# THE KEMPSMITH UNIVERSAL DIVIDING HEAD

## Its Construction and Use

# KEMPSMITH Universal Dividing Heads

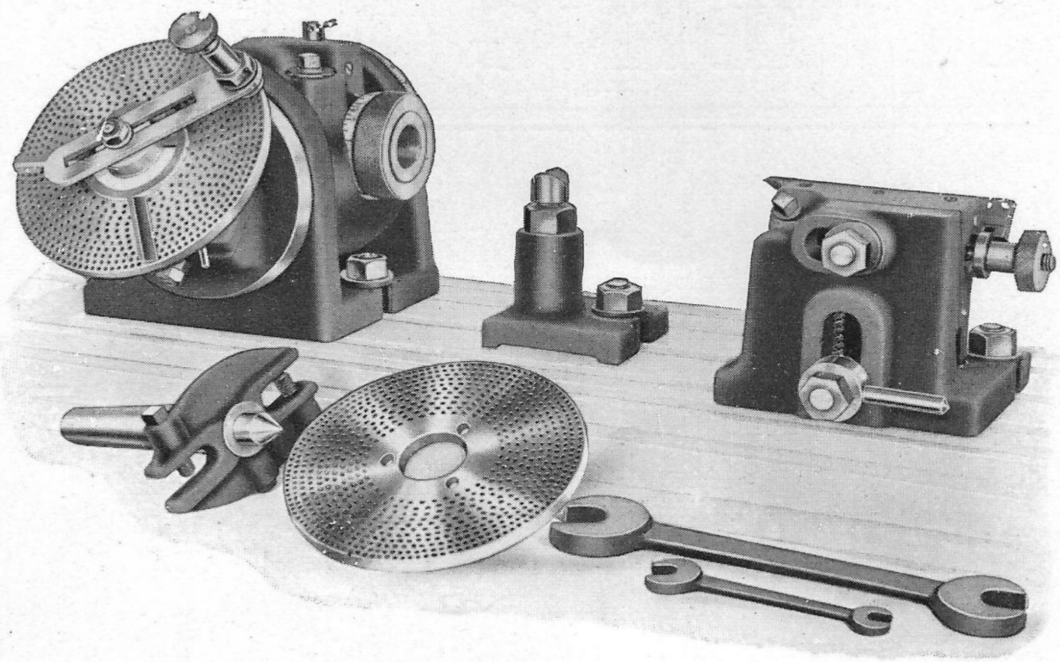

FIG. 1

## DESCRIPTION

**THE UNIVERSAL DIVIDING HEAD** is probably the most important mechanism connected with the Universal Milling Machine. It is subjected to frequent and varied use, and the work done by it must, as a rule, be thoroughly accurate. The ideal dividing head therefore must be essentially accurate; must be of such construction as best to preserve that accuracy, both by its rigidity and by its method of adjustment; must be compact and convenient, and universal in its scope. We have aimed to embody all of these considerations in this new improved Universal Dividing Head. It combines simplicity and convenience with rigidity and accuracy. There is a notable absence of complicated and frail mechanism.

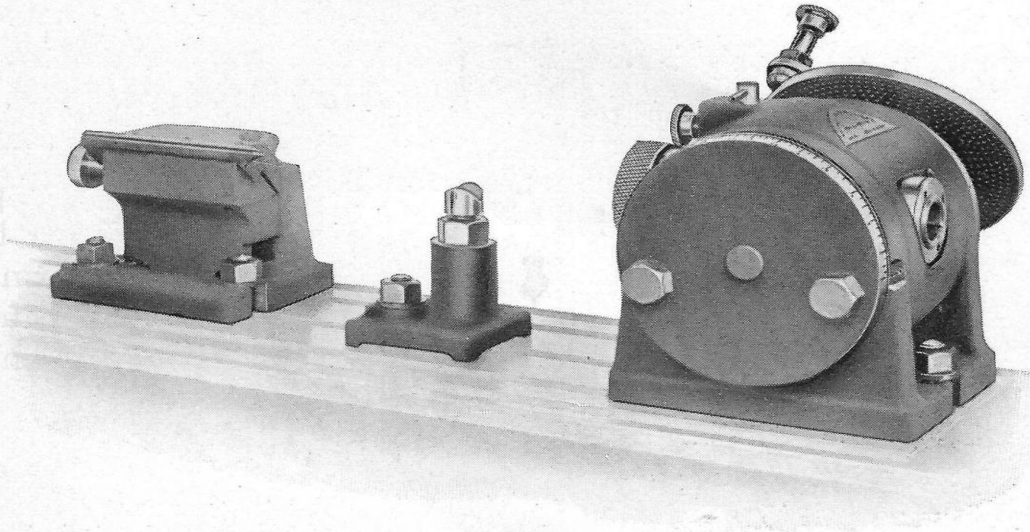

FIG. 2

**THE WORM WHEEL.** The most important feature of the dividing head is the dividing mechanism. A large diameter worm wheel is essential to the best work. The usual method of arranging for a large diameter worm wheel is to mount it at the extreme front or rear end of the spindle, practically outside of the head frame, which makes its large diameter possible. Its location there not only brings the working strain at one end of the spindle, but also the casing presents an obstruction where work is to be done close in to the head.

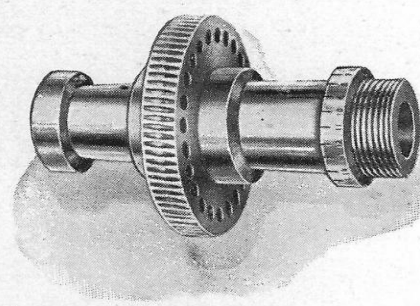

FIG. 3

On our Dividing Head the worm wheel is mounted centrally inside the head block, between the front and rear spindle bearings. It is keyed and pressed to the spindle, insuring positive movement to spindle when engaged by worm. The worm is located at an angle, the worm shaft being at an angle of 36 degrees from the horizontal. This brings the point of mesh of the worm with worm wheel correspondingly around to an angle from the vertical, and this makes it possible to utilize a great deal of extra space for the worm wheel, otherwise occupied necessarily by the worm, when located directly

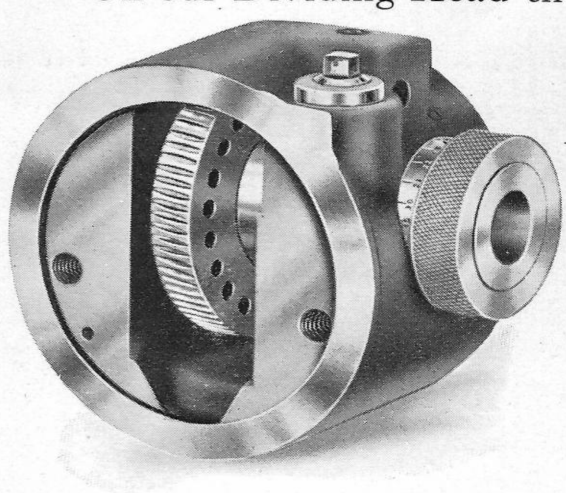

FIG. 4

over or under the worm wheel. The result is that the worm wheel can be made extremely large in proportion to the size of the head —5¼ inch diameter on the 10½ inch swing head, and 6½ inch diameter on the 13¼ inch swing head. The position and the large relative size of the worm wheel are shown by the illustrations of the spindle assembled, Figure 3, and of the rotating block with spindle complete in position, Figure 4, also the front and top elevations of this Dividing Head shown by the line drawings, Figures 6 and 7.

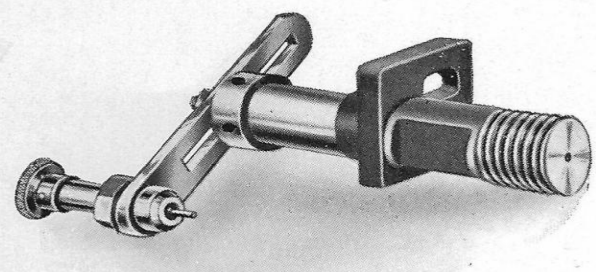

FIG. 5

**WORM** is in one piece with the worm shaft which runs in a long and liberal bearing. This bearing extends up to the shoulder formed by the worm proper, and consequently affords strong bearing support close to the point of mesh. The worm runs constantly in oil, the oil pocket being shown in Figures 4 and 7. The wear between the worm and worm wheel is very easily taken up through the outside adjusting screw shown. This adjustment is in a straight line, perpendicular to the axis of the worm wheel, and thus preserves the alignment and accuracy in repeated adjustments. The worm is easily disengaged from the worm wheel for quick index through the worm wheel direct. This is done through means entirely independent; the adjustment, therefore, is not disturbed. Another advantage is that, in the common necessity of tightening the nut on arbors which have been put in the spindle, the strain is relieved from the worm wheel teeth.

The index plunger arm is mounted on the worm shaft, therefore indexing direct to the worm wheel, leaving no chance for error or inaccuracy through a train of gears or other intermediate.

The fact that the worm shaft is set at an angle, as already described, likewise locates the index plate at an angle from the vertical. This makes it much easier for the operator to read in indexing, because it is directly in his line of vision in his natural operating position, and does not require him to stoop or be otherwise inconvenienced as when the index plate is vertical.

**SPINDLE** is large, with liberal taper bearings, and has a simple and powerful locking device, shown by the clamp bushing in Figure 6. It is furnished with the same size taper and threaded nose as on the main spindle of the universal millers on which the head is regularly furnished, making all tools interchangeable. It has a large hole running through, an idea of which can be gathered from Figure 32, which shows the work passed through the spindle. The rear end of the spindle is arranged to receive an extension stud for use in gearing direct from the leadscrew to the spindle for cutting fine leads as described on page 17. The rotating block carrying the spindle, swings through an arc of 150 degrees, from 10 degrees below the horizontal to 50 degrees beyond the perpendicular. It is powerfully clamped in a horizontal or vertical or angular position through two bolts shown in Figure 2. These bolts clamp the whole surface of flanges around the periphery at both front and rear sides of the head.

## TABLE OF DIVIDING HEAD DIMENSIONS

| Size of Head | 10½″ | 13¼″ |
|---|---|---|
| Length of Base | 8″ | 9⅜″ |
| Width of Base | 6¼″ | 8″ |
| Trunnions | 5¾″ | 7¼″ |
| Diameter Worm Wheel | 5¼″ | 6½″ |
| Diameter Worm | 1½″ | 1$\frac{15}{16}$″ |
| Spindle Front Bearing | 2$\frac{15}{64}$″ | 2$\frac{13}{16}$″ |
| Length of Spindle | 7$\frac{15}{16}$″ | 10$\frac{5}{16}$″ |
| Number of B. & S. Taper | 10 | 11 |
| Hole through Spindle | 1$\frac{1}{16}$″ | 1¼″ |
| Diameter of Spindle Nose | 2¼″ | 3″ |
| Thread of Spindle Nose | 10 RH | 8 RH |
| Diameter Index Plate | 7¼″ | 7¼″ |
| From Base to Chuck in vertical position | 10⅛″ | 14″ |
| TAILSTOCK | | |
| Length of Base | 6½″ | 8¾″ |
| Width of Base | 5⅜″ | 6⅜″ |
| Net Weight Complete | 125 lbs. | 200 lbs. |
| Code Word | KERUX | KERWY |

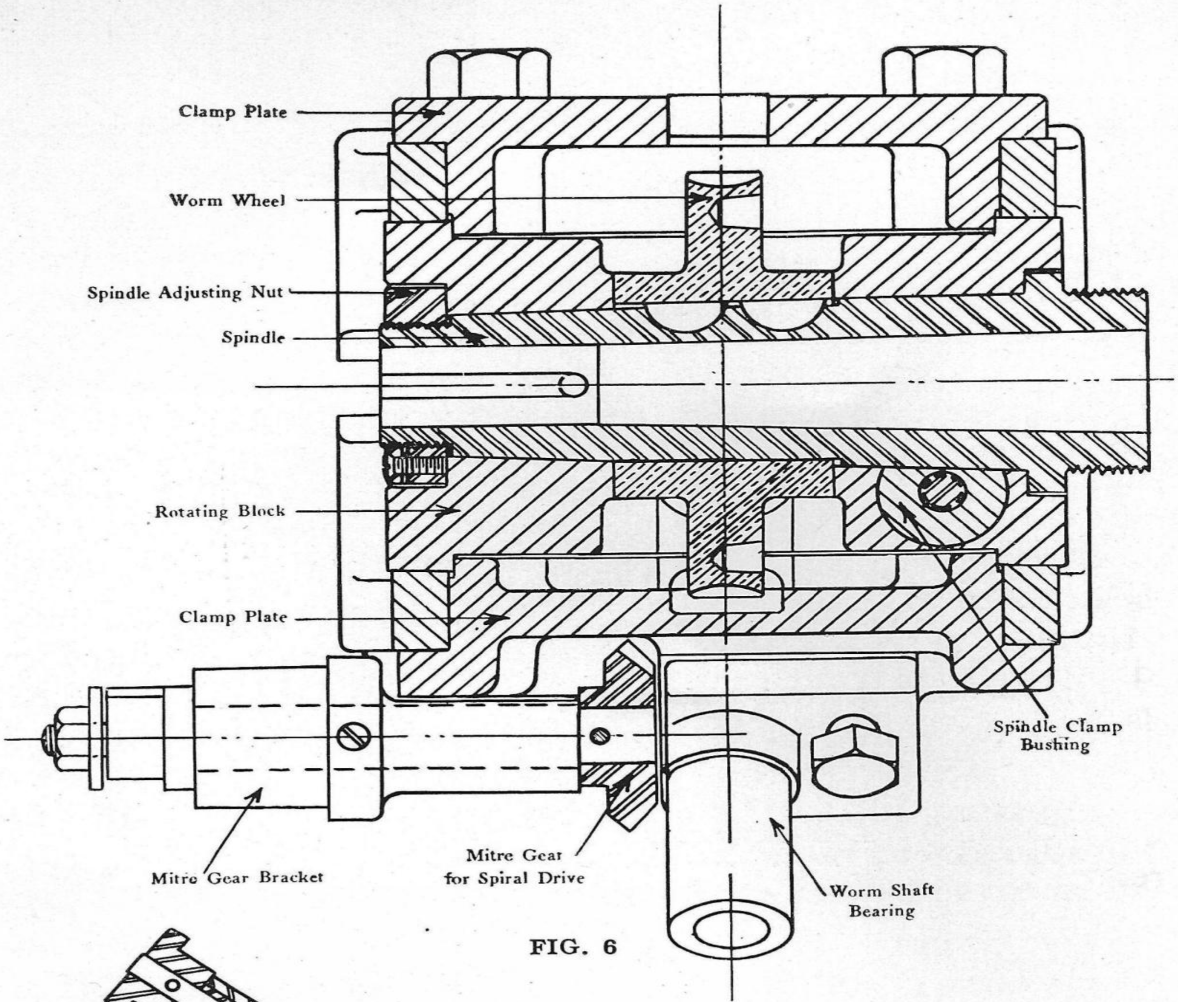
Clamp Plate
Worm Wheel
Spindle Adjusting Nut
Spindle
Rotating Block
Clamp Plate
Spindle Clamp Bushing
Mitre Gear Bracket
Mitre Gear for Spiral Drive
Worm Shaft Bearing

