft or overhead belts.

Pulley:—16" diameter for $4\frac{1}{2}$ " double belt, runs 300 R.P.M.

Spindle:—Forged crucible steel, running in bronze bearings, adjustable for wear. Flanged front end with positive drive for arbors and face mills, No. 11 B. & S. taper hole. Through hole, 1" diameter with draw-in and discharge rod for arbors.

Spindle Speeds:—Eighteen changes in geometrical progression from 15 to 360 R.P.M. Ratio of gearing, 20 to 1.

Feeds:—All automatic and positive. Driven from constant speed shaft. Range, $\frac{1}{2}$ " to 16" per minute.

Motor Recommended:—Constant speed, 5 H. P. Must be capable of carrying 50% overload for one hour.

Over-Arm:—Solid steel, accurately parallel with spindle. Distance from under side of arm to center of spindle, $6\frac{7}{8}$ ".

Arbor Supports:—Two, bushed with bronze, one each for Style A and B arbors.

Table:—Has a working surface of 47" x 12". Has three T slots $1\frac{1}{16}$ " wide, oil grooves and screened pockets connecting with telescopic tubing for cutter lubricant return.

Lubrication:—Automatic flooding of all gears and bearings from reservoir in the base.

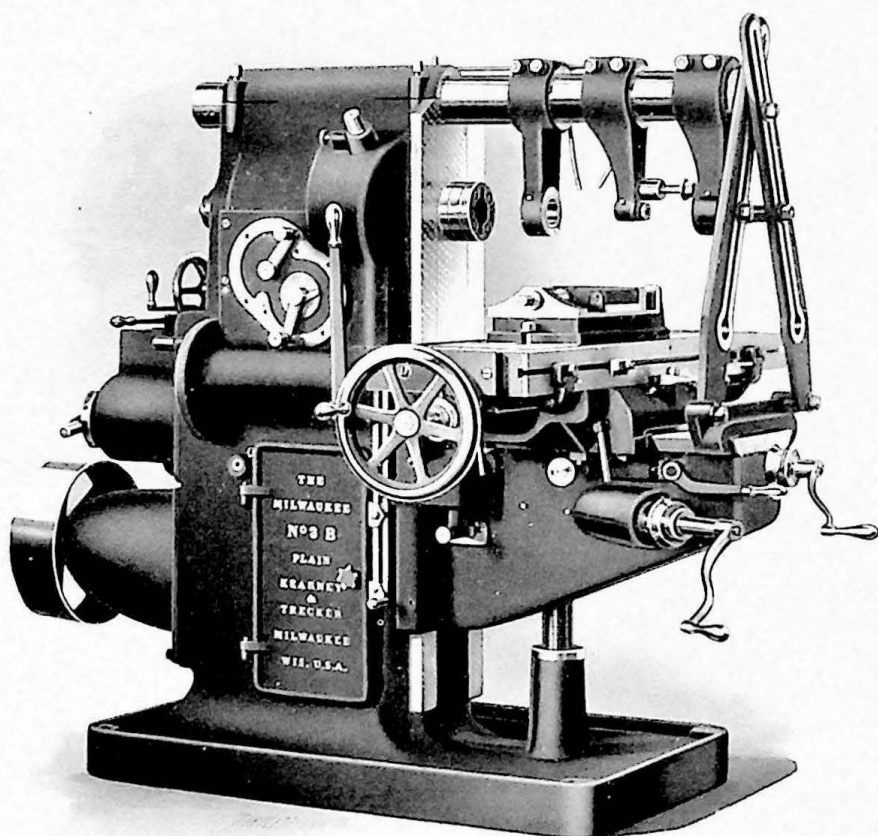
Cutter Lubrication:—Pump supplied with each machine. Improved means furnished for returning lubricant to reservoir.

Tools Recommended:—See pages 66 and 67.

Vise:—Jaws are $7\frac{1}{4}$ " wide, 2" deep. Opens with steel jaws, $5\frac{1}{4}$ ", without steel jaws, $6\frac{1}{4}$ ".

Equipment:—Vise and all necessary wrenches.

Net Weight: —(in pounds)	3900
Shipping Weight: —(domestic)	4400
Shipping Weight: —(foreign)	4800
Number of Boxes: —(foreign)	2
Cubic Feet: —(foreign)	107



No. 3B PLAIN MILLING MACHINE

Pat. Oct. 23rd, 1906. Others Pending.

Automatic Feeds

Table.....	36"
Cross.....	12"
Vertical.....	20"
Code Word.....	ENERGY

NO. 3B PLAIN MILLING MACHINE

Drive:—Constant speed. Belt direct to line shaft. No countershaft or overhead belts.

Pulley:—16" diameter for 5" double belt, runs 350 R.P.M.

Spindle:—Forged crucible steel, running in bronze bearings, adjustable for wear. Flanged front end with positive drive for arbors and face mills, No. 12 B. & S. taper hole. Through hole, 1" diameter with draw-in and discharge rod for arbors.

Spindle Speeds:—Eighteen changes in geometrical progression from 13 to 320 R.P.M. Ratio of gearing, 27 to 1.

Feeds:—All automatic and positive. Driven from constant shaft. Range, $\frac{1}{2}$ " to 16" per minute.

Motor Recommended:—Constant speed, $7\frac{1}{2}$ H. P. Must be capable of carrying 50% overload for one hour.

Over-Arm:—Solid steel, accurately parallel with spindle. Distance from under side of arm to center of spindle, $7\frac{3}{4}$ ".

Arbor Supports:—Three, bushed with bronze, one for Style A and two for Style B arbors.

Table:—Has a working surface of 54" x 14". Has three T slots $1\frac{1}{16}$ " wide, oil grooves and screened pockets connecting with telescopic tubing for cutter lubricant return.

Lubrication:—Automatic flooding of all gears and bearings from reservoir in the base.

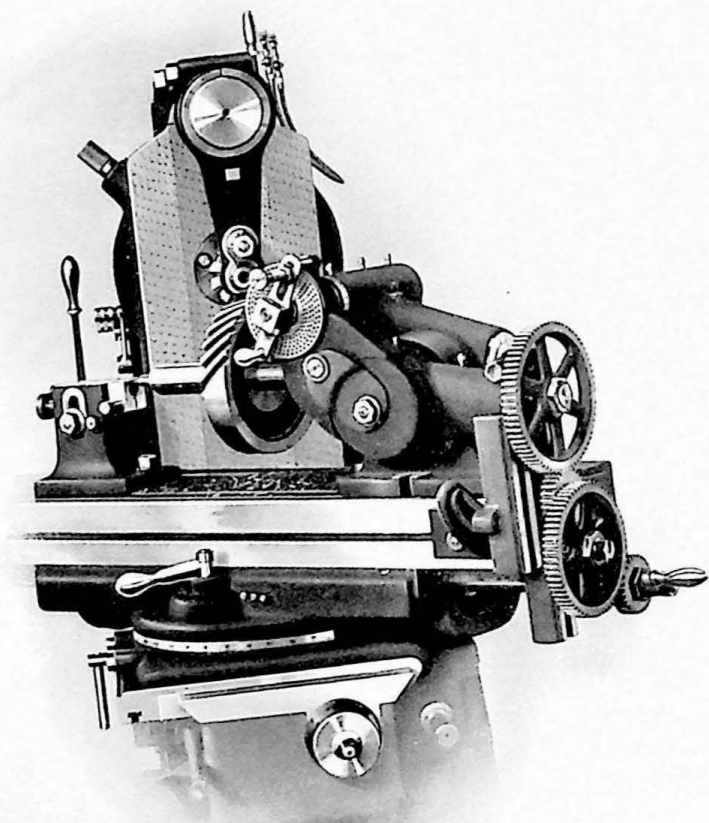
Cutter Lubrication:—Pump supplied with each machine. Improved means furnished for returning lubricant to reservoir.

Tools Recommended:—See pages 68 and 69.

Vise:—Jaws are $8\frac{1}{4}$ " wide, $2\frac{1}{4}$ " deep. Opens with steel jaws, $6\frac{1}{4}$ ", without steel jaws, $7\frac{1}{4}$ ".

Equipment:—Vise and all necessary wrenches.

Net Weight: —(in pounds)	5500
Shipping Weight: —(domestic)	6200
Shipping Weight: —(foreign)	6500
Number of Boxes: —(foreign)	2
Cubic Feet: —(foreign)	132

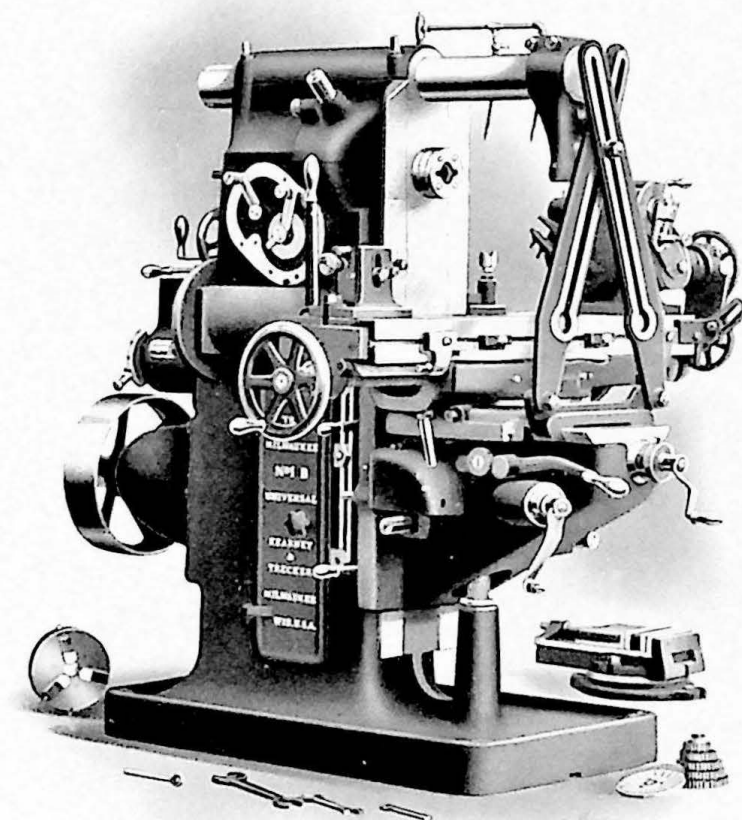


MILLING TEETH IN SPIRAL GEAR

DIMENSIONS OF MILWAUKEE UNIVERSAL MILLERS

(Number of machine cannot be used as a basis of
comparison with other makes.)