FIG. 6

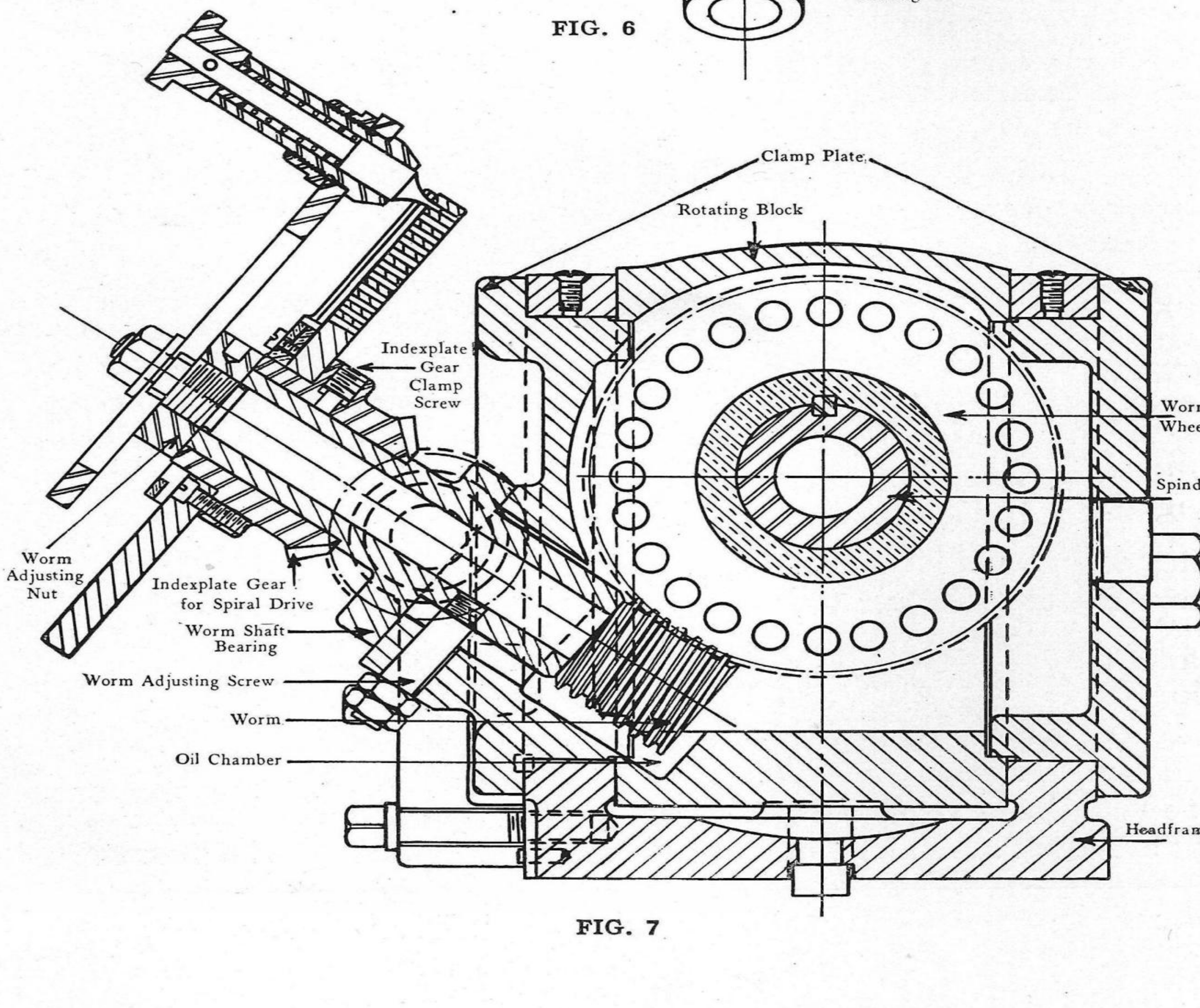
Clamp Plate
Rotating Block
Indexplate Gear Clamp Screw
Worm Wheel
Spindle
Worm Adjusting Nut
Indexplate Gear for Spiral Drive
Worm Shaft Bearing
Worm Adjusting Screw
Worm
Oil Chamber
Headframe

FIG. 7

# INSTRUCTIONS

**To Throw Worm Out for Quick Indexing** through spindle direct: Loosen the hexagon head screw, clamping the worm shaft bearing casting to the head plate (shown in Figure 6 also Figure 27); throw the small lever to the left as far as it will go, and tighten screw again. In returning the worm into mesh, lever is thrown back to the right; be sure to bring this lever around until it is stopped in order to bring the worm full into mesh.

**To Take Up Wear Between Worm and Worm Wheel:** Loosen, by turning to left, the two adjusting nuts shown on worm adjusting screw, Figure 7, sufficient to overcome back lash when worm and worm wheel are in mesh.

**To Remove Index Plate:** Remove index plunger crank by taking off 3/8 inch hexagon nut. Then remove sectors, then the three index plate screws, and draw off the plate. These parts all pass freely over the worm adjusting nut. Do not remove the worm adjusting nut. It is not necessary, and only destroys the careful adjustment made at the factory.

Wear in spindle is taken up through spindle adjusting nut, shown at rear of spindle Figure 6.

End thrust on worm shaft is taken up through worm adjusting nut Figure 7.

To set the head at any angle: Loosen the two clamp screws shown at the rear of the head, Figures 2 and 6; set the rotating block to the angle desired and tighten both screws.

Oil the head thoroughly regularly, especially before starting spiral cutting jobs.

In using the dividing head, observe the following: In preparing for a job, first see that the worm is thrown out of mesh, and that the spindle is clamped through the clamp bushing, Figure 6. This relieves the teeth of the worm wheel of the strain in mounting and fastening the work on the centers, or tightening the arbor nut, or mounting or removing chuck.

Likewise, always see that the spindle is clamped while under cut, to be released only while indexing, except in the case of spiral cutting.

In ordinary indexing through the worm, see that the screws, Figure 7, beneath the index plate, clamp tight against the sleeve (one against a flat) to hold the plate stationary. In spiral cutting, these screws should be loosened.

In indexing through worm, see that the quick index plunger is withdrawn from worm wheel, and held so by fastening with thumb screw.

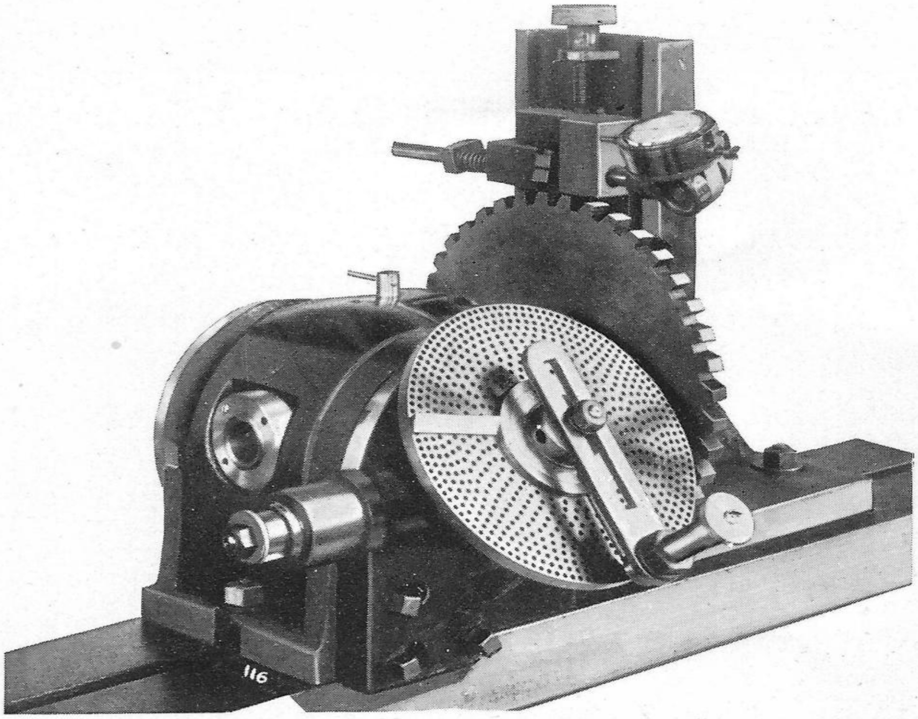

FIG. 8

# TESTS

Accuracy of the worm wheel is very important. Figure 8 shows the method employed in testing the accuracy of the worm wheel in every other tooth. The master plate is mounted in the spindle and has 40 perfect divisions. It is therefore possible to test the relative and cumulative error for the teeth individually. The maximum relative error allowed is .0005 on the master plate, and the maximum cumulative error at any point is .002 on the master plate. The average is less than half of this.

Figure 9 shows, in reduced size, a representative average record sheet as made out from these tests. The forty divisions of the circle correspond to the forty notches on the master plate; the test starts with division 1, and shows the traceable error in thousandths of an inch, from one tooth to another of the worm wheel, reaching a maximum accumulated error of .001 on the opposite side of the worm wheel. The master plate is 11 inches in diameter, and the worm wheel is 5¼ inches in diameter, consequently *errors showing on the master plate are reduced to less than half on the worm wheel proper.*

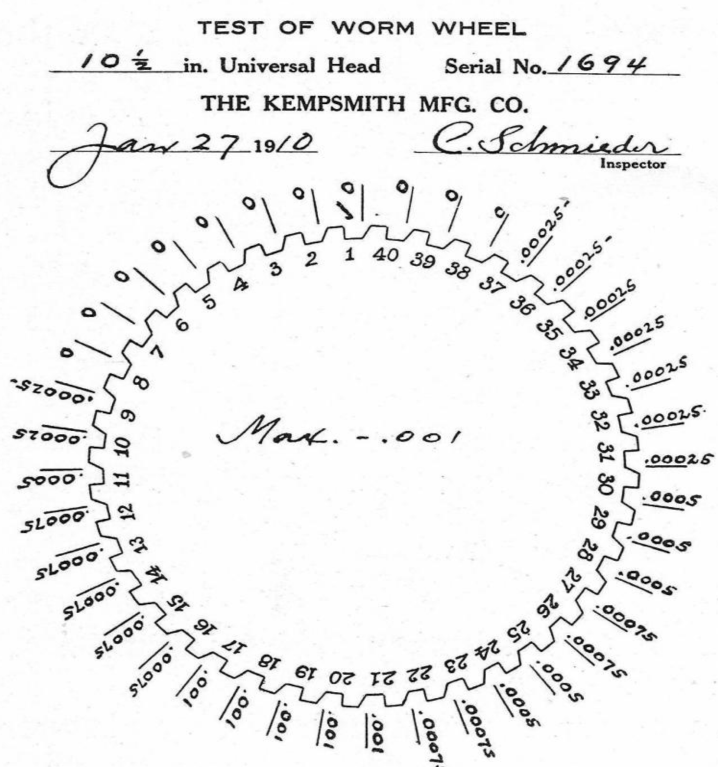


FIG. 9

Figure 10 shows the manner of testing the spindle alignments. The maximum error allowed is .001 at the outer end of the 18 inch test bar shown. This test is repeated when the Dividing Head is shipped with its machine.

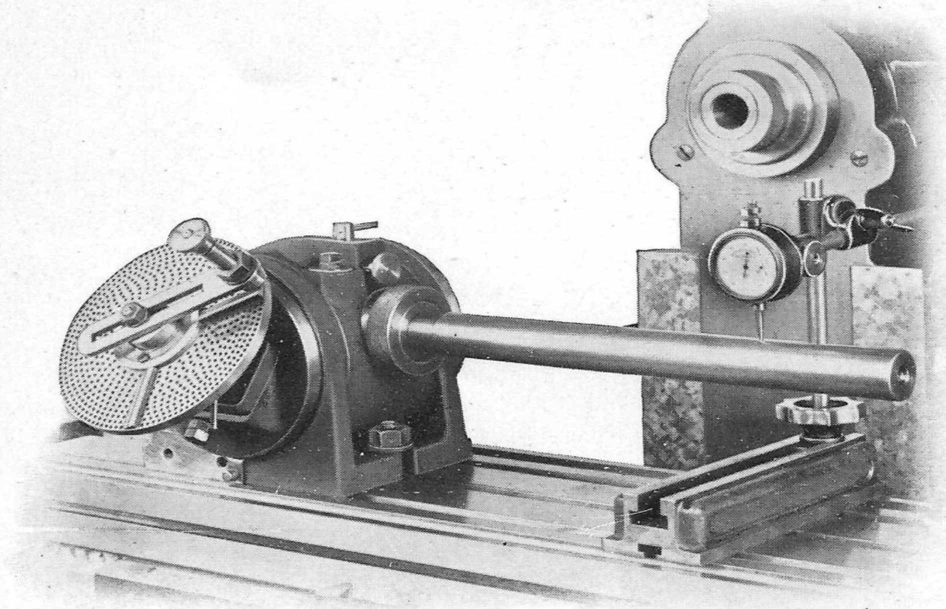

FIG. 10

Figure 11 shows method of testing vertical alignment. With the circular plate stationary all points must show within .001 on the indicator.