No. of Machine	1-B	2-B	3-B
Table feed—automatic.....	24"	30"	36"
Cross feed—automatic.....	8"	10"	12"
Vertical feed—automatic.....	17"	18"	19"
Working surface of table.....	38 $\frac{3}{8}$ " x 9 $\frac{1}{2}$ "	47" x 12"	54" x 14"
Center of spindle to over-arm.....	5 $\frac{5}{8}$ "	6 $\frac{7}{8}$ "	7 $\frac{3}{4}$ "
B. & S. taper hole in spindle.....	No. 10	No. 11	No. 12
Index centers swing.....	10"	12"	14"
Index centers take in length.....	21"	26"	32"
Three jaw universal chuck.....	6"	8"	9"
Width of vise jaws.....	6 $\frac{1}{4}$ "	7 $\frac{1}{4}$ "	8 $\frac{1}{4}$ "
Depth of vise jaws.....	1 $\frac{1}{2}$ "	2"	2 $\frac{1}{4}$ "
Vise opens without steel jaws.....	5 $\frac{1}{8}$ "	6 $\frac{1}{4}$ "	7 $\frac{1}{4}$ "
Number of speed changes.....	18	18	18
Range of speed (R.P.M.).....	15 to 354	15 to 360	13 to 320
Number of feed changes.....	12	12	12
Range of feed (in inches per minute)...	$\frac{1}{2}$ to 16	$\frac{1}{2}$ to 16	$\frac{1}{2}$ to 16
Diameter of driving pulley.....	14"	16"	16"
Width of driving belt (double).....	4"	4 $\frac{1}{2}$ "	5"
Speed of driving pulley (R.P.M.).....	250	300	350
H. P. of motor for electric drive.....	3	5	7 $\frac{1}{2}$
Net weight (in pounds, about).....	2900	4200	6000
Shipping weight (domestic).....	3200	4700	6600
Shipping weight (foreign).....	3600	5200	7000
Number of boxes (foreign).....	1	2	2
Cubic Feet (foreign).....	70	115	132
Code Word.....	Falcon	Famous	Favorite



No. 1B UNIVERSAL MILLING MACHINE

Pat. Oct. 23rd, 1906. Others Pending.

Automatic Feeds

Table.....	24"
Cross.....	8"
Vertical.....	17"

Code Word.....FALCON

NO. 1B UNIVERSAL MILLING MACHINE

Drive:—Constant speed. Belt direct to line shaft. No counter-shaft or overhead belts.

Pulley:—14" diameter for 4" double belt, runs 250 R. P. M.

Spindle:—Forged crucible steel, running in bronze bearings, adjustable for wear. Flanged front end with positive drive for arbors and face mills, No. 10 B. & S. taper hole. Through hole, $\frac{3}{4}$ " diameter with draw-in and discharge rod for arbors.

Spindle Speeds:—Eighteen changes in geometrical progression from 15 to 354 R. P. M. Ratio of gearing, 17 to 1.

Feeds:—All automatic and positive. Driven from constant speed shaft. Range, $\frac{1}{2}$ " to 16" per minute.

Motor Recommended:—Constant speed, 3 H. P. Must be capable of carrying 50% overload for one hour.

Over-Arm:—Solid steel, accurately parallel with spindle. Distance from under side of arm to center of spindle, $5\frac{5}{8}$ ".

Arbor Support:—One, bushed with bronze, for style A arbor.

Table:—Has a working surface of $38\frac{3}{8}$ " by $9\frac{1}{2}$ ". Has two T slots $\frac{11}{16}$ " wide, oil grooves and screened pockets connecting with telescopic tubing for cutter lubricant return.

Spiral Dividing Centers:—Swing 10" and take 21" in length. Spindle has $\frac{1}{16}$ " through hole with No. 10 B. & S. taper. Front end threaded to receive chuck. Spindle can be set in any position from 10° beyond vertical to 5° below horizontal. Head interchanges with graduated vise base so that the spindle becomes completely universal. Tail-stock adjusted vertically and graduated in degrees.

Lubrication:—Automatic flooding of all gears and bearings, from reservoir in the base.

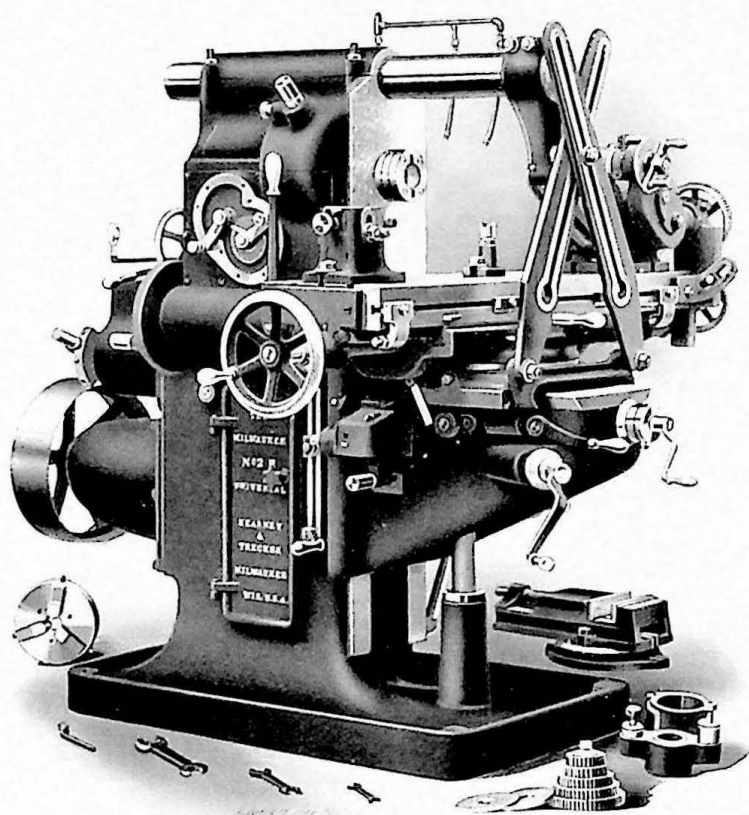
Cutter Lubrication:—Pump supplied with each machine. Improved means furnished for returning lubricant to reservoir.

Tools Recommended:—See pages 64 and 65.

Vise:—Swivel, is graduated in degrees. Jaws are $6\frac{1}{4}$ " wide, $1\frac{1}{2}$ " deep. Opens with steel jaws, $4\frac{1}{8}$ ", without steel jaws, $5\frac{1}{8}$ ".

Equipment:—Spiral dividing centers, center rest, index plates, change gears, 6"—3 jaw universal chuck, swivel vise, index chart and all necessary wrenches.

Net Weight: —(in pounds)	2900
Shipping Weight: —(domestic)	3200
Shipping Weight: —(foreign)	3600
Number of Boxes: —(foreign)	1
Cubic Feet: —(foreign)	70



No. 2B UNIVERSAL MILLING MACHINE

Pat. Oct. 23rd, 1906. Others Pending.

Automatic Feeds

Table.....	30"
Cross.....	10"
Vertical.....	18"

Code Word.....FAMOUS

NO. 2B UNIVERSAL MILLING MACHINE

Drive:—Constant speed. Belt direct to line shaft. No counter-shaft or overhead belts.

Pulley:—16" diameter for 4½" double belt, runs 300 R. P. M.

Spindle:—Forged crucible steel, running in bronze bearings, adjustable for wear. Flanged front end with positive drive for arbors and face mills, No. 11 B. & S. taper hole. Through hole, 1" diameter with draw-in and discharge rod for arbors.

Spindle Speeds:—Eighteen changes in geometrical progression from 15 to 360 R. P. M. Ratio of gearing, 20 to 1.

Feeds:—All automatic and positive. Driven from constant speed shaft. Range, ½" to 16" per minute.

Motor Recommended:—Constant speed, 5 H. P. Must be capable of carrying 50% overload for one hour.

Over-Arm:—Solid steel, accurately parallel with spindle. Distance from under side of arm to center of spindle, 67⁄8".

Arbor Supports:—Two, bushed with bronze, one each for Style A and B arbors.

Table:—Has a working surface of 47" x 12". Has three T slots 1½" wide, oil grooves and screened pockets connecting with telescopic tubing for cutter lubricant return.

Spiral Dividing Centers:—Swing 12" and take 26" in length. Spindle has 1¼" through hole with No. 11 B. & S. taper. Front end threaded to receive chuck. Spindle can be set in any position from 10° beyond vertical to 5° below horizontal. Head interchanges with graduated vise base so that the spindle becomes completely universal. Tail-stock adjusted vertically and graduated in degrees.

Lubrication:—Automatic flooding of all gears and bearings from reservoir in the base.

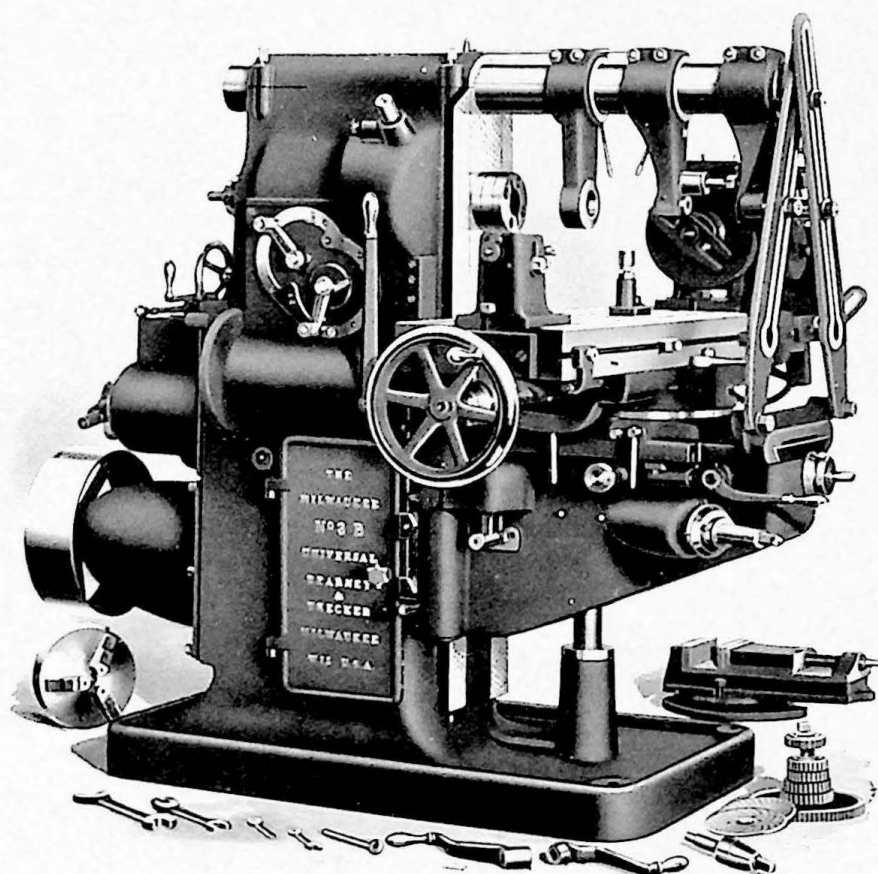
Cutter Lubrication:—Pump supplied with each machine. Improved means furnished for returning lubricant to reservoir.

Tools Recommended:—See pages 66 and 67.

Vise:—Swivel, is graduated in degrees. Jaws are 7¼" wide, 2" deep. Opens with steel jaws, 5¼", without steel jaws, 6¼".

Equipment:—Spiral dividing centers, center rest, index plates change gears, 8"—3 jaw universal chuck, swivel vise, index chart and all necessary wrenches.

Net Weight: —(in pounds)	4200
Shipping Weight: —(domestic)	4700
Shipping Weight: —(foreign)	5200
Number of Boxes: —(foreign)	2
Cubic Feet: —(foreign)	115



No. 3B UNIVERSAL MILLING MACHINE

Pat. Oct. 23rd, 1906. Others Pending.

Automatic Feeds

Table.....	36"
Cross.....	12"
Vertical.....	19"
Code Word.....	FAVORITE

NO. 3B UNIVERSAL MILLING MACHINE

Drive:—Constant speed. Belt direct to line shaft. No counter-shaft or overhead belts.

Pulley:—16" diameter for 5" double belt, runs 350 R. P. M.

Spindle:—Forged crucible steel, running in bronzed bearings, adjustable for wear. Flanged front end with positive drive for arbors and face mills, No. 12 B. & S. taper hole. Through hole, 1" diameter with draw-in and discharge rod for arbors.

Spindle Speeds:—Eighteen changes in geometrical progression from 13 to 320 R. P. M. Ratio of gearing, 27 to 1.

Feeds:—All automatic and positive. Driven from constant speed shaft. Range, $\frac{1}{2}$ " to 16" per minute.

Motor Recommended:—Constant speed, $7\frac{1}{2}$ H. P. Must be capable of carrying 50% overload for one hour.

Over-Arm:—Solid steel, accurately parallel with spindle. Distance from under side of arm to center of spindle, $7\frac{3}{4}$ ".

Arbor Supports:—Three, bushed with bronze, one for Style A and two for Style B arbors.

Table:—Has a working surface of 54" x 14". Has three T slots $1\frac{1}{16}$ " wide, oil grooves and screened pockets connecting with telescopic tubing for cutter lubricant return.

Spiral Dividing Centers:—Swing 14" and take 32" in length. Spindle has $1\frac{1}{2}$ " through hole with No. 12 B. & S. taper. Front end threaded to receive chuck. Spindle can be set in any position from 10° beyond vertical to 5° below horizontal. Head interchanges with graduated vise base so that the spindle becomes completely universal.

Lubrication:—Automatic flooding of all gears and bearings from reservoir in the base.

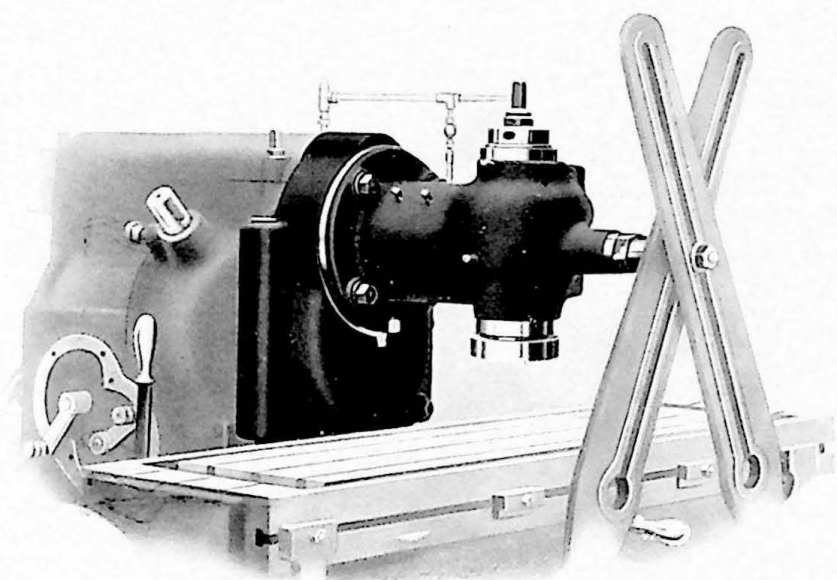
Cutter Lubrication:—Pump supplied with each machine. Improved means furnished for returning lubricant to reservoir.

Tools Recommended:—See pages 68 and 69.

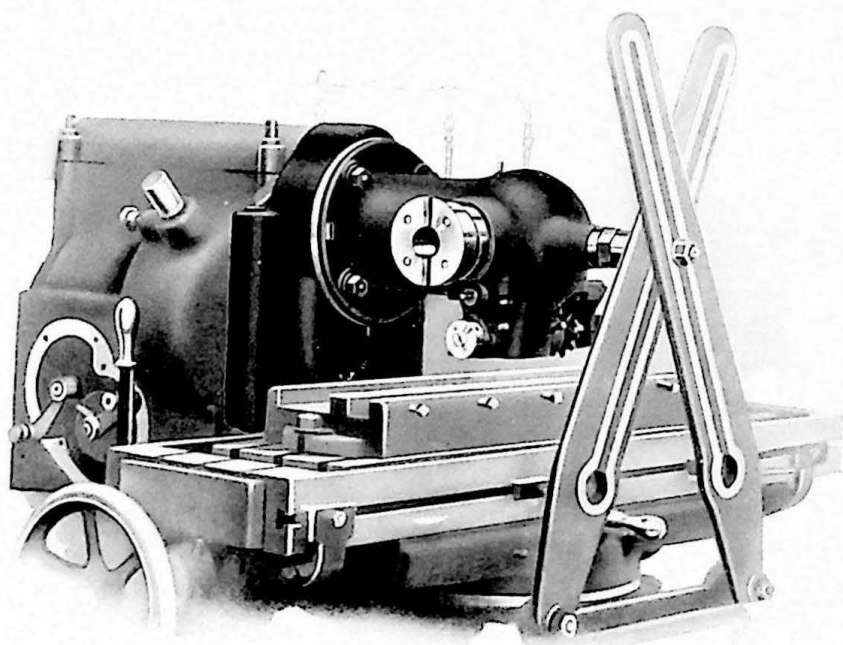
Vise:—Swivel, is graduated in degrees. Jaws are $8\frac{1}{4}$ " wide, $2\frac{1}{4}$ " deep. Opens with steel jaws, $6\frac{1}{4}$ ", without steel jaws, $7\frac{1}{4}$ ".

Equipment:—Spiral dividing centers, center rest, index plates, change gears, 9"—3 jaw universal chuck, swivel vise, index chart and all necessary wrenches.

Net Weight: —(in pounds)	6000
Shipping Weight: —(domestic)	6600
Shipping Weight: —(foreign)	7000
Number of Boxes: —(foreign)	2
Cubic Feet: —(foreign)	132



VERTICAL SPINDLE ATTACHMENT



VERTICAL SPINDLE WITH RACK
CUTTING ATTACHMENT

Number of attachment corresponds to number of
machine to which it is adapted.

When ordering give number stamped on front of knee.

VERTICAL SPINDLE ATTACHMENT

This attachment conforms to the general design of the machine, both as to appearance and efficiency and is held in place by being clamped to the knee slide on the column of the machine and can be changed very quickly.

The spindle runs in bronze bearings with adjustment for wear, has taper hole, draw-in rod and flanged end that are duplicates in every way of the horizontal spindle so that tools will interchange. It can be set at any angle, graduations in degrees being provided for that purpose.

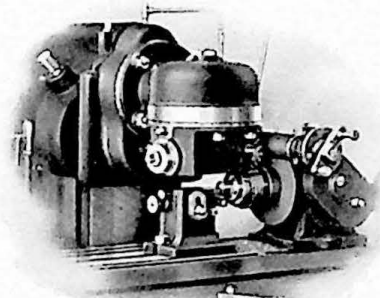
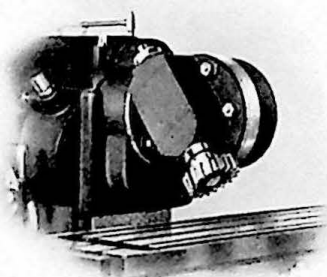
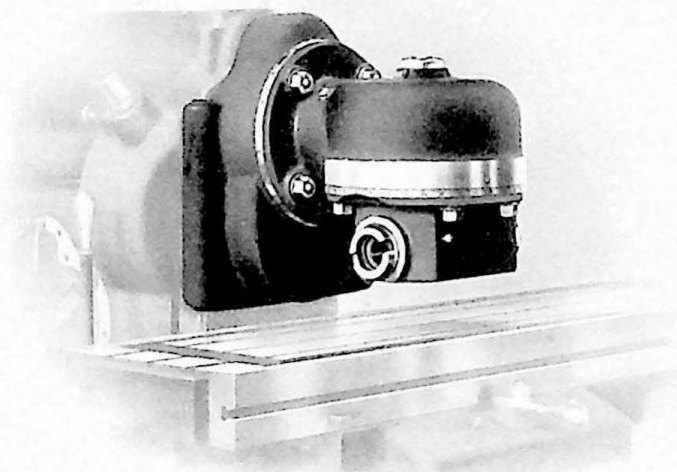
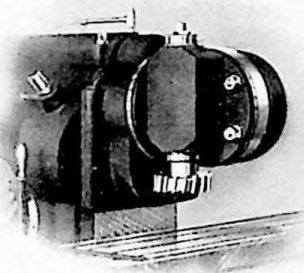
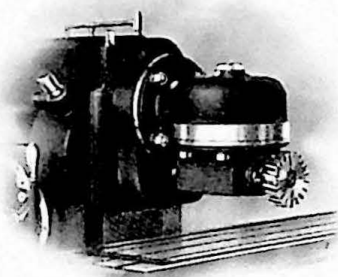
A very large percentage of our machines are equipped with this useful feature as it enables the operator to use either the horizontal or vertical spindle according to which best fits the conditions. Face mills are the most economical cutters. See pages 60 and 61. Face mill arbors. See pages 58 and 59.

No.	B. & S. taper hole in spindle	End of spindle to table in lowest position	Center of spindle to face of column	Net Weight Lbs.	Code Word
1	10	17"	9 1/2"	160	Lime
2	11	18"	12 5/8"	240	Limit
3	12	18 1/2"	15"	400	Limbo

RACK CUTTING ATTACHMENT

This attachment is supplied with vertical spindle when so ordered. It provides a cutter arbor at right angles to the regular arbor for such work as rack cutting, cross milling on long pieces, milling spirals on Universal Millers at certain angles beyond those ordinarily covered.

No.	Diameter of Arbor	Distance center of arbor to bottom	Net Weight Pounds	Code Word
1	1"	13 3/32"	20	Lineage
2	1"	13 3/32"	24	Linen
3	1 1/4"	15 3/32"	52	Liniment



UNIVERSAL MILLING ATTACHMENT

Number of attachment corresponds to number of machine to which it is adapted.
When ordering give number stamped on front of knee.

UNIVERSAL MILLING ATTACHMENT

There are few shops that do not, at some time, run up against a complicated piece of work that baffles the ingenuity of their best mechanics. It was for just such cases as this that this attachment was designed. Not only is it suited to meet the unusual and occasional job, but for the every day and the usual as well. There is no conceivable angle at which it cannot be set and the construction is such as to enable it to withstand severe and constant usage.

Like the Vertical Spindle and other attachments, it is held in place by being clamped to the knee slide on the column of the machine and can be changed very quickly.