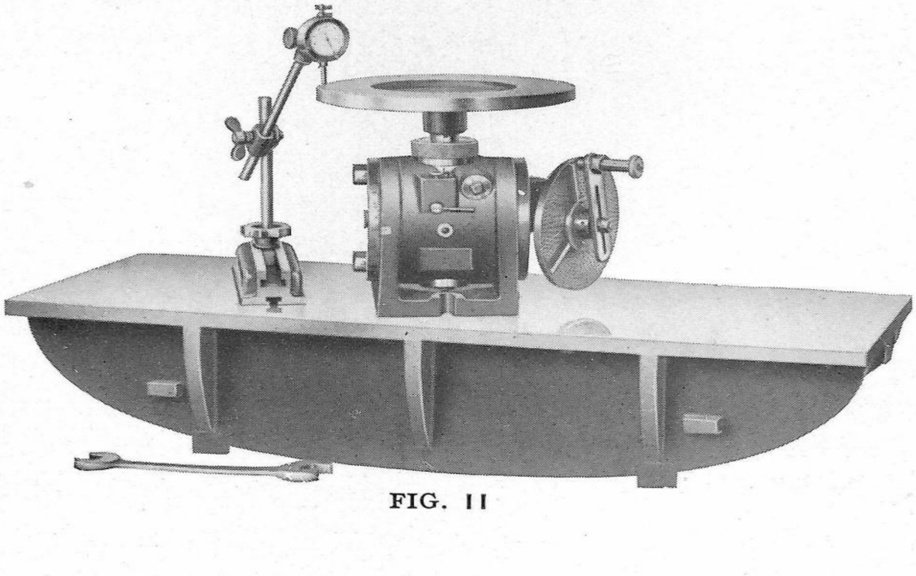

FIG. 11

Figure 12 illustrates method of testing alignment of spindle and tailstock center. The maximum allowance on this test is less than .001 in 18 inches and the majority of heads leave our factory perfect in this alignment.

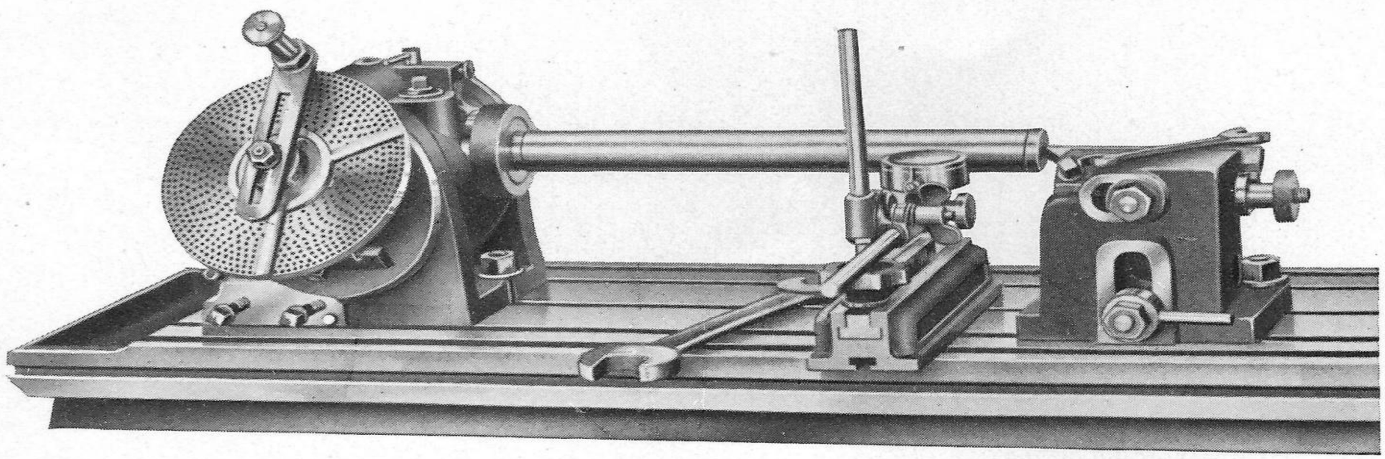

FIG. 12

# INDEXING

**QUICK INDEXING,** direct through spindle is the simplest form of indexing, and can be used to advantage in milling squares, hexagons, in fluting taps or reamers, in cutting teeth of small pinions, and in such work in which the number of divisions is some factor of 24. The worm is first thrown out of mesh. The spindle can then be revolved by hand. Loosen the thumb screw in front of plunger lever shown at top of Figure 13, which will release quick index plunger pinion; then turn the spindle slightly until the plunger pilot engages a hole in the worm wheel. (Fig. 13.) For indexing subsequent divisions, release the plunger by swinging forward the lever for the quick index plunger pinion, and revolve the spindle the proper distance before releasing lever. The front of spindle is graduated in 24 divisions, corresponding to 24 holes in the worm

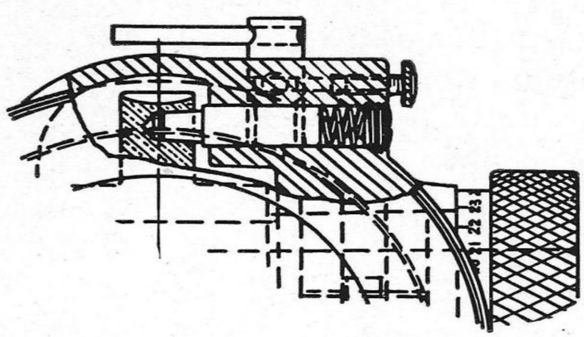

FIG. 13

wheel. If the work being done requires 24 divisions, a one-twenty-fourth revolution of the spindle, in other words, advancing from one graduation to the next, between each cut, will produce 24 divisions. If 12 divisions are wanted, every other graduation will be passed over in indexing; if 8 divisions, the plunger is locked in every third hole, and so on, through 6, 4, 3, and 2 divisions.

When you change from direct indexing to indexing through worm, see that the index plunger is released from worm wheel and held so by tightening the thumb screw; also that worm is brought into mesh with wheel, as per instructions.

**INDEXING THROUGH THE WORM** is accomplished on the Dividing Head by the following principle: The worm wheel has 80 teeth, and the worm is double thread; the ratio of the worm and worm wheel, therefore is 40 to 1, and it takes 40 complete revolutions of the worm for one complete revolution of the worm wheel, consequently of the spindle, which carries the worm wheel. Therefore a piece of work carried in the spindle would be divided into 40 equal divisions by being revolved 1–40 of its circumference with each full revolution of the worm. Similarly, a half revolution of the worm will result in 80 divisions, and a double revolution of the worm for each division, will result in 20 divisions. The formula, therefore is $\frac{40}{N}$ in which N represents the number of divisions desired, and the quotient is the number of revolutions or fractions of a revolution to the worm. This requires the use of an index plate carrying various circles of accurately spaced holes, and a plunger adjustable to any of these circles, as shown in Figure 14. The revolution of the arm carrying the plunger revolves the worm, consequently it is evident that a large variety of fractions or revolutions of the worm can be obtained through the various positions of the index plunger, in one or the other of the two index plates which we furnish, one with 30, 41, 43, 48, 51, 57, 69, 81, 91, 99, 117 circles of holes, the other with 38, 42, 47, 49, 53, 59, 77, 87, 93, 111, 119 circles of holes. These two plates make possible a total of 195 division changes as given in the accompanying table, Figure 15. The correct movement of the index plunger is

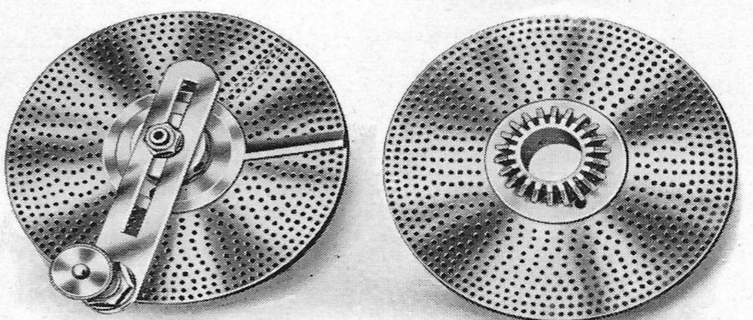

FIG. 14

greatly assisted by the use of the sectors, which are adjustable to include varying sections of the different circles of holes.

We give the entire procedure for cutting, for example, 124 divisions: The index plate carrying the 93 circle is mounted on the index plate gear which forms a sleeve on the worm shaft bearing; the index plate is held to this by the three screws provided, and the index plate gear is to be firmly held to position on the worm shaft bearing through the two clamp screws. (See Figure 7). This will hold the index plate stationary. The sectors are then set and clamped by their screw, so as to include in the arc between their beveled edges, 31 of the holes in the 93 circle. (The sectors should always be set for one more hole than is called for in the operation; in other words, in setting sectors, do not count the hole which contains the plunger). The index crank is then mounted on the end of the worm shaft and is so set that the index plunger is in the 93 circle. The sectors are swung to bring one of the arms directly behind the index plunger in position. After seeing that the dividing head spindle is suitably clamped as directed, the first cut is taken, whatever the nature of the work may be. Then the spindle clamp is released, the plunger is revolved through the included arc of the sectors to the hole next to the other arm. The sectors having 31 holes in this arc, this means that the plunger is advanced 30 holes. This is followed by swinging again the sectors through a similar arc until the arm is brought up behind the plunger, the spindle again clamped and the second cut taken. This procedure should be followed between each successive division, and will produce at the end, a total of 124 accurate divisions around the circumference of the work being done.

If the number of divisions required is less than 40, this will mean for each division one or more full revolutions of the worm, therefore of the index plunger, and a certain number of holes beyond. For instance, to obtain 16 divisions, the sectors should be set to include 25 holes in the 48 circle, and for each succeeding division, the index plunger should be given two full revolutions, plus the included arc of the sectors, which would be the 24 holes additional in the 48 circle, as called for by the table.

On page 33 we give a Supplementary Index Table for indexing work through given angles, based on the standard Index Table herewith.

| No. of Divisions | Index Circle | Turns of Index | Holes Additional | No. of Divisions | Index Circle | No. of Holes | No. of Divisions | Index Circle | No. of Holes | No. of Divisions | Index Circle | No. of Holes | No. of Divisions | Index Circle | No. of Holes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | ANY | 20 | .... | 41 | 41 | 40 | 87 | 87 | 40 | 154 | 77 | 20 | 245 | 49 | 8 |
| 3 | 30 | 13 | 10 | 42 | 42 | 40 | 88 | 77 | 35 | 155 | 93 | 24 | 248 | 93 | 15 |
| 4 | ANY | 10 | .... | 43 | 43 | 40 | 90 | 81 | 36 | 156 | 117 | 30 | 255 | 51 | 8 |
| 5 | ANY | 8 | .... | 44 | 77 | 70 | 91 | 91 | 40 | 160 | 48 | 12 | 260 | 91 | 14 |
| 6 | 30 | 6 | 20 | 45 | 81 | 72 | 92 | 69 | 30 | 162 | 81 | 20 | 264 | 99 | 15 |
| 7 | 42 | 5 | 30 | 46 | 69 | 60 | 93 | 93 | 40 | 164 | 41 | 10 | 265 | 53 | 8 |
| 8 | ANY | 5 | .... | 47 | 47 | 40 | 94 | 47 | 20 | 165 | 99 | 24 | 270 | 81 | 12 |
| 9 | 81 | 4 | 36 | 48 | 48 | 40 | 95 | 38 | 16 | 168 | 42 | 10 | 276 | 69 | 10 |
| 10 | ANY | 4 | .... | 49 | 49 | 40 | 96 | 48 | 20 | 170 | 51 | 12 | 280 | 42 | 6 |
| 11 | 77 | 3 | 49 | 50 | 30 | 24 | 98 | 49 | 20 | 172 | 43 | 10 | 285 | 57 | 8 |
| 12 | 48 | 3 | 16 | 51 | 51 | 40 | 99 | 99 | 40 | 174 | 87 | 20 | 290 | 87 | 12 |
| 13 | 91 | 3 | 7 | 52 | 91 | 70 | 100 | 30 | 12 | 180 | 81 | 18 | 295 | 59 | 8 |
| 14 | 42 | 2 | 36 | 53 | 53 | 40 | 102 | 51 | 20 | 182 | 91 | 20 | 296 | 111 | 15 |
| 15 | 30 | 2 | 20 | 54 | 81 | 60 | 104 | 91 | 35 | 184 | 69 | 15 | 300 | 30 | 4 |
| 16 | 48 | 2 | 24 | 55 | 77 | 56 | 105 | 42 | 16 | 185 | 111 | 24 | 304 | 38 | 5 |
| 17 | 51 | 2 | 18 | 56 | 42 | 30 | 106 | 53 | 20 | 186 | 93 | 20 | 308 | 77 | 10 |
| 18 | 81 | 2 | 18 | 57 | 57 | 40 | 108 | 81 | 30 | 188 | 47 | 10 | 310 | 93 | 12 |
| 19 | 38 | 2 | 4 | 58 | 87 | 60 | 110 | 77 | 28 | 190 | 38 | 8 | 312 | 117 | 15 |
| 20 | ANY | 2 | .... | 59 | 59 | 40 | 111 | 111 | 40 | 192 | 48 | 10 | 320 | 48 | 6 |
| 21 | 42 | 1 | 38 | 60 | 30 | 20 | 112 | 42 | 15 | 195 | 117 | 24 | 324 | 81 | 10 |
| 22 | 77 | 1 | 63 | 62 | 93 | 60 | 114 | 57 | 20 | 196 | 49 | 10 | 328 | 41 | 5 |
| 23 | 69 | 1 | 51 | 64 | 48 | 30 | 115 | 69 | 24 | 198 | 99 | 20 | 330 | 99 | 12 |
| 24 | 48 | 1 | 32 | 65 | 91 | 56 | 116 | 87 | 30 | 200 | 30 | 6 | 336 | 42 | 5 |
| 25 | 30 | 1 | 18 | 66 | 99 | 60 | 117 | 117 | 40 | 204 | 51 | 10 | 340 | 51 | 6 |
| 26 | 91 | 1 | 49 | 68 | 51 | 30 | 118 | 59 | 20 | 205 | 41 | 8 | 344 | 43 | 5 |
| 27 | 81 | 1 | 39 | 69 | 69 | 40 | 119 | 119 | 40 | 210 | 42 | 8 | 345 | 69 | 8 |
| 28 | 42 | 1 | 18 | 70 | 42 | 24 | 120 | 30 | 10 | 212 | 53 | 10 | 348 | 87 | 10 |
| 29 | 87 | 1 | 33 | 72 | 81 | 45 | 124 | 93 | 30 | 215 | 43 | 8 | 360 | 81 | 9 |
| 30 | 30 | 1 | 10 | 74 | 111 | 60 | 128 | 48 | 15 | 216 | 81 | 15 | 364 | 91 | 10 |
| 31 | 93 | 1 | 27 | 75 | 30 | 16 | 130 | 91 | 28 | 220 | 77 | 14 | 370 | 111 | 12 |
| 32 | 48 | 1 | 12 | 76 | 38 | 20 | 132 | 99 | 30 | 222 | 111 | 20 | 372 | 93 | 10 |
| 33 | 99 | 1 | 21 | 77 | 77 | 40 | 135 | 81 | 24 | 228 | 57 | 10 | 376 | 47 | 5 |
| 34 | 51 | 1 | 9 | 78 | 117 | 60 | 136 | 51 | 15 | 230 | 69 | 12 | 380 | 38 | 4 |
| 35 | 42 | 1 | 6 | 80 | 48 | 24 | 138 | 69 | 20 | 232 | 87 | 15 | 384 | 48 | 5 |
| 36 | 81 | 1 | 9 | 81 | 81 | 40 | 140 | 42 | 12 | 234 | 117 | 20 | 385 | 77 | 8 |
| 37 | 111 | 1 | 9 | 82 | 41 | 20 | 145 | 87 | 24 | 235 | 47 | 8 | 390 | 117 | 12 |
| 38 | 38 | 1 | 2 | 84 | 42 | 20 | 148 | 111 | 30 | 236 | 59 | 10 | 392 | 49 | 5 |
| 39 | 117 | 1 | 3 | 85 | 51 | 24 | 150 | 30 | 8 | 238 | 119 | 20 | 396 | 99 | 10 |
| 40 | ANY | 1 | .... | 86 | 43 | 20 | 152 | 38 | 10 | 240 | 30 | 5 | 400 | 30 | 3 |