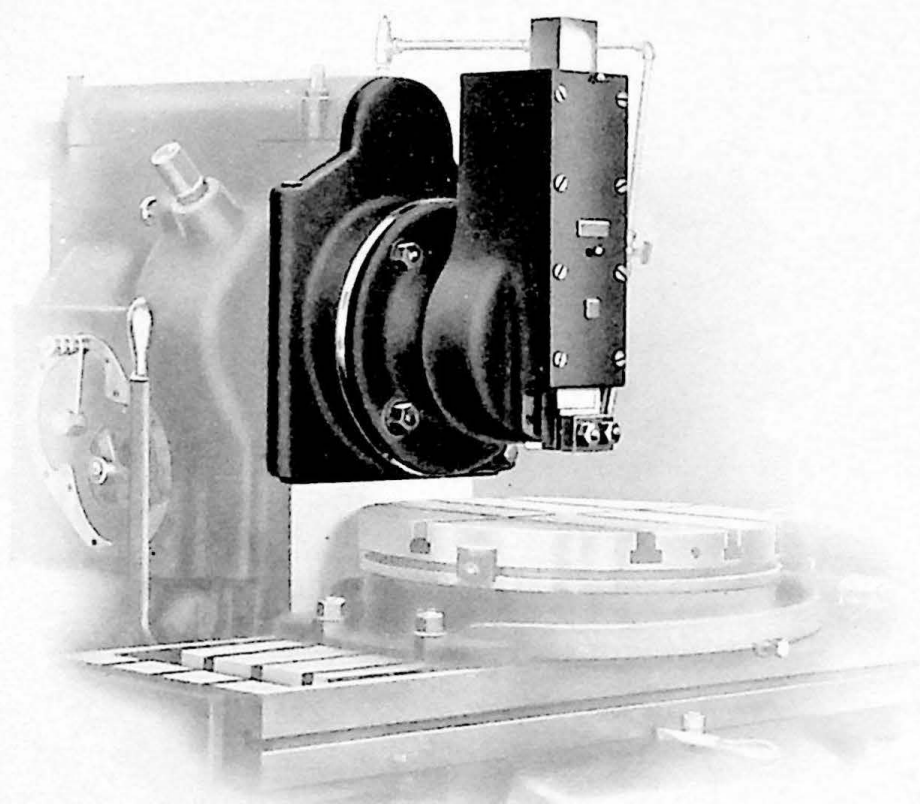
The spindle runs in bronze bearings with adjustment for wear and is made of hardened steel, ground on the outside and in the taper hole, this being No. 10 B. & S. on all sizes. Clutch drive is provided for arbors and cutters, also draw-in and discharge rod.

The drive is from a spur gear, carried by the flanged end of the main spindle, through bevel gears to a wide faced pinion on the spindle, these being made of hardened steel and carefully fitted. Spirals of any angle can be cut on both Universal and Plain machines if the latter are fitted with Universal Spiral Dividing Centers which we are prepared to supply. (See pages 52 and 53.

It can be used as an ordinary Vertical Spindle and is recommended for face milling with cutters up to 6" diameter. Use arbors 43, 44 or 45, pages 58 and 59; face mills up to F14, page 60.

Can also be used for cutting racks.

No.	B. & S. taper hole in spindle	Distance center of spindle to bottom	Distance center of spindle to face of column	Net Weight Lbs.	Code Word
1	10	$11\frac{7}{32}"$	$10\frac{7}{8}"$	265	Ocelot
2	10	$13\frac{5}{64}"$	$11\frac{1}{4}"$	290	Ochre
3	10	$19\frac{1}{16}"$	$11\frac{1}{2}"$	325	Ochery



SLOTING ATTACHMENT

Number of attachment corresponds to number of machine to which it is adapted.
When ordering give number stamped on front of knee.

ROTARY TABLE

This attachment, as the name implies, is a work table for holding parts that are to be circular milled such as segments and parts of circles ending in projections. Also used for straight milling as with a face mill on two or more sides of the same piece at one chucking, gear cutting on large diameter gears, complicated die work, etc.

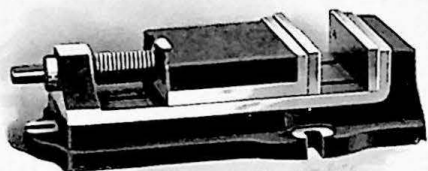
The worm wheel is almost as large in diameter as the table and is accurately cut on a machine built for this purpose. The worm has adjustment for wear and the worm shaft carries a collar graduated in minutes, the table itself being graduated in degrees.

When used on a machine supplied with any style of dividing centers shown on page 52, index plate and crank belonging to these may be used on the rotary table in place of the graduated collar for making divisions. Where these plates and crank are supplied with the rotary table alone, an extra charge is made.

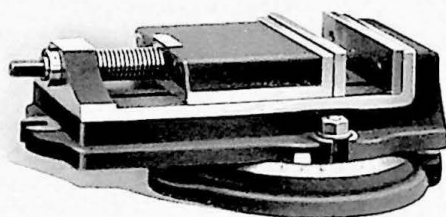
The center hole is made taper with the largest end at the bottom so that arbors can be used that will accurately center and hold the work down. The top end of this hole is straight for a short distance for convenience in centering where a plug is used from the top.

Power feed is provided, this being driven from a shaft parallel with the table screw and can be tripped at any point, either by hand or automatically. Power feed cannot be furnished for rotary table on Style A Manufacturing Millers.

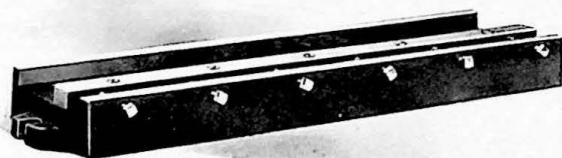
No.	Diam. of table	Diam. over oil pan	Height	Weight Lbs.	Code Word	Code Word Index Plates and crank
1	14"	17"	5"	267	Rotund	Raven
2	17"	20"	5"	364	Rouser	Rostrum
3	20"	23"	5"	484	Royalist	Rotten



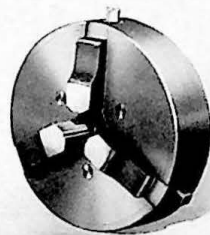
PLAIN VISE



SWIVEL VISE



RACK VISE



MILLING MACHINE CHUCK

Number of attachment corresponds to number of machine to which it is adapted.
When ordering give number stamped on front of knee.

MILLING MACHINE VISE—PLAIN

This vise is of improved flanged construction with cross slots and side ears so that it can be held either way on the work table. Furnished as part of the regular equipment of Plain and Manufacturing Millers.

No.	Width of steel jaws	Depth of steel jaws	Opens with steel jaws	Opens without steel jaws	Weight Lbs.	Code Word
1	6 $\frac{1}{4}$ "	1 $\frac{1}{2}$ "	4 $\frac{1}{8}$ "	5 $\frac{1}{8}$ "	60	Locust
2	7 $\frac{1}{4}$ "	2"	5 $\frac{1}{4}$ "	6 $\frac{1}{4}$ "	95	Lofty
3	8 $\frac{1}{4}$ "	2 $\frac{1}{4}$ "	6 $\frac{1}{4}$ "	7 $\frac{1}{4}$ "	135	Lotus

MILLING MACHINE VISE—SWIVEL

This is the plain vise with the addition of a circular base, graduated in degrees. It can be removed from the circular base and used as a plain vise if desired. Furnished as part of the regular equipment of Universal Milling Machines.

No.	Width of steel jaws	Depth of steel jaws	Opens with steel jaws	Opens without steel jaws	Weight Lbs.	Code Word
1	6 $\frac{1}{4}$ "	1 $\frac{1}{2}$ "	4 $\frac{1}{8}$ "	5 $\frac{1}{8}$ "	84	Lyceum
2	7 $\frac{1}{4}$ "	2"	5 $\frac{1}{4}$ "	6 $\frac{1}{4}$ "	137	Lydian
3	8 $\frac{1}{4}$ "	2 $\frac{1}{4}$ "	6 $\frac{1}{4}$ "	7 $\frac{1}{4}$ "	162	Lyric

RACK VISE

This is a vise intended to hold long pieces lengthwise of the table such as racks or any work that requires a long clamping jaw.

No.	Length	Opens with steel jaws	Opens without steel jaws	Weight Lbs.	Code Word
1	29 $\frac{1}{2}$ "	4 $\frac{7}{8}$ "	6 $\frac{1}{8}$ "	96	Lunar
2	29 $\frac{1}{2}$ "	4 $\frac{7}{8}$ "	6 $\frac{1}{8}$ "	96	Lunate
3	36"	8"	9 $\frac{1}{4}$ "	208	Lupine

MILLING MACHINE CHUCK

This is a universal chuck with three jaws, all of which are operated by the application of wrench to one pinion. It is provided with face plate to fit dividing heads of corresponding numbers.

No.	Diameter	Weight Lbs.	Code Word
1	6"	16	Rosette
2	8"	26	Rostral
3	9"	39	Rosin



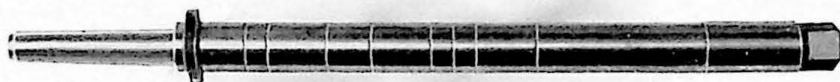
COLLET



CUTTER ARBORS (Style C)



CUTTER ARBORS (Style A)



CUTTER ARBORS (Style B)



ROTARY TABLE ARBOR

When ordering collets and arbors give number
stamped on front of knee.

COLLETS

Collets are tapped to suit draw-in bar in spindle of Milling Machine. Only B. & S. taper holes are listed, but Morse taper holes can also be furnished promptly.

No.	B. & S. Taper Outside	B. & S. Taper Inside	Machine Where Used	Code Word	Net Price
1	10	4	No. 1	Hawk	\$3.50
2	10	5	No. 1	Hawser	3.50
3	10	7	No. 1	Haze	3.50
4	10	9	No. 1	Hazel	4.00
5	11	7	No. 2	Hound	4.50
6	11	9	No. 2	Hero	5.00
7	11	10	No. 2	Helmet	5.50
8	12	7	No. 3	Hilt	5.50
9	12	9	No. 3	Hindoo	5.50
10	12	10	No. 3	Hive	6.50
11	12	11	No. 3	Hobby	6.50
12	7	4	Collets	Hovel	2.00
13	7	5	Collets	Hover	2.00

ARBORS FOR FACE MILLING CUTTERS STYLE C

No.	Diameter	B. & S. Taper Shank	Miller	Code Word	Net Price
43	1"	10	No. 1	Cask	\$5.50
44	1 1/4"	10	No. 1	Casket	6.00
45	1 1/2"	10	No. 1	Casque	6.50
66	1"	11	No. 2	Chisel	6.50
67	1 1/4"	11	No. 2	Churn	7.00
68	1 1/2"	11	No. 2	Catnip	8.00
87	1"	12	No. 3	Cork	7.50
88	1 1/4"	12	No. 3	Coul	8.00
89	1 1/2"	12	No. 3	Cream	8.50

CUTTER ARBORS

These arbors have clutch drive collars to engage with clutch collar on spindle of millers so that there can be no slip to damage spindle or arbor. The back end is tapped to suit draw-in bar in spindle. Style A arbor has bearing outside of nut and is made small so that the arm bracket will pass over the top of the vise or other work when using small diameter cutters. Style "B" arbors have hardened and ground bearing back of the nut which can be adjusted to any point to suit requirements.

No.	Diameter	Length from Shoulder to Nut	B. & S. Taper	Style	Machine Where Used	Code Word	Net Price
40	7/8"	8"	10	A	No. 1	Calk	\$ 7.00
41	1"	8"	10	A	No. 1	Cadet	7.00
42	1 1/4"	8"	10	A	No. 1	Cake	7.00
60	7/8"	10"	11	A	No. 2	Caliph	9.00
61	1"	10"	11	A	No. 2	Calf	9.00
62	1 1/4"	10"	11	A	No. 2	Cane	9.00
63	1"	18 1/2"	11	B	No. 2	Chief	14.00
64	1 1/4"	18 1/2"	11	B	No. 2	Chemist	14.00
65	1 1/2"	18 1/2"	11	B	No. 2	Cad	14.00
80	7/8"	12"	12	A	No. 3	Clay	10.00
81	1"	12"	12	A	No. 3	Clevis	10.00
82	1 1/4"	12"	12	A	No. 3	Cleave	10.00
83	1"	20"	12	B	No. 3	Cockle	15.00
84	1 1/4"	24"	12	B	No. 3	Cornet	16.00
85	1 1/2"	24"	12	B	No. 3	Conoid	16.00
86	1 3/4"	24"	12	B	No. 3	Clarion	20.00

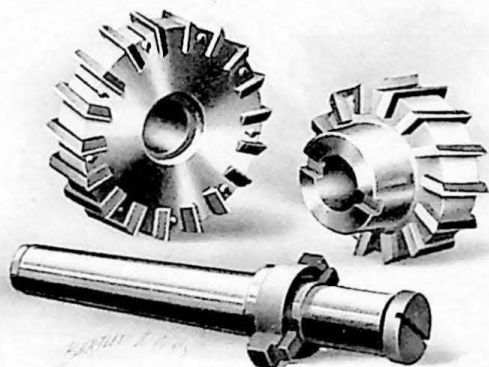
ROTARY TABLE ARBOR

This arbor is for holding and centering gears and similar work on rotary table.

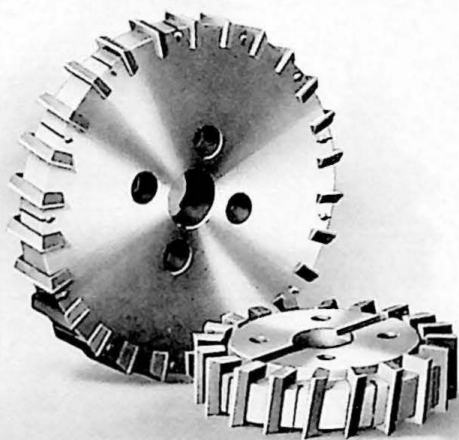
1" diameter, 6" from shoulder to nut.

Same arbor for all sizes of tables.

Price.....\$7.00. Code Word.....ROSSEL.



FACE MILLING CUTTERS, F15 AND SMALLER



FACE MILLING CUTTERS, F26 AND LARGER

MILLING CUTTERS

Milling cutters with inserted teeth of high speed steel, adapted for use in connection with our Millers, have been a regular part of our product for some years. Their use has added to the popularity of our machines by increasing their output.

FACE MILLING CUTTERS

Use Style C arbor, pages 58 and 59

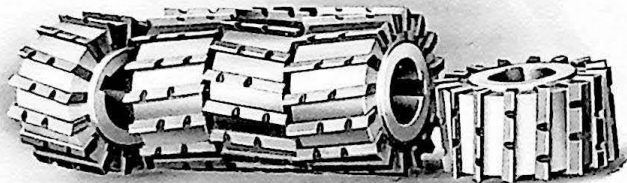
No.	Diam.	Face	Hole	Arbors for Millers			Code Word	Net Price
				No. 1	No. 2	No. 3		
F-7	2 1/2"	1 1/2"	1"	43	66	87	Butter	\$ 8.00
F-8	2 3/4"	1 1/2"	1"	43	66	87	Buttock	8.75
F-9	3"	1 1/2"	1"	43	66	87	Buxom	9.50
F-10	3 1/2"	1 1/2"	1"	43	66	87	Burg	10.25
F-11	4"	1 1/2"	1 1/4"	44	67	88	Bumkin	11.00
F-12	4 1/2"	1 1/2"	1 1/4"	44	67	88	Bullion	11.75
F-13	5"	1 1/2"	1 1/4"	44	67	88	Bumble	12.50
F-14	6"	1 3/8"	1 1/2"	45	68	89	Bunion	14.00
F-15	7"	1 3/8"	1 1/2"	.....	.....	89	Bureau	16.00

FACE MILLING CUTTERS

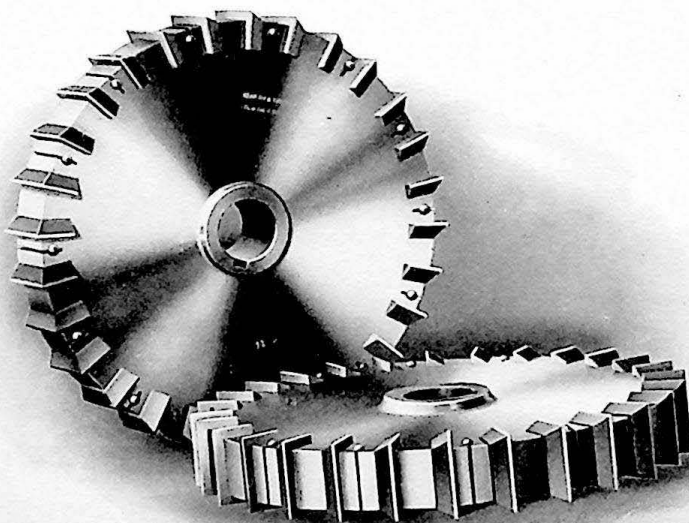
Carried directly by flanged spindle.

(For centering plug-see sets of tools.)

No.	Diam.	Face	Machine	Code Word	Net Price
F-26	6"	1 9/16"	No. 1	Bumper	\$14.00
F-27	7"	1 1/16"	No. 1	Burgess	16.00
F-28	7"	1 1/16"	No. 2	Bunch	17.00
F-29	8"	1 1/16"	No. 1	Bunchy	18.00
F-30	8"	1 9/16"	No. 2	Bulb	20.00
F-31	8"	2"	No. 3	Budget	20.00
F-32	10"	1 9/16"	No. 2	Buckram	24.00
F-33	10"	2"	No. 3	Buffet	24.00
F-34	12"	2"	No. 3	Buckle	28.00



SLAB MILLING CUTTERS



SIDE MILLING CUTTERS

SLAB MILLING CUTTERS

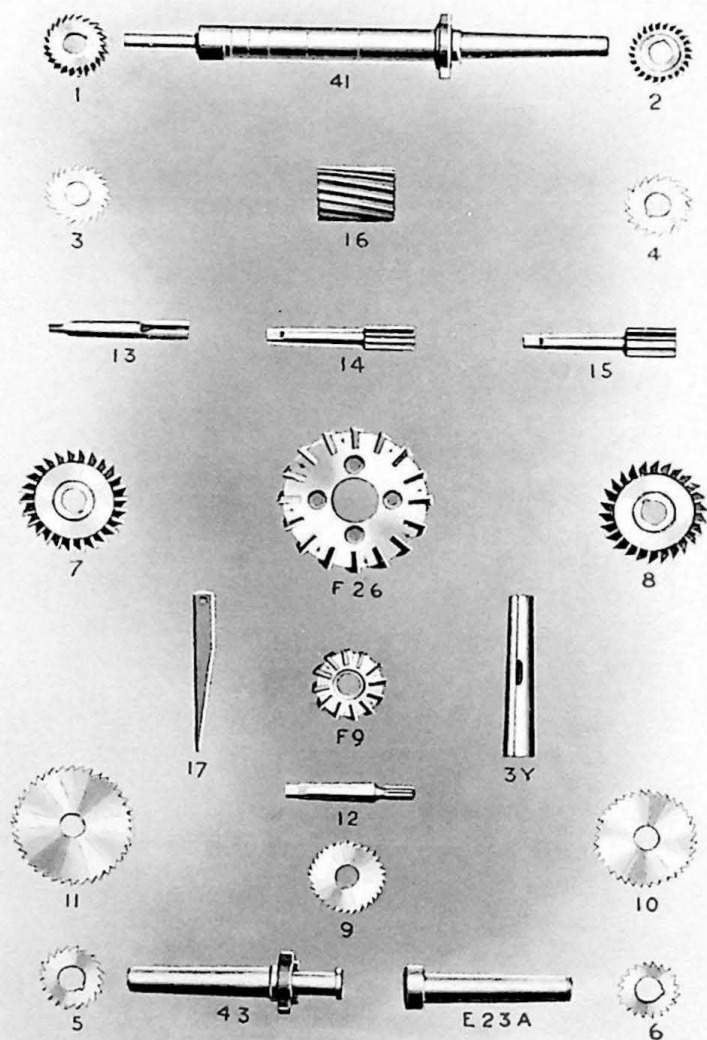
These cutters are interlocking each cutter being $\frac{1}{16}$ " longer than the length given in the list so that if three cutters 2" long were assembled on the arbor they would measure 6 $\frac{1}{16}$ " long over all and if a pair of our side cutters were used on each end the width of cut would be 6". Where two or more are ordered they will be supplied alternately, right and left hand. Any exact length can be obtained by making one cutter special to fill out the required length.

No.	Diameter	Length	Hole	Code Word	Net Price
M-51	3 $\frac{1}{2}$ "	1 $\frac{1}{4}$ "	1"	Polygon	\$7.50
M-510	3 $\frac{1}{2}$ "	1 $\frac{3}{4}$ "	1"	Polemic	9.00
M-52	3 $\frac{1}{2}$ "	1 $\frac{3}{4}$ "	1 $\frac{1}{2}$ "	Polygram	9.00
M-520	4"	2"	1 $\frac{1}{2}$ "	Potter	10.50
M-53	4"	2"	1 $\frac{1}{2}$ "	Pollard	10.50
M-530	4 $\frac{1}{2}$ "	2"	1 $\frac{1}{4}$ "	Potony	12.00
M-531	4 $\frac{1}{2}$ "	2"	1 $\frac{1}{2}$ "	Pollux	12.00
M-54	4 $\frac{1}{2}$ "	2"	1 $\frac{3}{4}$ "	Polyglot	12.00

SIDE MILLING CUTTERS

SIDE MILLING CUTTERS are for use in facing both sides of a piece at once (in which case they are used in pairs), milling slots or for use in gangs. The hubs are $\frac{1}{16}$ " shorter than the blades so that when used in connection with slab mills the blades will over-reach the smaller cutter producing a better result.