FIG. 15. INDEX TABLE OF DIVISIONS.

In cutting gears in this manner with the dividing head, it is necessary to have the cutter central over the work, and the cut the correct depth of tooth according to pitch. To secure this, first bring the blank under the cutter to such point that the cutter in revolving nips a tissue paper held between it and the blank, or any other method to indicate that the cutter is just touching the work. Then the blank is withdrawn horizontally from under the cutter, the vertical feed dial is set at zero, and the work is raised the correct distance in thousandths of an inch, as indicated on the standard cutters for various pitches.

We do not attempt to give any hard and fast rules for the correct mounting of blanks for fluting taps or reamers, and similar work, as these vary with individual practice and opinion, in shape and depth and position of cuts.

# HIGH NUMBER INDEXING ATTACHMENT

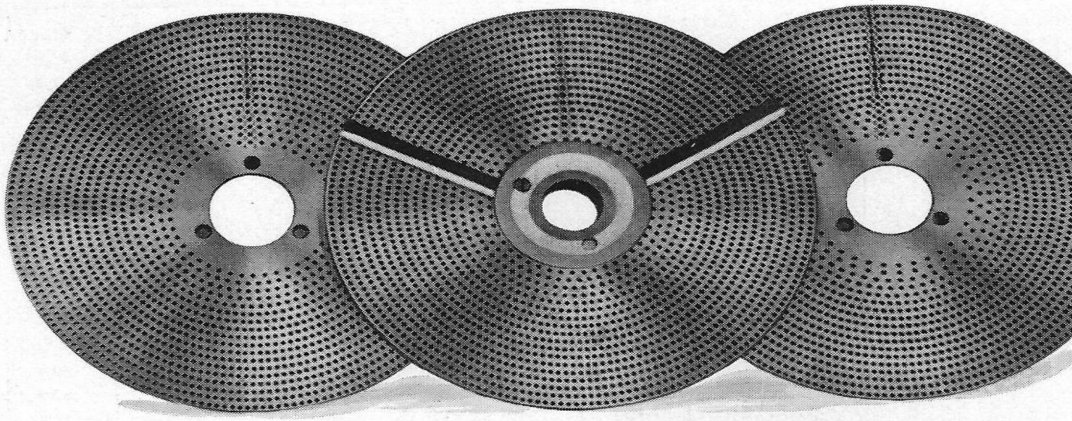

FIG. 16

The two standard index plates, 7¼ inch diameter, provide all division changes up to 60, all even numbers and multiples of 5, up to 120, and a very liberal number between 120 and 400,—195 division changes in all. This is amply sufficient for all usual dividing requirements. Where certain odd divisions are required, not possible with the standard plates, we can furnish a High Number Indexing Attachment. This consists of three special index plates 9⅞ inch diameter, each with 18 circles of holes, ranging from 34 holes in the smallest circle on one plate, to 199 holes in the outside circle on another plate; also a special set of sectors to fit these plates, and an index chart. The standard plunger arm is long enough to be used also with these larger plates. They are mounted and used in the same manner as the standard plates. (See Figure 38 showing the high number plate in use). They provide 252 division changes from 2 to 398, of which 154 are for divisions greater than 120; therefore they are especially adapted to high number indexing. The standard and high number plates together, 5 in all, provide a total of 317 different divisions between 2 and 400, including all divisions up to 200. There are 37 divisions under 200, not possible on the high number plates. These are all possible on the standard plates. The fact that the index plate is set at an angle allows the use of these larger plates without increase in the swing of the dividing head—also the use of still larger plates in very special individual instances.

These high number plates are not limited to plain dividing. They can be used as well in spiral work, as shown in Figure 38.

# SPIRAL MILLING

When the dividing head spindle is connected to the leadscrew of the miller through a train of change gears, the spindle revolves simultaneously with the leadscrew. The table carrying the dividing head and the work is fed longitudinally by the leadscrew, and at the same time the dividing head spindle carrying the work, is revolving. Thus a spiral is generated around the surface of the work in the centers; this spiral varies according to the ratios of the change gears. Figure 17 shows the dividing head set up in this manner for spiral cutting. A, gear on change gear shaft on dividing head (driven); B, first intermediate gear (driver, meshes with A); C, second intermediate gear (driven, meshes with D); D, gear on leadscrew (driver). The change gear bracket is very easily applied. It carries the shaft for receiving change gear A, and on this shaft is also a mitre gear (Figure 6) which meshes with the mitre gear affixed to index plate. The exact position of the bracket when applied is determined by the stop pin on the side of the head. If change gears, A B C D, all had equal numbers of teeth, one revolution of the leadscrew would produce one revolution of the worm.

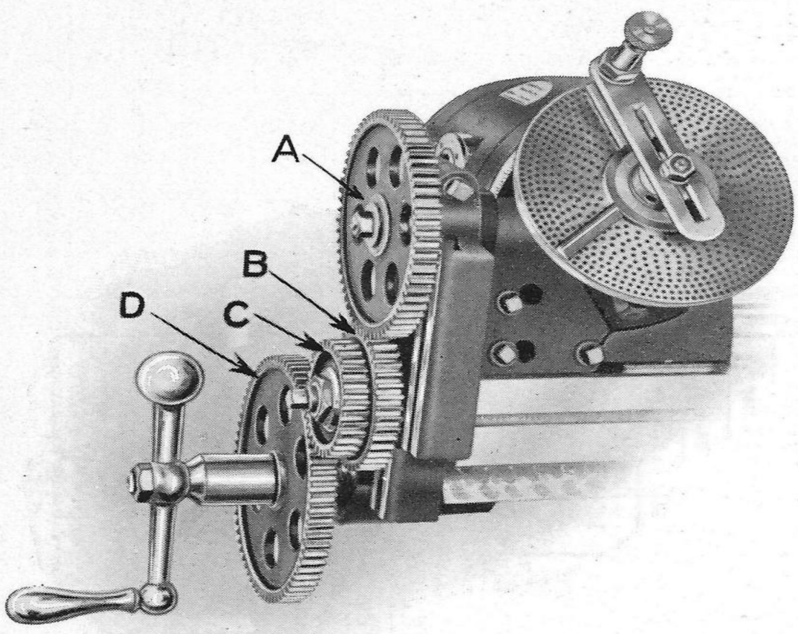

FIG. 17

The leadscrews on our machines have four threads to the inch. For each inch of table travel the worm would revolve four times. The ratio of worm and worm wheel is 40 to 1. For one complete revolution of the spindle therefore, the table would travel 10 inches;—the spiral would have a lead of 10 inches. This is the lead of our machines. If the ratios of the change gears are changed, so that for instance the leadscrew makes two revolutions while the worm makes only one, it is evident that the resulting lead would be twice as long, or 20 inches. If for each revolution of the leadscrew the worm is revolved twice, the resulting lead would be but one half of the lead of the machine, or 5 inches. This develops the following formula for determining the selection of change gears to produce a desired lead:

$$\frac{\text{Lead of spiral to be cut}}{\text{Lead of machine}} = \frac{\text{product of driven gears}}{\text{product of driving gears}} = \frac{A \times C}{B \times D}$$

In explanation: The lead of machine is 10. It is desired to cut a spiral with a lead of 36 inches. The fraction therefore is $\frac{36}{10}$, or separated into factor $\frac{3 \times 12}{2 \times 5}$. These represent the change gears, but in order to make the numerators and denominators correspond to the teeth in change gears furnished, multiply both terms of the first factor by the same suitable number and both terms of the second factor perhaps by another number:

$$\frac{(3 \times 24) \quad X \quad (12 \times 8)}{(2 \times 24) \quad X \quad (\ 5 \times 8)} = \frac{72 \times 96}{48 \times 40}$$

The gear on change gear shaft (A) has 72 teeth; first intermediate gear (B) 48 teeth; second intermediate gear (C) 96 teeth, and gear on leadscrew (D) has 40 teeth. This formula is the

TABLE II. LEADS FROM ONE TURN IN 1.550 IN. TO ONE TURN IN 100. IN.

| LEAD OF SPIRAL IN INCHES | Gear on Ch. Gr. Shaft A | 1st Interm. Gear B | 2nd Interm. Gear C | Gear on Lead Screw D | LEAD OF SPIRAL IN INCHES | Gear on Ch. Gr. Shaft A | 1st Interm. Gear B | 2nd Interm. Gear C | Gear on Lead Screw D | LEAD OF SPIRAL IN INCHES | Gear on Ch. Gr. Shaft A | 1st Interm. Gear B | 2nd Interm. Gear C | Gear on Lead Screw D | LEAD OF SPIRAL IN INCHES | Gear on Ch. Gr. Shaft A | 1st Interm. Gear B | 2nd Interm. Gear C | Gear on Lead Screw D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 550 | 24 | 72 | 40 | 86 | 5 926 | 32 | 48 | 64 | 72 | 12 222 | 96 | 48 | 44 | 72 | 22.857 | 64 | 48 | 96 | 56 |
| 1 594 | 24 | 70 | 40 | 86 | 5 953 | 64 | 40 | 32 | 86 | 12.273 | 48 | 44 | 72 | 64 | 22.909 | 72 | 40 | 56 | 44 |
| 1 628 | 28 | 96 | 48 | 86 | 5 969 | 44 | 48 | 56 | 86 | 12.318 | 44 | 64 | 86 | 48 | 23.036 | 96 | 56 | 86 | 64 |
| 1 666 | 24 | 72 | 48 | 96 | 6.000 | 48 | 64 | 56 | 70 | 12.343 | 72 | 40 | 48 | 70 | 23.333 | 64 | 40 | 70 | 48 |
| 1 705 | 24 | 72 | 44 | 86 | 6 060 | 40 | 44 | 64 | 96 | 12.375 | 72 | 40 | 44 | 64 | 23.454 | 86 | 40 | 48 | 44 |
| 1 809 | 28 | 72 | 40 | 86 | 6 139 | 44 | 40 | 48 | 86 | 12.444 | 56 | 40 | 64 | 72 | 23.516 | 86 | 32 | 56 | 64 |
| 1 860 | 24 | 72 | 48 | 86 | 6 143 | 86 | 64 | 32 | 70 | 12.500 | 96 | 48 | 40 | 64 | 23.571 | 96 | 28 | 44 | 64 |
| 1.913 | 24 | 64 | 44 | 86 | 6.201 | 40 | 48 | 64 | 86 | 12.541 | 86 | 40 | 56 | 96 | 23.863 | 72 | 44 | 70 | 48 |
| 3 819 | 40 | 64 | 44 | 72 | 9.166 | 96 | 64 | 44 | 72 | 17 063 | 86 | 28 | 40 | 72 | 36 000 | 72 | 48 | 96 | 40 |
| 5.426 | 40 | 48 | 56 | 86 | 11.518 | 48 | 56 | 86 | 64 | 21 428 | 96 | 28 | 40 | 64 | 68.571 | 96 | 32 | 64 | 28 |
| 5.500 | 44 | 40 | 48 | 96 | 11.667 | 56 | 64 | 96 | 72 | 21.818 | 72 | 44 | 64 | 48 | 80.000 | 96 | 32 | 64 | 24 |
| 5.625 | 48 | 64 | 72 | 96 | 11.786 | 44 | 48 | 72 | 56 | 21.989 | 86 | 44 | 72 | 64 | 81.905 | 86 | 24 | 64 | 28 |
| 5.714 | 48 | 56 | 64 | 96 | 12.000 | 96 | 40 | 32 | 64 | 22.000 | 96 | 48 | 44 | 40 | 92.143 | 96 | 28 | 86 | 32 |
| 5.833 | 48 | 64 | 56 | 72 | 12.031 | 70 | 40 | 44 | 64 | 22.337 | 86 | 44 | 64 | 56 | 100.000 | 96 | 24 | 70 | 28 |
| 5.847 | 44 | 56 | 64 | 86 | 12.121 | 96 | 44 | 40 | 72 | 22.396 | 86 | 56 | 70 | 48 | | | | | |
| 5.893 | 44 | 56 | 72 | 96 | 12.177 | 72 | 44 | 64 | 86 | 22.500 | 72 | 28 | 56 | 64 | | | | | |
| 5.919 | 40 | 44 | 56 | 86 | 12.216 | 40 | 64 | 86 | 44 | 22.803 | 86 | 44 | 56 | 48 | | | | | |

FIG. 18

basis for computing the table of leads for spiral cutting, extracts from which are given, Figure 18. This table complete gives a total of 396 different leads, and is sent out nicely framed, with other tables for use in cutting spirals. We furnish regularly a set of 12 change gears, having 24, 28, 32, 40, 44, 48, 56, 64, 70, 72, 86, and 96 teeth. In special cases, requiring odd leads not given, one or more special change gears may be needed. These can be determined through the above formula.

To ascertain the lead of spiral which any given set of change gears will produce, multiply the product of the driven gears by 10, and divide by the product of the drivers: $\frac{A \times C \times 10}{B \times D}$.

**GEARING DIRECT TO SPINDLE.:** As the leads grow shorter, the gear ratios increase. For any lead under about 1½ inch, these ratios become so high, because of the 40 to 1 ratio of worm and worm wheel that practically all the power is consumed in transmission and short leads are therefore out of the question if attempted in the usual manner. We have added a valuable new feature on this dividing head, in providing for short leads, such as worm or screw threads, by which the gear train is led direct from the leadscrew to the spindle, and not through the worm, an extension stud being provided in the spindle to receive the change gear. Figure 19 shows the dividing head set up in this manner. There is **no** gear on the change gear shaft, and the ratio of 40 to 1 through the worm is avoided. The leadscrew is geared direct to spindle; the lead of the machine therefore is the pitch of the leadscrew, or ¼ in., and the formula for selecting change gears, derived as above is: lead $= \frac{A \times C}{B \times D \times 4}$. Figure 20 represents the table of leads obtained in this manner, a total of 178 leads, ranging from .120 in. to 1.5 in., using the same set of change gears, and entirely supplementary to the leads obtainable through the worm which begin with 1.550 in. in the tables.

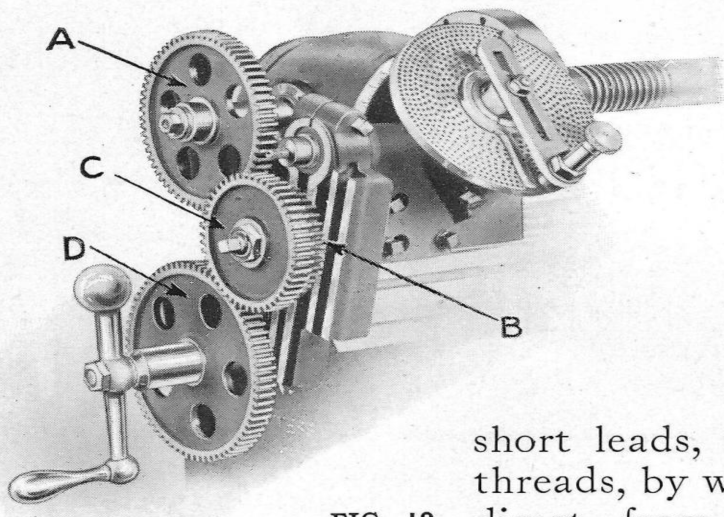


FIG. 19

These two methods of setting the head, provide a total of 574 different leads, a complete continuous range from less than ⅛ inch to 100 inch leads.

TABLE I. LEADS FROM .109" TO 1.5"

| LEAD OF SPIRAL IN INCHES | Gear on Spdle. Ext. A | 1st Interm. Gear B | 2nd Interm. Gear C | Gear on Lead Screw D | LEAD OF SPIRAL IN INCHES | Gear on Spdle. Ext. A | 1st Interm. Gear B | 2nd Interm. Gear C | Gear on Lead Screw D |
|---|---|---|---|---|---|---|---|---|---|
| .109 | 70 | 40 | 24 | 90 | .528 | 86 | 32 | 44 | 56 |
| .120 | 72 | 56 | 24 | 64 | .536 | 96 | 28 | 40 | 64 |
| .125 | 64 | 32 | 24 | 96 | .545 | 72 | 44 | 64 | 48 |
| .127 | 64 | 56 | 32 | 72 | .547 | 96 | 48 | 70 | 64 |
| .135 | 56 | 48 | 40 | 86 | .550 | 86 | 44 | 72 | 64 |
| .140 | 48 | 64 | 72 | 96 | .558 | 86 | 44 | 64 | 56 |
| .146 | 48 | 64 | 56 | 72 | .560 | 86 | 56 | 70 | 48 |
| .149 | 56 | 48 | 44 | 86 | 562 | 72 | 28 | 56 | 64 |
| .500 | 96 | 24 | 32 | 64 | 1.466 | 86 | 24 | 72 | 44 |
| .504 | 72 | 48 | 86 | 64 | 1.500 | 96 | 24 | 72 | 48 |
| .511 | 72 | 56 | 70 | 44 | | | | | |
| .514 | 72 | 40 | 64 | 56 | | | | | |
| .515 | 96 | 32 | 44 | 64 | | | | | |
| .518 | 64 | 24 | 56 | 72 | | | | | |
| .522 | 86 | 32 | 56 | 72 | | | | | |
| .525 | 72 | 40 | 56 | 48 | | | | | |

FIG. 20

# ANGLES FOR SPIRAL MILLING

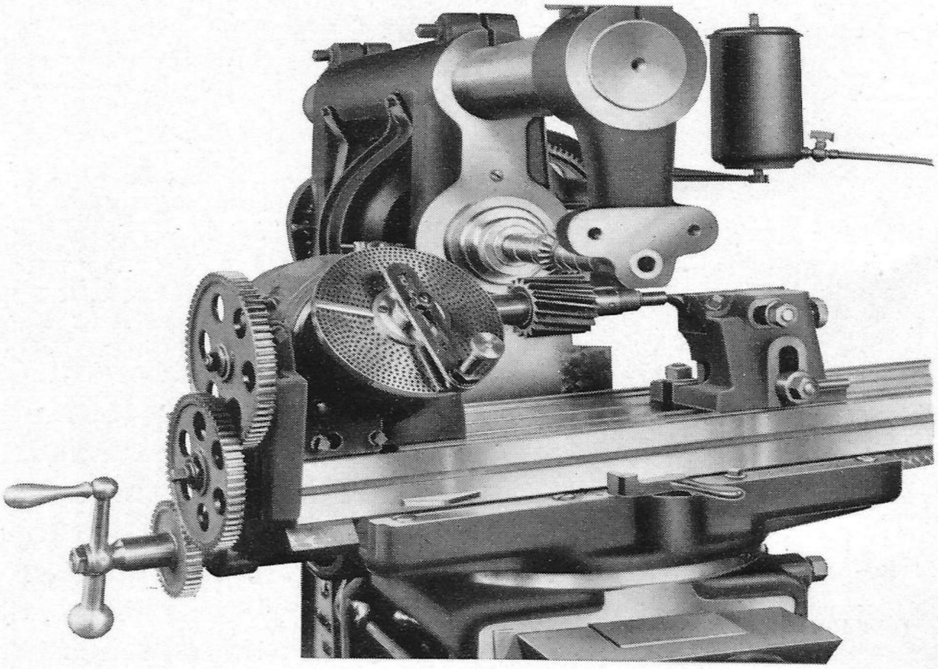

FIG. 21

In spiral cutting there must be a certain angle between cutter and work, in order to bring the spiral, at the point of cut, in line with the cutter, so as to retain the correct shape of the cutter in the tooth or groove being milled. On Universal Millers, this is accomplished by swiveling the milling machine table carrying the dividing head and the work; on Plain millers, on the contrary the cutter is swiveled, being done through the swiveling spindle of the Universal Milling

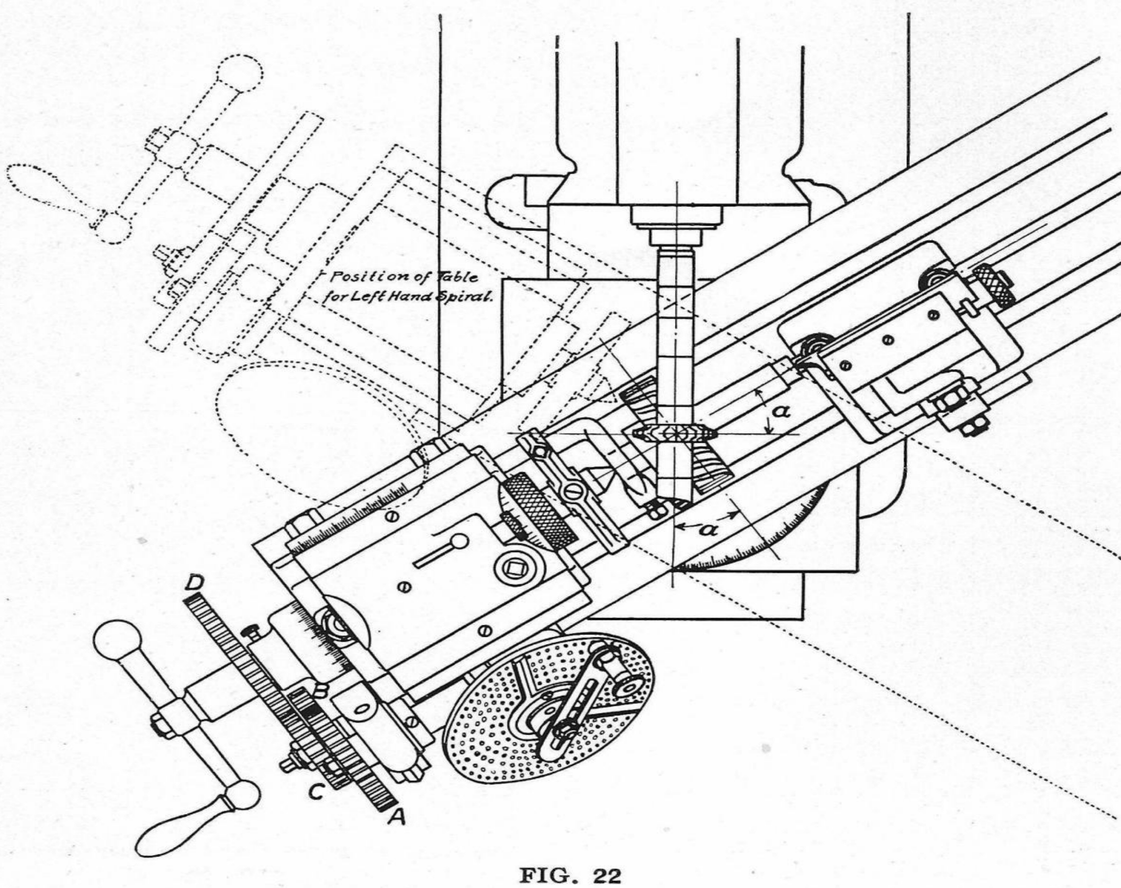


FIG. 22

Attachment. Figures 21 and 22 show in different ways the Universal Dividing Head as set up for cutting usual spirals—the position of head and tailstock on the milling machine table, position of the table, relation of the cutter to the work, application of the change gears and spiral cutting mechanism, etc. For left hand spirals, the table is swiveled in the reverse direction, as indicated, and an idler gear inserted in the change gear train, to change the direction of rotation of the work. After the cutter and work and change gears are correctly mounted, and **before** swiveling the table to the angle required, the same precautions should be followed in setting work for the cut, as we have previously given for spur gears. (Page 12). To ascertain if the change gears as mounted, produce the correct lead, first set the work so that the cutter traces a fine spiral mark as the work is fed forward by hand.

After a spiral cut is taken, in returning the table by hand for the next cut, it is advisable to see that the table is lowered so that the work clears the cutter.

**Always** in preparing for spiral milling, see that the screws clamping the index plate mitre gear are loosened. Indexing for the teeth in spiral milling, is accomplished as already described, page 11.

**THE ANGLE OF THE SPIRAL** depends upon the lead of the spiral and the diameter of the work. The greater the lead of a spiral of any given diameter, the smaller the angle; the greater the diameter for any given lead, the greater the angle. In the spiral cutting charts furnished regularly, we give a table of the correct

**TABLE III. CHANGE GEARS AND ANGLES FOR SPIRALS**

EXAMPLE:—A 2¼" Spiral Cutter is to be cut, the angle of Spiral to be 11°. The proper lead of the Spiral, in inches, is therefore 36.