No.	Diameter	Face	Hole	Code Word	Net Price
Z-31	5"	1"	1"	Valor	\$12.00
Z-32	5"	1"	1 $\frac{1}{4}$ "	Valorous	12.00
Z-33	6"	1"	1"	Vanish	14.00
Z-331	6"	1"	1 $\frac{1}{4}$ "	Vanity	14.00
Z-332	6"	1"	1 $\frac{1}{2}$ "	Vase	14.00
Z-34	7"	1 $\frac{1}{8}$ "	1"	Vanily	16.00
Z-35	7"	1 $\frac{1}{8}$ "	1 $\frac{1}{4}$ "	Vandal	16.00
Z-36	7"	1 $\frac{1}{8}$ "	1 $\frac{1}{2}$ "	Vandalism	16.00
Z-37	7"	1 $\frac{1}{8}$ "	1 $\frac{3}{4}$ "	Vane	16.00
Z-371	8"	1 $\frac{1}{8}$ "	1"	Vaunt	18.00
Z-372	8"	1 $\frac{1}{8}$ "	1 $\frac{1}{4}$ "	Vell	18.00
Z-373	8"	1 $\frac{1}{8}$ "	1 $\frac{1}{2}$ "	Vennel	18.00
Z-374	8"	1 $\frac{1}{8}$ "	1 $\frac{3}{4}$ "	Verger	18.00
Z-38	9"	1 $\frac{1}{8}$ "	1 $\frac{1}{4}$ "	Valley	20.00
Z-39	9"	1 $\frac{1}{8}$ "	1 $\frac{1}{2}$ "	Valiant	20.00
Z-40	9"	1 $\frac{1}{8}$ "	1 $\frac{3}{4}$ "	Vagrant	20.00
Z-401	11"	1 $\frac{1}{8}$ "	1 $\frac{1}{4}$ "	Valance	24.00
Z-41	11"	1 $\frac{1}{8}$ "	1 $\frac{1}{2}$ "	Vagary	24.00
Z-42	11"	1 $\frac{1}{8}$ "	1 $\frac{3}{4}$ "	Vale	24.00
Z-421	13"	1 $\frac{1}{8}$ "	1 $\frac{1}{2}$ "	Valencia	30.00
Z-43	13"	1 $\frac{1}{8}$ "	1 $\frac{3}{4}$ "	Vapor	30.00
Z-431	15"	1 $\frac{1}{8}$ "	1 $\frac{1}{2}$ "	Valerate	36.00
Z-44	15"	1 $\frac{1}{8}$ "	1 $\frac{3}{4}$ "	Vault	36.00



SET OF TOOLS FOR No. 1 MILLERS

SET OF TOOLS FOR No. 1 MILLING MACHINES

The set of tools shown on the opposite page and listed below was selected with a view to an outfit that would be of real value and covers a wide range of work.

The larger cutters and those most likely to be used extensively are of special quality high speed steel. The balance are of carbon tool steel.

MILLING CUTTERS.

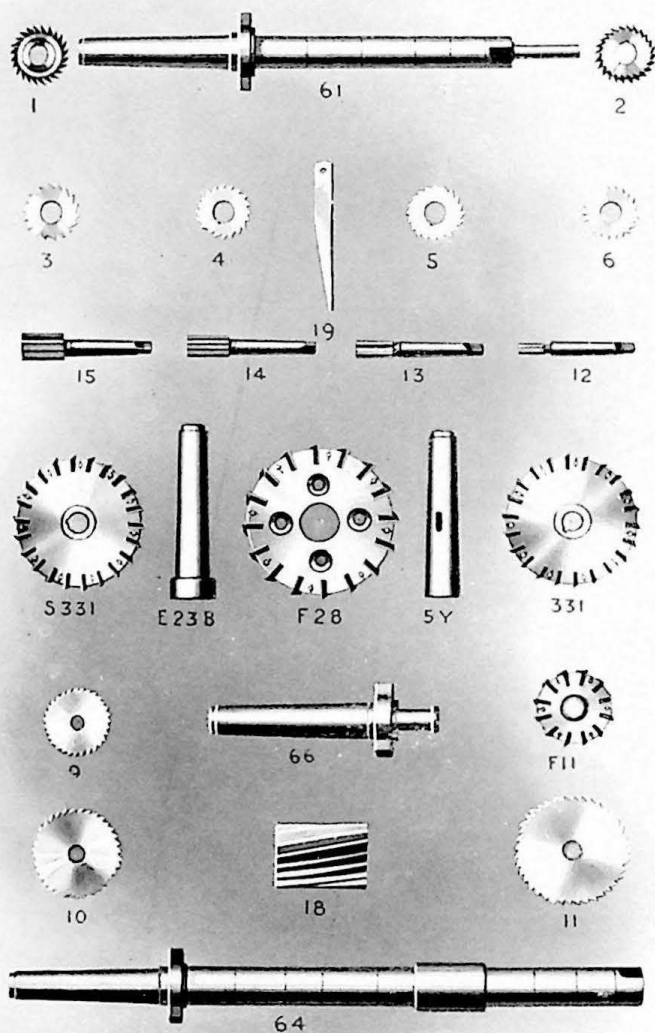
No.	Style	Diam.	Face	Hole	Steel	Code Word	Price
1	60° L. H.	2 3/4"	1 1/2"	1"	Carbon	Hag	\$ 2.00
2	60° R. H.	2 3/4"	1 1/2"	1"	"	Haft	2.00
3	Plain	2 1/2"	1 1/4"	1"	"	Hackney	1.00
4	"	2 1/2"	3/8"	1"	"	Hackle	1.10
5	"	2 1/2"	1/2"	1"	"	Hable	1.20
6	"	2 1/2"	3/4"	1"	"	Habnab	1.45
7	Side	4"	1 1/2"	1"	Speed	Habitat	6.65
8	"	4"	1 1/2"	1"	"	Haggard	6.65
9	Metal Saw	3"	1 1/16"	1"	Carbon	Haik	.70
10	" "	4"	3 3/32"	1"	"	Hakot	.85
11	" "	5"	1 1/8"	1"	"	Haleyon	1.00
12	End Mill	1 1/2"	1 1/8"	.....	"	Halibut	1.00
13	" "	3 3/4"	1 5/8"	.....	"	Halse	1.25
14	" "	1"	1 7/8"	.....	"	Halter	1.45
15	" "	1 1/4"	2"	.....	"	Hamble	1.60
16	Spiral	2 1/4"	3"	1"	Speed	Hallux	7.00
F 9	Face	3"	1 1/2"	1"	"	Buxom	9.50
F26	"	6"	1 7/16"	1 7/8"	"	Bumper	14.00

ARBORS, COLLETS, ETC.

17	Collet Drift	}	Haze	3.50
31	Collet, 7x10 B. & S. Tapers.....			
41	Style A Cutter Arbor, 1" diameter, 8" shoulder to nut.....			
43	Style C Face Mill Arbor, 1" diameter.....		Cadet	7.00
E23A	Spindle Centering Plug		Cask	5.50
			Handsel	2.00

Price—Set complete.....\$70.00. Code Word.....KHANATE.

Unless whole set is taken, individual list prices apply.



SET OF TOOLS FOR No. 2 MILLERS

SET OF TOOLS FOR No. 2 MILLING MACHINES

The set of tools shown on the opposite page and listed below was selected with a view to an outfit that would be of real value and covers a wide range of work.

The larger cutters and those most likely to be used extensively are of special quality high speed steel. The balance are of carbon tool steel.

MILLING CUTTERS.

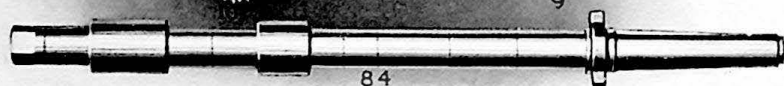
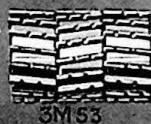
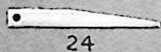
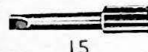
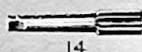
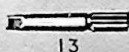
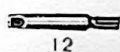
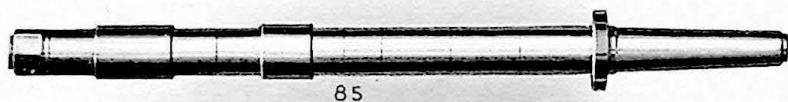
No.	Style	Diam.	Face	Hole	Steel	Code Word	Price
1	60° L. H.	2 3/4"	1 1/2"	1"	Carbon	Hag	\$ 2.00
2	60° R. H.	2 3/4"	1 1/2"	1"	"	Haft	2.00
3	Plain	2 1/2"	1 1/4"	1"	"	Hackney	1.00
4	"	2 1/2"	3/8"	1"	"	Hackle	1.10
5	"	2 1/2"	1 1/2"	1"	"	Hable	1.20
6	"	2 1/2"	3/4"	1"	"	Habnab	1.45
9	Metal Saw	3"	1/16"	1"	"	Haik	.70
10	"	4"	3/32"	1"	"	Hakot	.85
11	"	5"	1/8"	1"	"	Halcyon	1.00
12	End Mill	1 1/2"	1 1/8"	.....	"	Halibut	1.00
13	"	3/4"	1 5/8"	.....	"	Halse	1.25
14	"	1"	1 7/8"	.....	"	Halter	1.45
15	"	1 1/4"	2"	.....	"	Hamble	1.60
18	Spiral	2 3/4"	4"	1 1/4"	Speed	Hamate	10.00
331	Side	6"	1"	1 1/4"	"	Vanity	14.00
S331	"	6"	1"	1 1/4"	"	Vanity	14.00
F11	Face	4"	1 1/2"	1 1/4"	"	Bunkin	11.00
F28	"	7"	1 9/16"	1 7/8"	"	Bunch	17.00

ARBORS, COLLETS, ETC.

19	Collet Drift.....	} Hound	4.50
5Y	Collet, 7x11 B. & S. Tapers.....		
61	Style A Cutter Arbor, 1" diameter, 10" shoulder to nut.....	Calf	9.00
64	Style B Cutter Arbor, 1 1/4" diameter, 18 1/2" shoulder to nut.....	Chemist	14.00
66	Style C Face Mill Arbor, 1" diameter.....	Chisel	6.50
E23B	Spindle Centering Plug.....	Halser	2.50

Price—Set complete.....\$105.00. Code Word.....KHAYA.

Unless whole set is taken, individual list prices apply.



SET OF TOOLS FOR No. 3 MILLERS

SET OF TOOLS FOR No. 3 MILLING MACHINES

The set of tools shown on the opposite page and listed below was selected with a view to an outfit that would be of real value and covers a wide range of work.

The larger cutters and those most likely to be used extensively are of special quality high speed steel. The balance are of carbon tool steel.

MILLING CUTTERS.