The Table of the Universal Miller, (or the cutter spindle of the Universal Milling Att.) is swiveled and clamped at an angle of 11°, and change gears 72, 48, 96 40 are mounted as directed.

| LEAD OF SPIRAL IN INCHES | Gear on Ch. Gr. Shaft A | 1st Interm. Gear B | 2nd Inter. Gear C | Gear on Lead Screw D | DIAMETER OF WORK TO BE CUT ⅛" | ¼" | ⅜" | ½" | ⅝" | ¾" | ⅞" | 1" | 1¼" | 1½" | 1¾" | 2" | 2¼" | 2½" | 2¾" | 3" | 3¼" | 3½" | 3¾" | 4" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.66 | 24 | 72 | 48 | 96 | 12¾ | 25 | 34¾ | 43¼° | | | | | | | | | | | | | | | | |
| 1.94 | 28 | 72 | 48 | 96 | 11¼ | 21¾ | 31 | 39 | 45 ° | | | | | | | | | | | | | | | |
| 2.08 | 32 | 64 | 40 | 96 | 10¼ | 20½ | 29½ | 37 | 43¼ | | | | | | | | | | | | | | | |
| 2.22 | 48 | 72 | 32 | 96 | 9¾ | 19¼ | 27½ | 35 | 41¼ | | | | | | | | | | | | | | | |
| 2.50 | 32 | 64 | 48 | 96 | 8¾ | 17 | 25 | 32 | 38 | 43¼° | | | | | | | | | | | | | | |
| 2.77 | 48 | 72 | 40 | 96 | 8 | 15½ | 23 | 29½ | 35¼ | 40½ | 44¾° | | | | | | | | | | | | | |
| 36.00 | 72 | 48 | 96 | 40 | ½ | 1¼ | 2 | 2½ | 3¼ | 3¾ | 4½ | 5 | 6¼ | 7½ | 8¾ | 10 | 11 | 12¼ | 13½ | 14¾ | 16 | 17 | 18¼ | 19¼ |
| 41.14 | 96 | 28 | 48 | 40 | ½ | 1 | 1¾ | 2¼ | 2¾ | 3¼ | 4 | 4½ | 5½ | 6½ | 7¾ | 8¾ | 9¾ | 10¾ | 11¾ | 13 | 14 | 15 | 16 | 17 |
| 45.00 | 72 | 48 | 96 | 32 | ½ | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 11¾ | 12¾ | 13¾ | 14¾ | 15½ |
| 48.00 | 96 | 32 | 64 | 40 | ½ | 1 | 1½ | 2 | 2½ | 3 | 3¼ | 3¾ | 4¾ | 5½ | 6½ | 7½ | 8½ | 9¼ | 10¼ | 11¼ | 12 | 13 | 13¾ | 14½ |
| 51.42 | 96 | 28 | 72 | 48 | ½ | ¾ | 1½ | 1¾ | 2¼ | 2¾ | 3 | 3½ | 4½ | 5¼ | 6 | 7 | 7¾ | 8¾ | 9½ | 10½ | 11¼ | 12 | 12¾ | 13¾ |
| 60.00 | 96 | 24 | 72 | 48 | ½ | ¾ | 1¼ | 1½ | 2 | 2¼ | 2½ | 3 | 3¾ | 4½ | 5¼ | 6 | 6¾ | 7½ | 8¼ | 9 | 9½ | 10¼ | 11 | 11¾ |
| 68.57 | 96 | 32 | 64 | 28 | ¼ | ¾ | 1 | 1¼ | 1¾ | 2 | 2¼ | 2½ | 3¼ | 4 | 4¼ | 5½ | 5¾ | 6½ | 7¼ | 8 | 8½ | 9 | 9¾ | 10¼ |

FIG. 23

angles of spirals of various leads, from 1.67 inch to 68.57 inches for diameters from 1/8 inch to 4 inches. Portions of this table are shown in Fig. 23. In special jobs, not covered by the table, the angle must be individually found. The usual process of determining the correct angle is complicated and involves trigonometry, so we do not give it in detail. There is, however, an easy shop method of securing a satisfactorily correct angle in such cases, where the lead is known. Set the work so that when it is fed forward by hand, the lead is indicated by a fine spiral line traced by the cutter stationary. Then place a scale carefully against the flat side of the cutter, and swivel the table until the line showing the lead is parallel to the scale. This will give the required angle. The angle can likewise be found by setting a combination bevel protractor so that it is parallel to the line showing the lead, when against the end of the work.

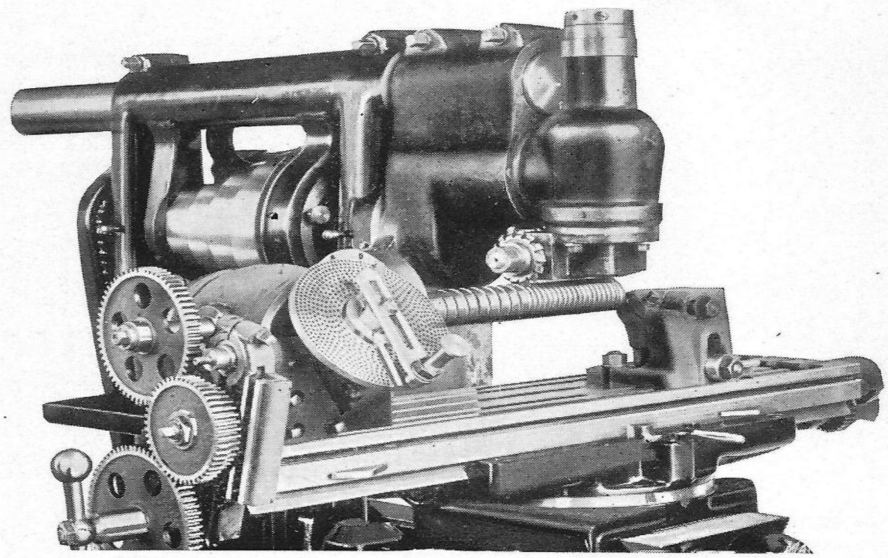

FIG. 23

The Universal milling machine table can be swiveled to an angle of about 50 degrees. For angles greater than this, it is necessary to use the Universal Milling Attachment, which swivels the cutter. Figure 24 shows the Dividing Head set up for a short lead spiral through gearing direct from leadscrew to spindle. The angle of the spiral is greater than the maximum swivel of the milling machine table. Table is therefore set at zero, and the Universal Attachment mounted, which permits swiveling the cutter to the angle of the spiral in the manner indicated. This attachment is also brought into use in all spiral milling on Plain Millers.

There are four principal standard styles of spiral work most commonly cut with the dividing head—spiral milling cutters, twist drills, worms, and spiral gears.

On our spiral charts, we give tables giving angles and leads, etc., for cutting spiral milling cutters of various diameters from 1/2 inch to 4 inch, and for cutting twist drills from 3-16 inch to 1 1/8 inch diameter. The shape and depth of the cut vary in individual cases, but standard cutters have been produced for these purposes. In cutting worms, the lead becomes of the nature of a screw thread, and our new arrangement for cutting short lead spirals adapts our dividing head admirably to worm cutting. The dividing head thus becomes in effect a thread miller. In the work of this nature the angle is so great that it is necessary to use the Universal Milling Attachment, as in Fig. 24.

The laying out of a pair of spiral gears is elaborate and complicated, and is explained in detail in any standard treatise on gearing. We attempt to give here only a few condensed rules and formulae.

The simplest case of spiral gears is that of gears with equal diameters and angles of 45 degrees. They will have a speed ratio of 1 to 1, the same circumferential speed, and same number of teeth.

The speed ratios may be varied:

1.—By changing the diameters of the gears, angle remaining.

2.—By changing the angles of the gears, diameters remaining.

3.—By changing both angles and diameters.

If the ratio is given, and the diameter of one gear, and if the center distance need not be fixed, any angle may be assumed and a diameter found for the other gear, to give the desired ratio. An indefinite number of combinations of angles and diameters will give the ratio required.

If the center distance is fixed, the diameters are governed accordingly.

If the diameters and speed ratio are given, the angle is determined:

$$1.\text{—cot angle of driver} = \frac{\text{rev. driven x dia. driven}}{\text{rev. driver x dia. driver}}$$

If the speeds and ratio are given, as is usually the case, the diameters and angles must be determined.

First, to determine the diameters by assuming a trial angle *a* we have the formula

$$2.\text{—Diameter of driver} = \frac{\text{2 x center distance}}{\dfrac{\text{revolutions of driver}}{\text{revolutions of driven}} \text{ x cot } a + 1}$$

in which the center distance and speeds of driver and driven gears are given, and $a$ = the tooth angle of the driver, (with the axis, not with the face). In assuming a trial angle it is well to remember that angles between 30° and 45° produce the most favorable conditions for durability, and that for smaller angles the wear is proportionately increased.

3.—Diameter of driven gear = 2 x center distance—dia. of driver.

Having found the gear diameters, the teeth are determined:

4.—No. of teeth in driver = Dia. of driver x cos *a* x diametral pitch.

5.—No. of teeth in driven = Dia. of driven x sin *a* x diametral pitch.

in which the pitch is selected according to the load on teeth.

If the teeth in the two gears, as thus found, do not have the exact desired ratio, select the nearest whole numbers having this ratio, as the final numbers of teeth in the spiral gears, and this means a new trial center distance (if this is not necessarily fixed) or a new trial angle *a*.

(a) If a changed center distance, angle *a* remaining:

6.—Final diameter $= \dfrac{\text{trial dia. x final number of teeth}}{\text{trial number of teeth.}}$

This applies to both driver and driven gears.

(b) If a new trial angle *a*, center distance remaining, proceed as in the first trial, remembering that if the trial number of teeth proved too great, the angle should be reduced, and conversely.

Having determined the final angle *a* for the driver, the angle for the driven is the shaft angle (usually 90°) minus angle *a*. From the diameters as found, the lead of the spiral is determined:

7.—Lead for driver = dia. of driver x 3.1416 x cot *a*.

8.—Lead for driven = dia. of driven x 3.1416 x tan *a*.

Change gears to be selected for obtaining these leads, as already explained, page 15.

The diameters referred to above are the pitch diameters. To find the outside diameters for the blanks,

9.—Add $\dfrac{2}{\text{diametral pitch}}$ to the pitch diameter.

To determine the number of teeth for which to select the proper standard gear cutter, the formula is

10.—For driver: $\dfrac{\text{number of teeth in driver}}{\cos^3 \text{ tooth angle } a}$

11.—For driven: $\dfrac{\text{number of teeth in driven}}{\sin^3 \text{ tooth angle } a}$

Figures 25 and 26 show the dividing head cutting a pair of special right hand spiral gears. The angle of shafts is 90° Ratio is 1 (driver) to 8 (driven).

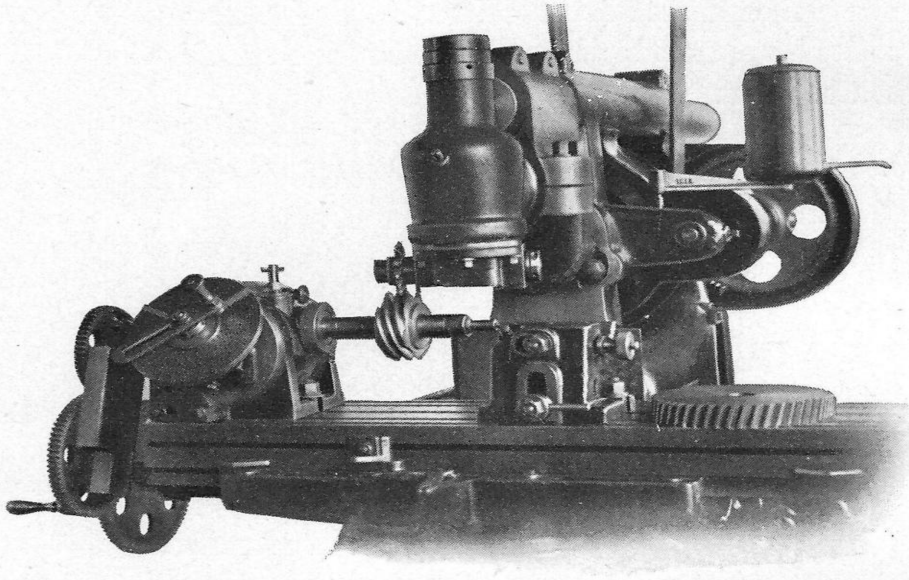

FIG. 25

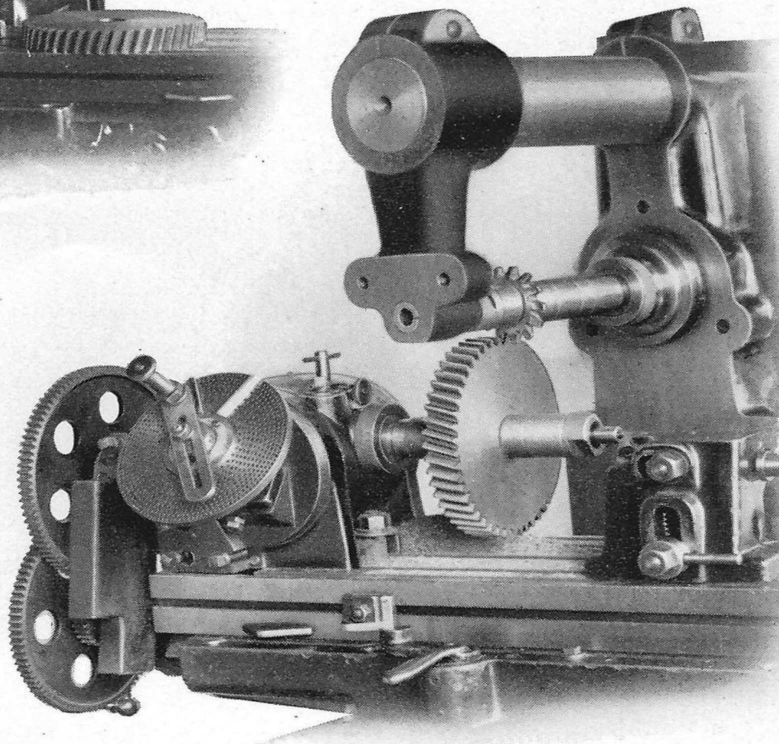

FIG. 26

Diameters 3.85 and 8.282. Numbers of teeth 6 and 48. Pitch 6. Angles 15° and 75°. Leads 3.2 and 96.5. The angle of the smaller gear is too great to cut with a cutter on the arbor, and the Universal Milling Attachment must be used. When using the Universal Attachment, the table is held at 0, and the attachment spindle swiveled to the angle of the spiral, (tooth angle *a*).

## BEVEL GEAR CUTTING

Cutting the teeth of bevel gears with a rotary cutter on the milling machine is somewhat more complicated than spur gear cutting. The inner end of the face of a bevel gear is smaller diameter than the outer end. Therefore there will be the same number of teeth for two different pitch diameters, and the teeth at the inner end will be finer pitch than at the outer end. A cutter correct for the pitch at the outer end will be incorrect for the other end. The correct bevel gear tooth becomes a sort of compromise between these two, and in forming the tooth, secondary cutting operations are required. We describe here the most practical and generally used shop method for correctly forming the teeth of bevel gears on a miller.