No.	Style	Diam.	Face	Hole	Steel	Code Word	Price
1	60° L. H.	2 3/4"	1 1/2"	1"	Carbon	Hag	\$ 2.00
2	60° R. H.	2 3/4"	1 1/2"	1"	"	Haft	2.00
3	Plain	2 1/2"	1 1/4"	1"	"	Hackney	1.00
9	Metal Saw	3"	1 1/4"	1"	"	Haik	.70
10	" "	4"	3 3/2"	1"	"	Hakot	.85
11	" "	5"	1 1/8"	1"	"	Haleyon	1.00
12	End Mill	1 1/2"	1 1/8"	.....	"	Halibut	1.00
13	" "	3/4"	1 5/8"	.....	"	Halse	1.25
14	" "	1"	1 7/8"	.....	"	Halter	1.45
15	" "	1 1/4"	2"	.....	"	Hamble	1.60
16	Spiral	2 1/4"	3"	1"	Speed	Hallux	7.00
20	Plain	3"	3/8"	1 1/4"	Carbon	Haver	1.45
21	"	3"	1/2"	1 1/4"	"	Heath	1.65
22	"	3"	3/4"	1 1/4"	"	Heben	2.00
23	"	3"	1"	1 1/4"	"	Helvine	2.50
36	Side	7"	1 3/8"	1 1/2"	Speed	Vandalism	16.00
S36	"	7"	1 3/8"	1 1/2"	"	Vandalism	16.00
3M 53	Slab*	4"	6"	1 1/2"	"	Pollage	31.50
F 9	Face	3"	1 1/2"	1"	"	Buxom	9.50
F13	"	5"	1 1/2"	1 1/4"	"	Bumble	12.50
F31	"	8"	2"	1 7/8"	"	Budget	20.00

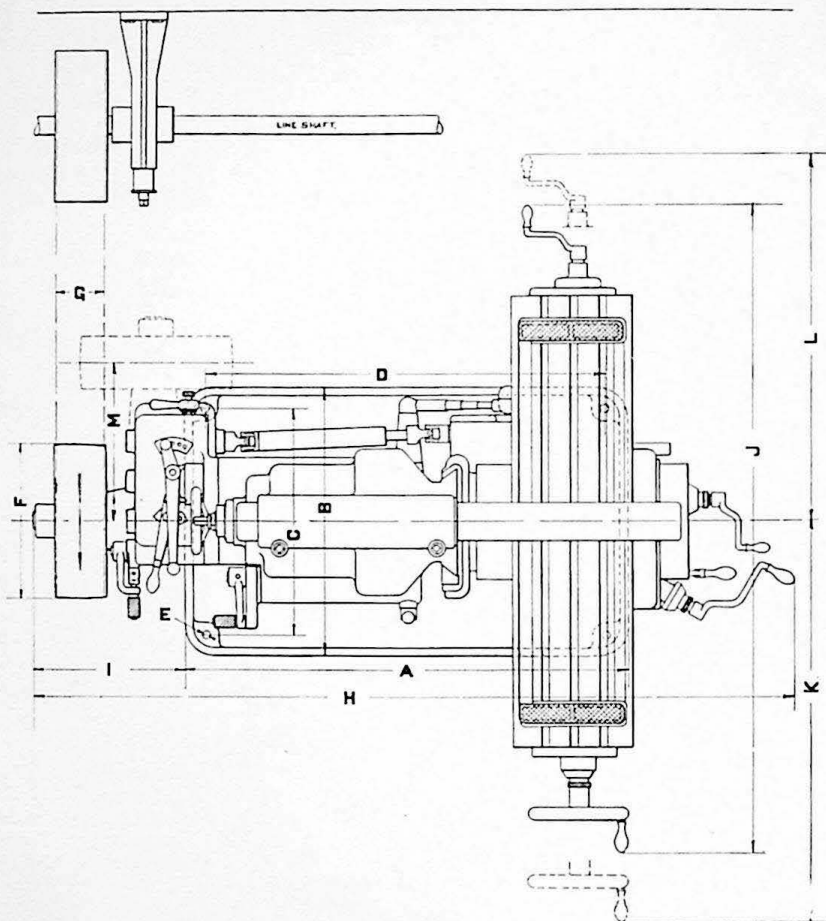
ARBORS, COLLETS, ETC.

81	Style A Cutter Arbor, 1" diameter, 12" shoulder to nut.....	Clevis	10.00
84	Style B Cutter Arbor, 1 1/4" diameter, 24" shoulder to nut.....	Comet	16.00
85	Style B Cutter Arbor, 1 1/2" diameter, 24" shoulder to nut.....	Conoid	16.00
87	Style C Face Mill Arbor, 1" diameter.....	Cork.	7.50
88	Style C Face Mill Arbor, 1 1/4" diameter.....	Coul	8.00
24	Collet Drift.....	Hilt	5.50
8Y	Collet, 7x12 B. & S. Tapers.....		
E23C	Spindle Centering Plug	Hanse	3.00

Price—Set complete.....\$175.00. Code Word.....KIBLAH.

Unless whole set is taken, individual list prices apply.

*This cutter consists of three M53 as listed on page 63 and additional units can be added if desired.



PLAN DIMENSIONS

	Manufacturing		Plain			Universal		
	No. 1	No. 2	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3
A	40"	45"	40"	45"	50"	40"	45"	50"
B	24"	28"	24"	28"	32"	24"	28"	32"
C	20 1/2"	24 1/4"	20 1/2"	24 1/4"	27 1/2"	20 1/2"	24 1/4"	27 1/2"
D	36 1/2"	41"	36 1/2"	41"	45 1/2"	36 1/2"	41"	45 1/2"
E	11 1/16"	11"	11 1/16"	11"	13 1/16"	11 1/16"	11"	13 1/16"
F	14"	16"	14"	16"	16"	14"	16"	16"
G	4"	4 1/2"	4"	4 1/2"	5"	4"	4 1/2"	5"
H	64"	75 1/2"	64"	75 1/2"	86"	64"	75 1/2"	86"
I	12"	14"	12"	14"	16"	12"	14"	16"
J	54 5/8"	63 3/4"	56 3/8"	66 3/4"	78 3/4"	57 1/2"	68 1/4"	80 1/2"
K	41 1/4"	49 1/4"	42 3/8"	47 5/8"	57 1/2"	39 7/8"	49 1/2"	59 1/2"
L	39"	45 5/8"	40 3/8"	49 1/4"	57 1/4"	40 3/8"	49 1/4"	57"
M	11 5/8"	16 3/4"	11 5/8"	16 3/4"	16 3/4"	11 5/8"	16 3/4"	16 3/4"

OPERATION

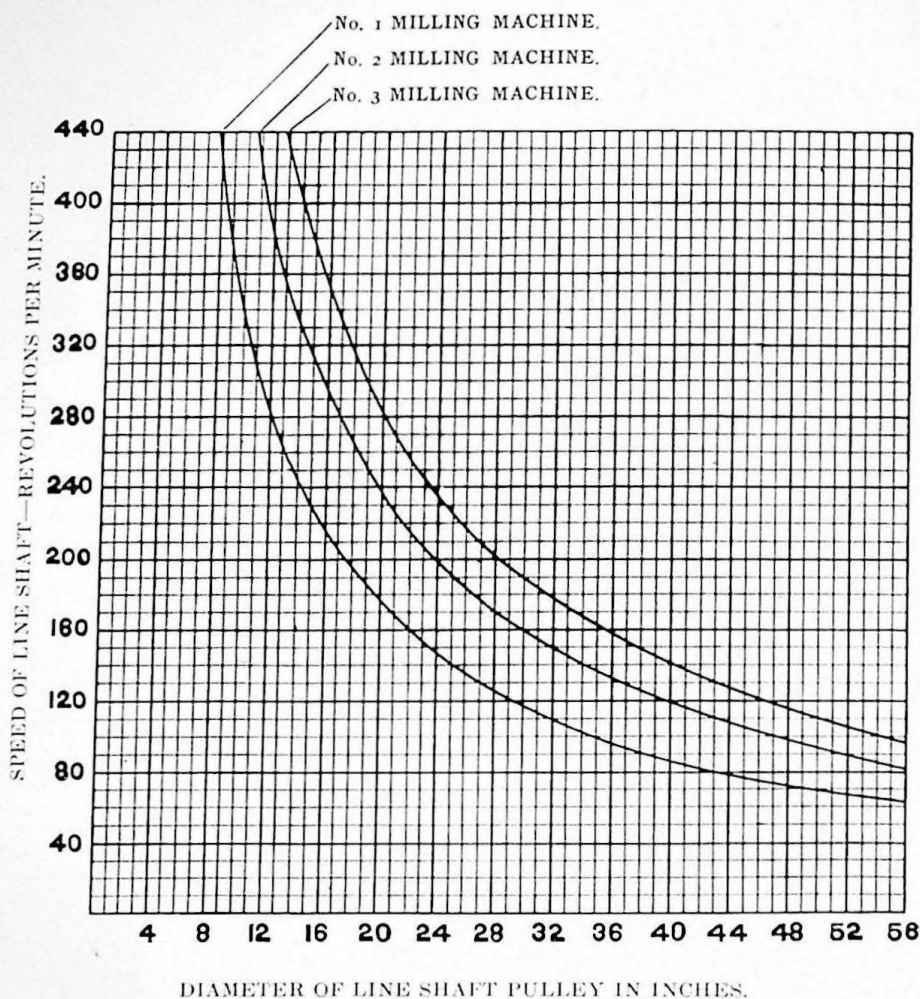
There is no machine in the whole list of metal cutting tools that will pay larger returns on intelligent supervision than the Milling Machine. Many superintendents contend that this is the place for low grade labor and up to a certain point this is true.

Overseeing The factory equipped with a number of machines should have a resourceful and ambitious man in charge of this equipment, one who will see personally that each job is set up as it should be and the cutters working properly. With such a man in charge, it is possible to have men comparatively little experienced as operators. The shop with only one machine, if the work is in lots, can depend on the foreman in charge of other work to oversee the miller and rely on an ambitious operator not necessarily greatly experienced. But if the work be varied, only one or two pieces of a kind and these differing greatly, satisfactory results can be obtained only by having an operator with ingenuity enough to meet and master these problems as they arise.

When the new machine is received, it should be looked over carefully and perfect familiarity acquired with all its features. The description found on pages 6 to 23 will be found helpful in this.

Erection Owing to the fact that no countershaft is used, erection is very quickly accomplished. Set the machine by placing a level on the work table, testing in both directions. Drop a weighted cord from the line shaft to test for parallelism with the over-arm. If right angle drive is used, test with the work table, taking care that the swivel carriage is set a zero if the machine is a universal.

Put wooden wedges under the base if the floor is out of true. Shingles will be found convenient for this. On upper floors, select, if possible, a location over a girder or other place free from vibration to obtain the best results. Bolt securely to the floor.



PULLEY DIAGRAM

The above diagram is a guide to the selection of the proper size pulley for the line shaft, this depending on the speed at which it runs.

Example:—The horizontal lines represent a difference of 10 in the speed of the line shaft. Now suppose that we have a No. 2 machine and the speed of the line shaft is 200. Following this line to the right until it meets the No. 2 curve and then following the line to the bottom we see that a 24" pulley is required.

Oiling The machine oil reservoir should be filled to within about 2" of the top with good quality of light machine oil. This oil should be taken out two or three times a year and either filtered or used for some other purpose. After the machine is started, streams of oil will be seen flowing back into the reservoir if the cover is removed, this being a sure indication that the lubrication is being successfully accomplished.