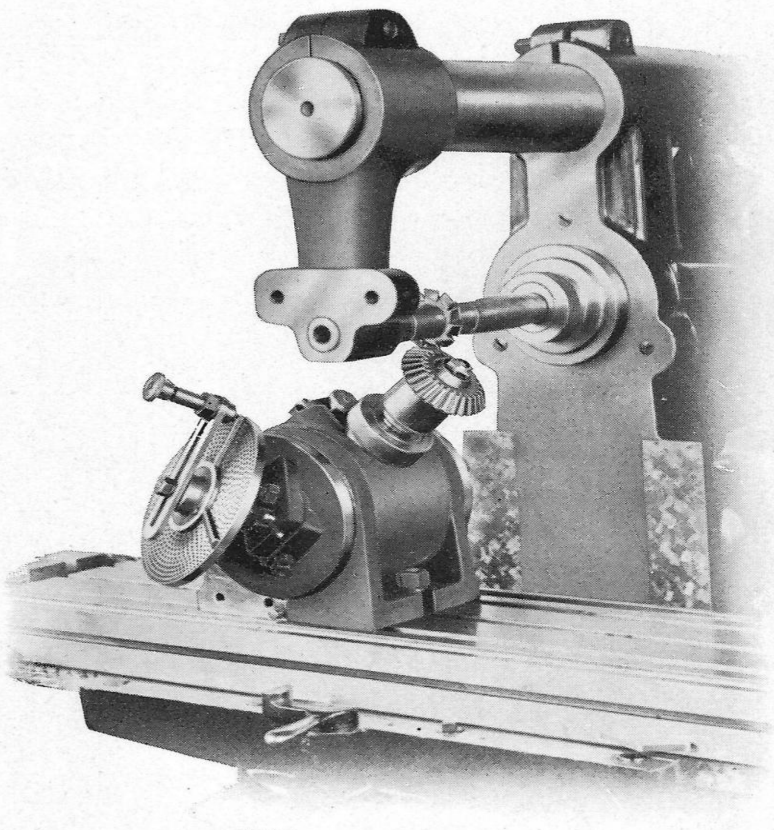

FIG. 27

Fig. 27 shows the general position of the dividing head, the work and the cutter. If on a Universal Miller, the swivel block should be set at zero. The dividing head is first arranged for indexing the number of teeth required, this being followed as already described page 10. The blank which we assume to be correctly formed for the face angle etc., is mounted on a short arbor, firmly held in the spindle. The pitch at large end should determine selection of the cutter, and cutters are manufactured particularly for bevel gear cutting of varying numbers of teeth. The dividing head is swung up and clamped at the correct cutting angle, in the position as shown. See that the blank is carefully set central with the cutter, and then set the graduated dial on the cross feed at 0.

By the micrometer dial on vertical shaft, adjust the blank for the correct given depth of the tooth for the pitch, for the trial cut (Fig. 28), taking care that this cut shall if anything be less than full proper depth, it being easy to increase this subsequently to the required depth.

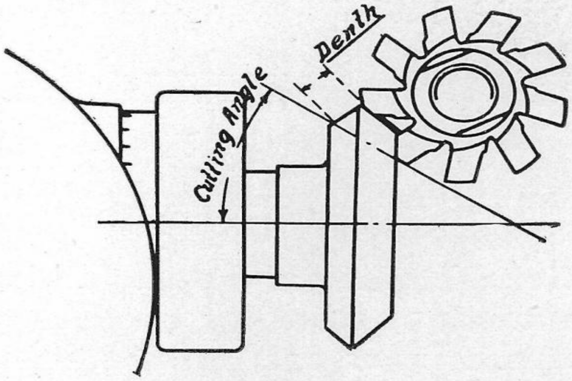


FIG. 28

When this is determined, cut two or three teeth. (Until the operator becomes thoroughly familiar with this work, it is advisable to carry this central cut around for all teeth of the gear. Later it would be unnecessary except in the heavier pitches). These teeth will not be of proper form, being much too wide on the pitch line at the outer end, which must be reduced relatively much more than at the inner end. To accomplish this: Set the work out of center in either direction, by means of the cross feed, a trial distance, which for best results can be approximately one-tenth to one-eighth of the thickness of the tooth at the pitch line at large end. Then through the index worm, rotate, or "roll", the work blank back toward the cutter in the direction opposite to the set-over (indicated by the arrow, Figure 29), until the cutter barely trims it at the inner end of the tooth. This "rolling" of the work blank results in a pronounced shaving taken off at the outer end of the tooth while the inner end is barely touched.

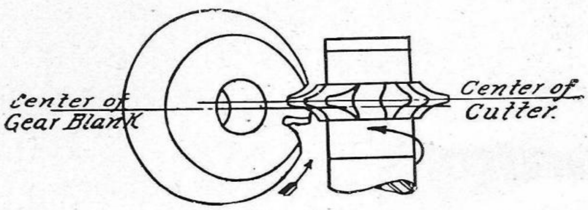


FIG. 29

Take this cut off two or three teeth, indexing as usual, then take a similar cut from the other side of these same teeth, by returning the work blank **double** the distance of its set-over, which means it is set over an equal distance on the opposite side of center, and rolling the blank in the **reverse** direction until the cutter trims the inner end of the tooth. A rule to observe is that the cutting side of the cutter should always be nearest the center of the work. This will give one or two complete teeth, which can then be tested at outer end with a tooth gauge at pitch line (Fig. 30). If the tooth is too large the set-over was not sufficient, and must be increased accordingly, and the entire procedure including rolling of the blank, repeated until the tooth conforms to gauge at large end. When the proper tooth has been reached by these trials, take the two set-over cuts as above described, first the one for all the teeth around the blank and then similarly for the other. Be careful to make the adjustment as determined for the original correct tooth. If, on completion, the gears do not run satisfactorily, the set-over distance is wrong, and must be changed dependent on the size of tooth at small end. If this is too large, set-over distance is too great, and if the small end is too thin, the set-over is not sufficient.

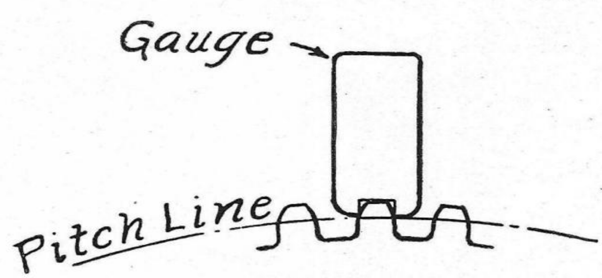


FIG. 30

# THE SIDE-CENTER TAILSTOCK

The center is not set into the middle of the top of the tailstock as usual, but is rectangular shape and set into the tailstock at an angle as shown in Figure 31; is firmly fixed in its position by a special clamp arrangement, and is provided with rapid and easy adjustment through the knob at the rear. This position brings the center proper within one eighth of an inch of the inner side of the tailstock as well as within one eighth inch of the top.

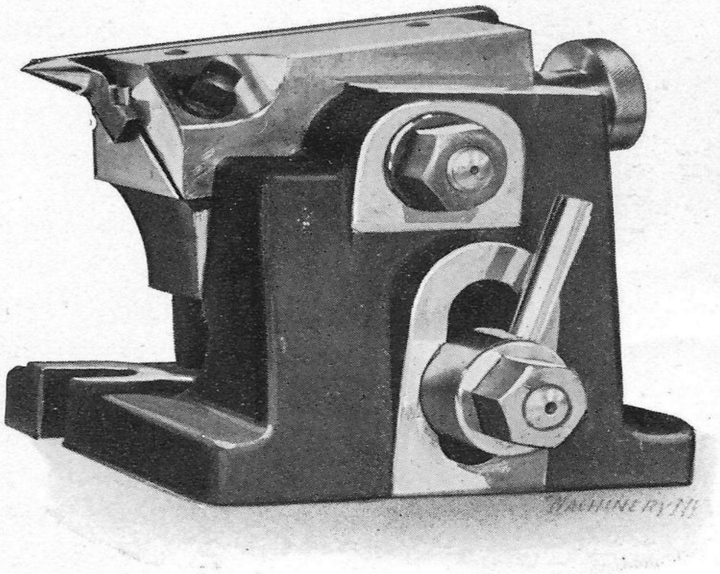

FIG. 31

This feature is valuable, as it provides for clearance for end milling cutters, and allows the use of much larger diameter end mills on many classes of work than would otherwise be possible, and thus dispenses largely with the use of very small end mills. This results in the more economical operation of the head and effectually increases the output of work in such instances. A typical job of this character is shown in Figure 32, in which a three inch end mill can clear the inner side of the tailstock in squaring the end of the feed screw.

The block carrying the center can be elevated through rack and pinion by means of the lever on the side, and tilted and clamped into alignment with the work. Figure 33 shows the dividing head used in making a spiral taper reamer, in which this feature of the tailstock is brought into use. The center block is provided with finished spots, which have a firm seat on pads, and this insures the center being brought back into accurate alignment with the head center when a taper job is finished.

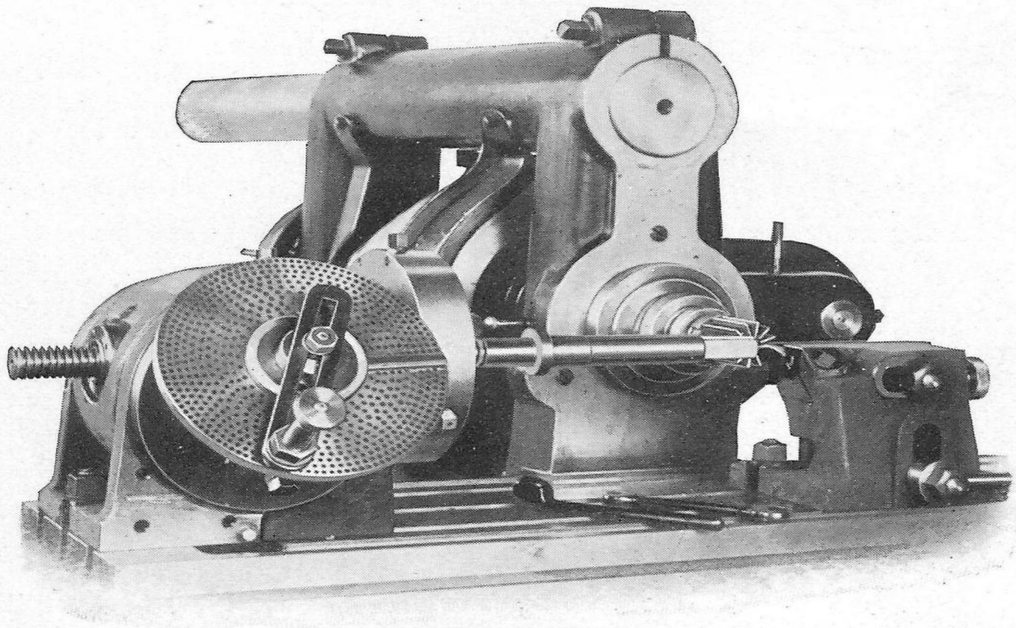

FIG. 32

This job is referred to in connection with the uses of the Side Center Tailstock (see page 26). It also illustrates the value of the large hole through the Dividing Head Spindle (1 1-16 inch on the 10½ inch size, 1¼ inch on the 13¼ inch size) which allows work of this nature to be passed through the head.

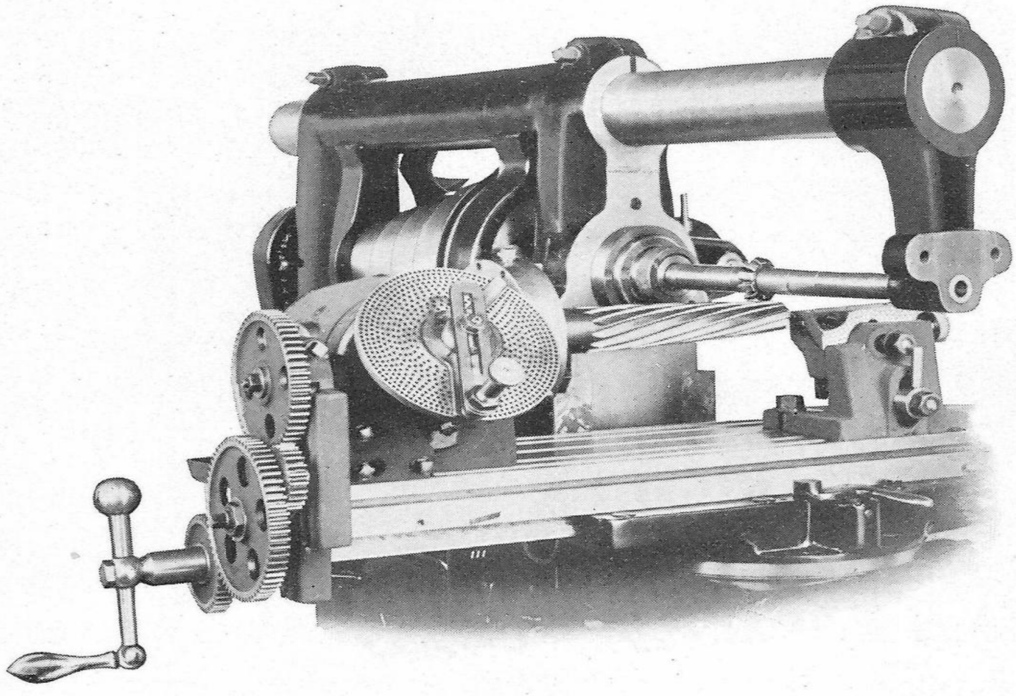

FIG. 33

Illustrates the elevating feature of the Tailstock in taper work (see page 26). Also demonstrates the possibility of swiveling the head for taper spiral work with the spiral mechanism in position.

# HOBBING WORM WHEELS

can be performed satisfactorily through the Universal Dividing head on the Universal Milling Machine. Two operations are required, first in "gashing" or roughing the teeth, second in finishing with a hob. Select a gashing cutter for a tooth slightly smaller than the finished tooth space on the worm wheel. The blank is mouuted on a mandrel between the centers, and set central with the cutter, as in the case of a spur gear. The table is then moved lengthwise until the center of the face of the blank is directly under the center of the arbor and cutter. The table is then clamped to prevent longitudinal movement. The swivel block is set at the correct angle of the teeth of the gear to be hobbed. The work is then fed **up** to the cutter through the vertical movement until the proper depth of tooth is reached, is then lowered, and indexed, the indexing being performed as with a spur gear. Figure 34 shows a worm wheel blank in this process of gashing. Note the angle of the teeth.