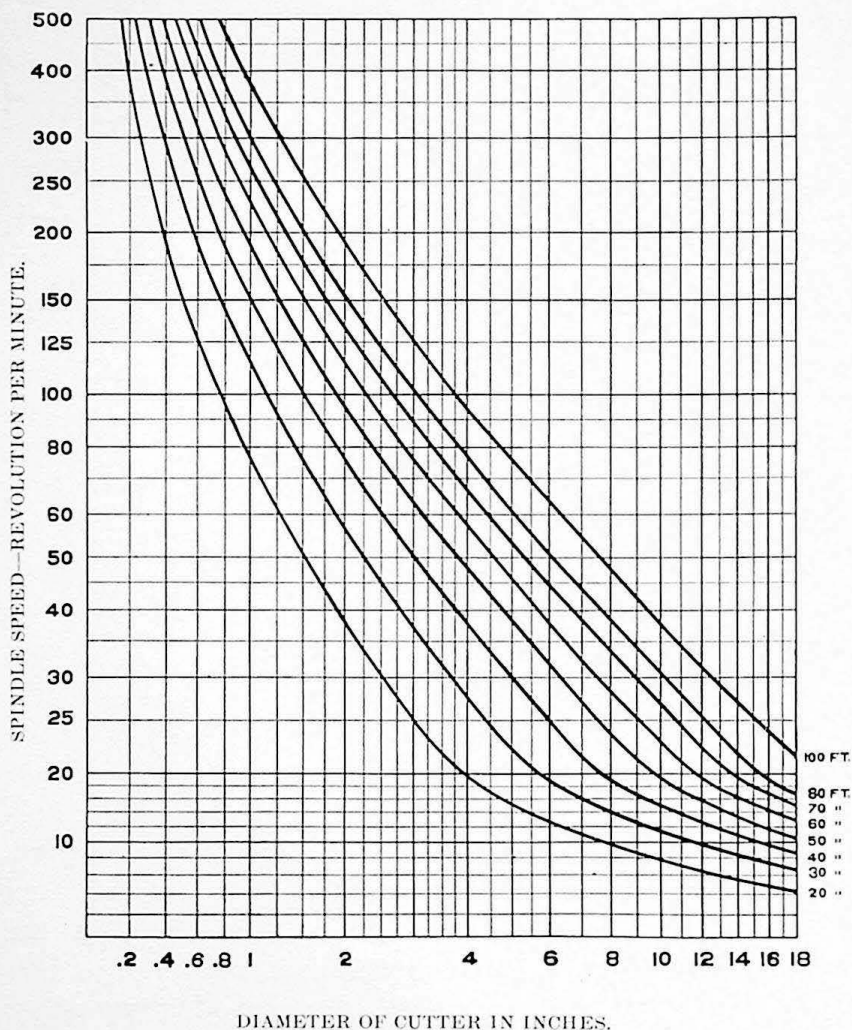
Fill the reservoir in the base of the machine, back of the door, with lard oil or other cutter lubricant. If the character of the work is such that no cutter lubricant is needed, enough should be supplied to keep the pump well oiled.

Line Pulley Select a pulley for the line shaft according to the directions given on the opposite page and use a double belt of the full width specified for 'G' in the table.

Throw the belt on the pulley with the starting lever drawn forward, pushing it quickly back as far as it will go to start the machine. Operate all levers to make sure that they are understood. The machine is now ready for duty.

Cutters Milling cutters should be small in diameter and have the largest possible holes. This, of course, should not be obtained at the expense of weakness in the cutters. There is scarcely space here to enter upon the subject of cutter design and this is not always in the hands of the Milling Machine foreman or operator, but these men have full charge of what is not less important and that is the location of the cutters on the arbors.

The thoughtless or careless man will take off the arbor nut, remove sufficient collars to make room for the cutters and replace the nut, leaving the cutters on the outer end of the arbor where they will be liable to spring the most, due to the torsion of the arbor and at the same time subjecting the outer bearing, the arm, the arm braces and the knee to the maximum strain. Sometimes the character of the work demands this arrangement. On page 2 will be seen a machine set up to mill a Corliss Engine cross head, this being done in two operations at one setting.



CUTTER SPEED DIAGRAM

The above diagram is a graphic way of finding out the proper speed in revolutions per minute for any given size of cutter at any given surface speed.

Example:— $\frac{3}{4}$ " diameter cutter, surface speed desired, 40 ft. Start at the bottom, following the .8" diameter line until it intersects the 40 ft. curve, then to the left—nearest speed, 200 revolutions per minute.

The inner set of cutters have the heaviest work to do and they are therefore placed as close to the end of the spindle as possible where the machine will offer a maximum resistance to distortion. After taking the first cut the table is moved out for the second cut, the advantage derived from finishing at one setting exceeding the disadvantage of cutter location. The cuts on pages 24 and 31 represent good practice in this regard.

Keying Be sure that the cutters are keyed and the arbor nut tight. This is very important for if the cutters fail to revolve with the arbor all the power of the machine will be thrown into the feed and since the cutters will not cut relief for themselves, damage is liable to be done. When tightening the arbor nut, lock the spindle, first setting the speed lever 19 for the slowest speed, have the arbor support in place to prevent springing the arbor with the wrench.

Speeds We are frequently asked to give cutter speeds for different kinds of material but for this we are unable to offer any general rule. Grey iron castings, for instance, are made in such a wide variety of chemical composition and hardness that what would be considered maximum surface speed in one shop might be far too low in another. We have seen our own cutters running at 100% higher speed in other shops than we found possible on our own work, due to the fact that our castings must be hard in order to insure permanency, especially in the sliding bearings.

The diagram on page 74 will be of aid in determining what is best under your conditions. A little experimenting and careful watching of how the cutters stand on the grade of material that you receive will determine approximately the surface speed that you are able to run. Having once determined this, it can be used as a guide to obtain the speed for any given size of cutter.

Starting It is advisable to start with a comparatively low speed and advance as you find it possible without too frequent stoppages to sharpen the cutters.

Feeds The same thing can be said of the feed—start low and go up as the cutters and the work will permit. The feed per revolution of cutter depends upon the speed of the spindle as well as upon the rate of feed so that it is sometimes possible to maintain a given feed by increasing the speed as each increase of speed reduces the feed per revolution of cutter but the distance covered per minute remains the same.

For example,—a feed of 5" per minute with a spindle speed of 18 is .238" per revolution of cutter. By increasing the speed to 26 the feed per revolution of cutter is reduced to .192" but the feed is still maintained at 5" per minute. Sometimes it is better to reduce the speed, depending upon the design of the cutter, depth of cut and finish required.

Chucking Chucking is of utmost importance and good fixtures pay well where there is any quantity of a kind. These fixtures should be as low as possible so as to keep the work down close to the top of the table and thus reduce leverage on the knee. These fixtures should be made strong and contain plenty of material and be arranged to back up the work at weak points and hold it rigidly. In order to obtain the best results from milling, the work must be more securely held than would be necessary on the machine operating with a single tool since the milling cutter is in reality a gang of tools all at work at one time.

Milling Steel Where steel is being milled, oil should be used on the cutters in quantity. The practice has grown up, on account of oil pots and tables not provided with means for returning the oil, to allow the lubricant to drip upon the cutters. By far the best results can be obtained by allowing the oil to run freely on the cutters, keeping them cool and washing away the chips that otherwise would accumulate between the teeth, reducing the efficiency of the cutter. The cutter that is freely flooded will not require grinding as often as one that is not so treated and the quality of the work produced will be much better.

Adjustments To adjust the spindle bearings, set the handle 19 between holes so that the spindle can be turned freely by hand by grasping either the front or back end. The nut on the back end can then be set up but should not be set so tight that the spindle cannot be turned freely.

The table gib is adjusted by end screws and both should be set up tight, the adjustment being such that the table will move freely but not too loose.

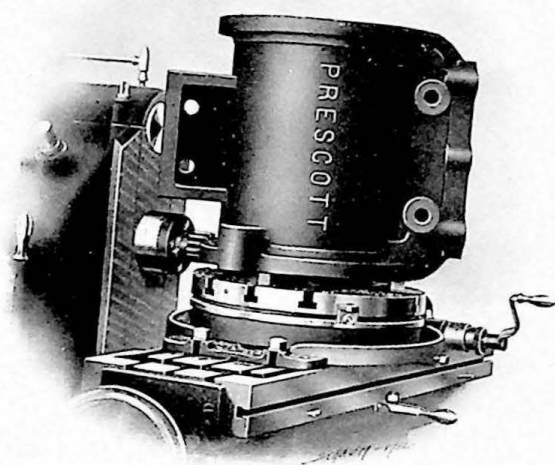
The worms in the Universal and Spiral Dividing Heads are taken up by two slotted head screws at the back of the worm housings that control an eccentric bushing. The top one of these two screws takes up the worm and the bottom one is used as a lock to prevent shoving the worm too tightly into the worm wheel. Both of these screws should be kept tight. The end play on the worm is taken up by a plug at the end of the shaft opposite the index plate, this plug being adjusted by a slotted head screw.

Vertical spindle and universal milling attachment spindles are taken up by a nut at the back end the same as the main spindle.

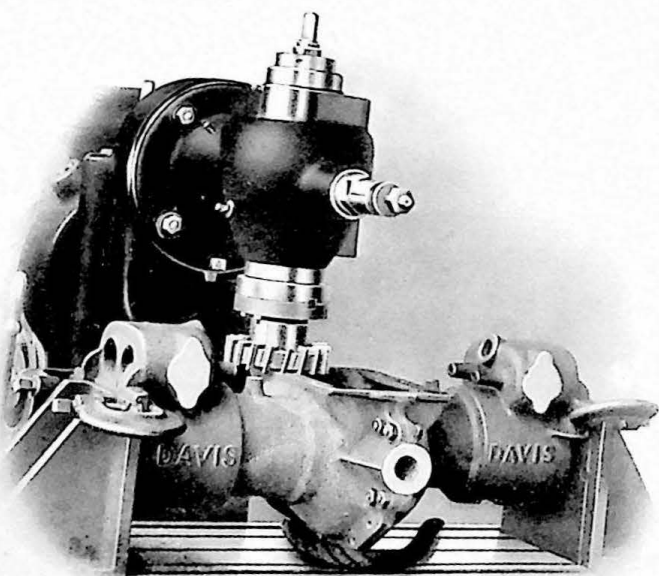
Oil Tight The column plate, pulley bracket and feed boxes are used to close openings in the column and to prevent the escape of oil. The joints are made oil tight with shellac the same as used by pattern-makers everywhere. This should be put on fairly thick and the bracket bolted in place before it dries, shellac is insoluble in oil and a permanent oil tight joint is made with little trouble.

To remove the column plate, drop the tumbler frame as low as it will go, remove the screws and force the plate out with the two slotted head screws provided for the purpose, swinging the top out first.

Cleanliness Keep the machine clean, not only on account of the effect on the machine but by reason of the general effect on the quality and quantity of the output. A nicely finished, neat appearing machine kept clean is an incentive to the keeping of other machines in the rest of the shop in order.



CIRCULAR MILLING



VERTICAL SPINDLE WORK

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