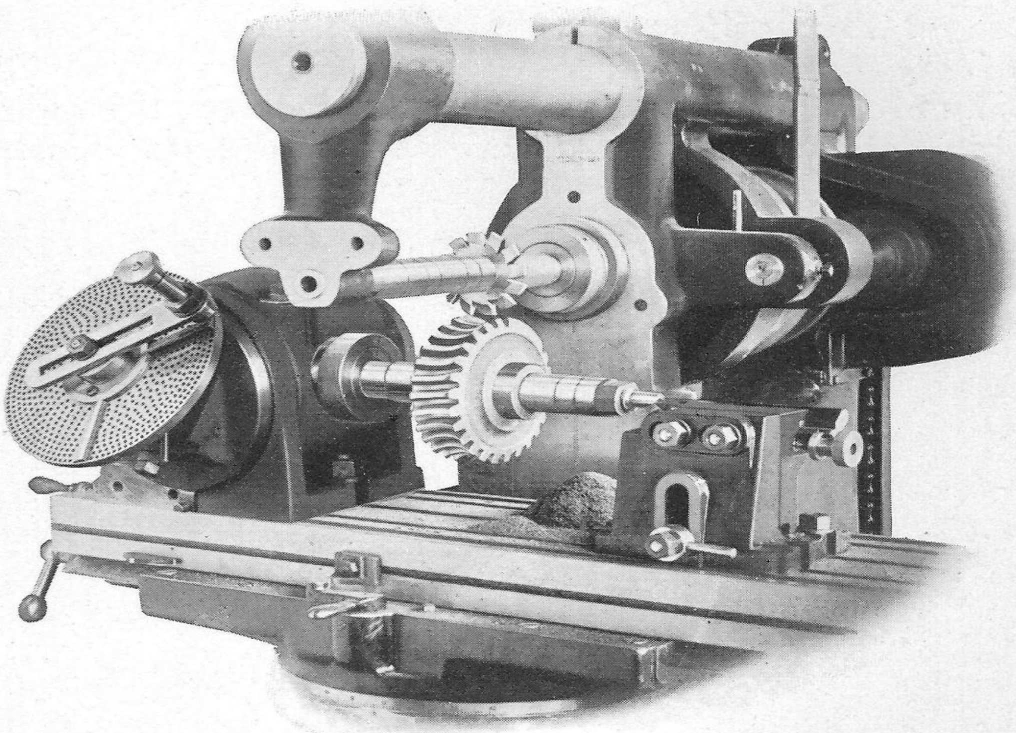

FIG. 34

This operation completed, the table is returned to zero, that is at right angles to the spindle, the cutter is replaced by the correct hob on the arbor, and the mandrel carrying the gashed blank is adjusted so that it revolves freely on the centers. Thus in revolving, the hob by the action of its lead, turns the gashed blank on the centers, and finishes the teeth to the correct angle and shape, the work being fed up against the hob until the correct depth of tooth is reached.

# CUTTING LARGE SPUR GEARS

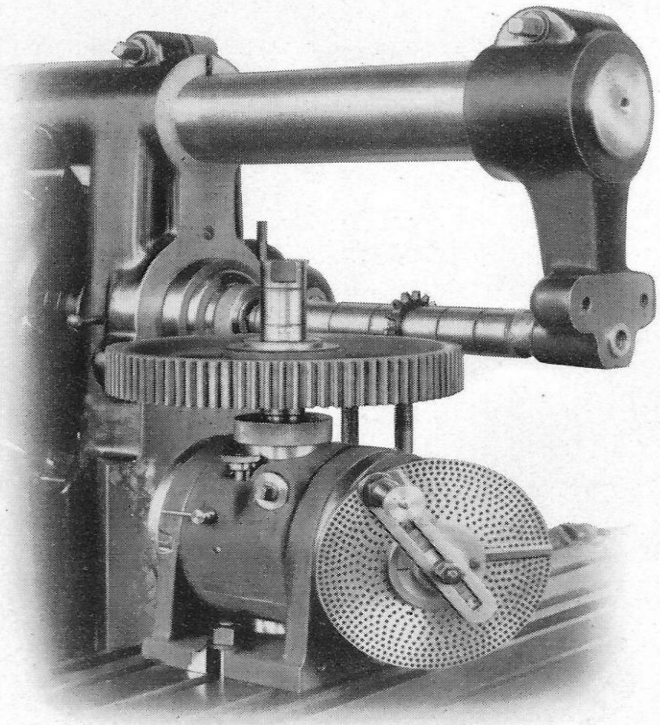

FIG. 35

In cutting spur gears carried on the dividing centers, the diameter of the gear is of course limited by the swing of the Dividing Head. In many shops, especially those doing jobbing work, gears of larger diameters are occasionally required of the Dividing Head. It is always possible to increase the swing of the centers through the use of raising blocks, but we show here a simpler method. Swivel and clamp the Dividing Head spindle to an exact vertical position. Mount the gear blank securely on a short strong arbor in the spindle. Provide a suitable support to the work at the periphery near the point of cut. Use the power vertical feed, feeding the work **up** against the cutter. In all other respects proceed as usual with a spur gear.

Figure 35 shows a 5 P. gear 18 inches diameter. In point of capacity it is possible to cut by this method, gears up to approximately 36 inches diameter on No. 1 Plain and Universal Millers, 42 inches diameter on No. 2 Plain and Universal Millers, 48 inches on No. 3 Plain and Universal Millers, but we advise against straining the Dividing Head by mounting too heavy and cumbersome gears on it.

There is quite a variety of work to which the dividing head is adapted when swung away from its usual position in line with the table, as shown here, mounted on the swivel base of the milling machine vise in the regular equipment of Universal Millers. The head is arranged to receive the center pin of the vise base, and can be clamped by the bolts in the circular slot. A boss is provided on the head frame, which can be filed and a zero line scratched as shown, and thus through the graduations

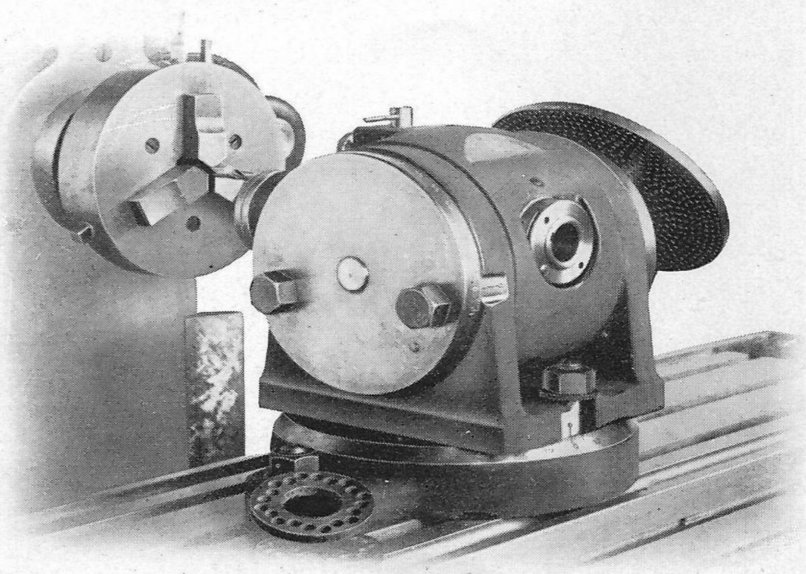

FIG. 36

on the base, the head can be set at any angle. Figure 34 shows it at 90 degrees or in line with the miller spindle. The work is carried on a stub arbor in the head spindle, a chuck on the miller spindle holds a twist drill, and through the indexing any desired number of accurately spaced holes can be drilled. In this same general manner the head is used often by tool makers for locating with precision various holes in jigs, and similar work. (See table of indexing for angles in degrees, page 33).

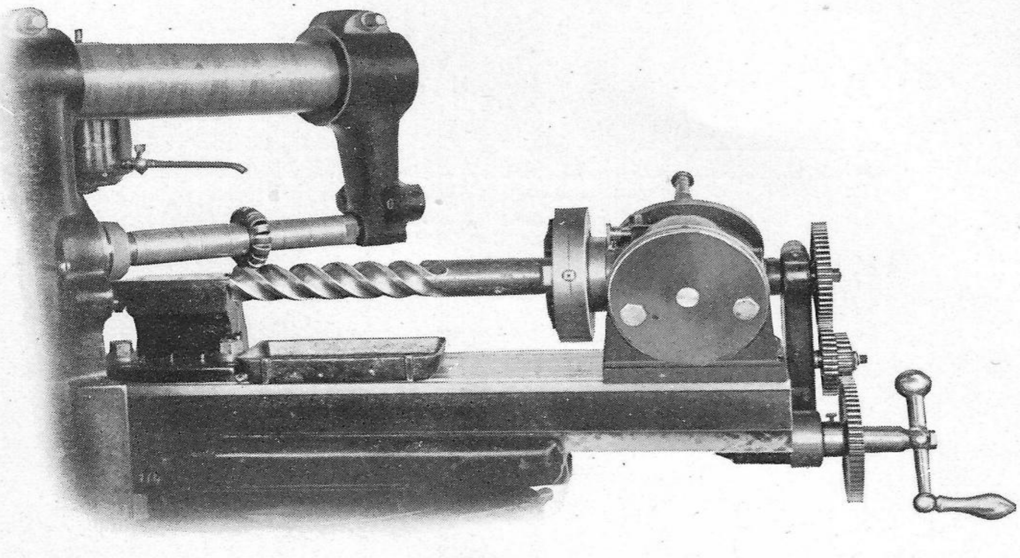

FIG. 37

The purpose of this illustration is merely to show the exceptional strength and rigidity of this Dividing Head. The spiral shown was taken at one cut, (1 inch convex cutter), is comparatively short lead, and demonstrates the adaptability of the Dividing Head to the heavier kinds of spiral work.

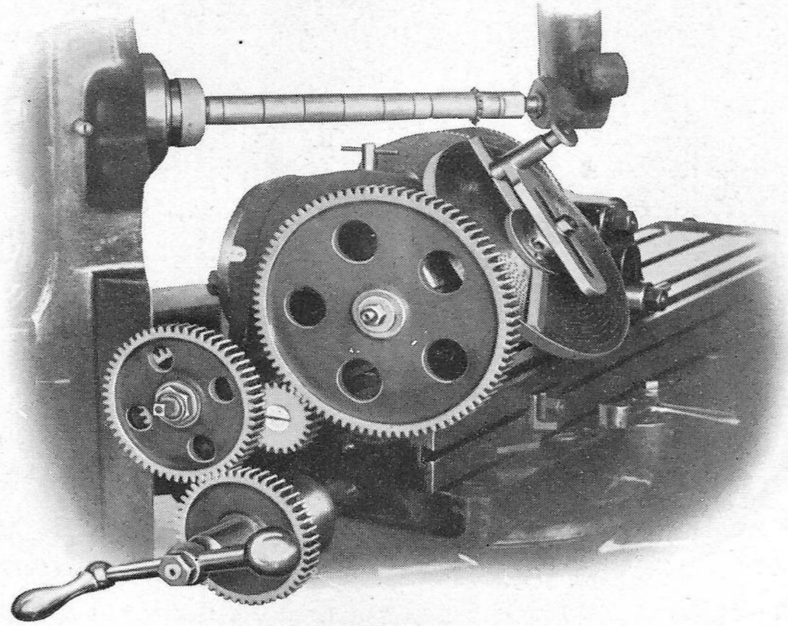

FIG. 38

The Dividing Head fitted with high number index plate (see page 14) cutting special spiral gear, 113 teeth, 20 pitch, 25.1 inch lead. This large index plate is as easily applied as the standard plate, does not interfere, and clears the edge of the miller table. This shows that the High Number Attachment can be used as well in cutting special spiral as special spur gears.

# CUTTING SPIRALS WITH AN END MILL

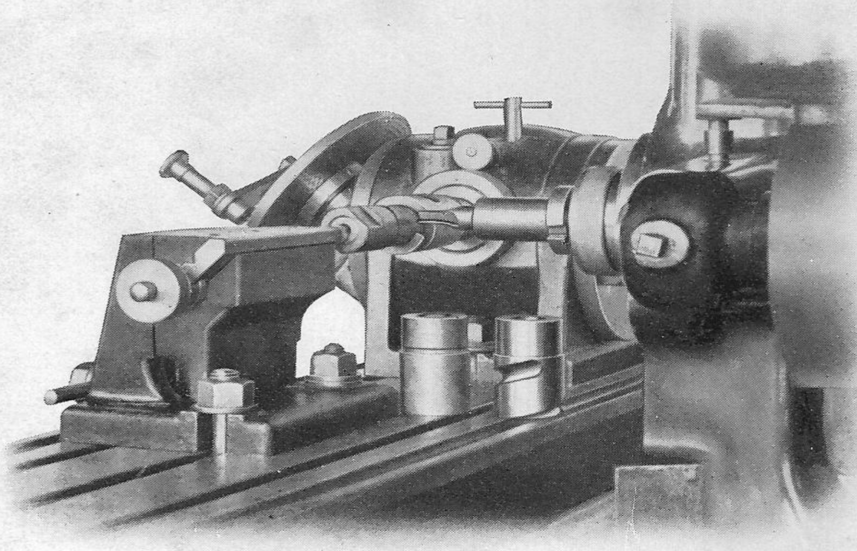

FIG. 39

Sometimes the conditions of a spiral cutting job will not permit the use of a milling cutter mounted as usual on the arbor; for instance, in milling a dove-tail or a T-slot spiral groove, or a combination straight and spiral groove, or a herringbone groove, or a spiral groove requiring parallel sides, or a spiral groove which must come to an abrupt end after partially passing through the work, etc. Such jobs can be done satisfactorily through using an end mill in the spindle. Fig. 39 shows an end mill cutting a groove on a piece on the dividing centers set in the usual position on the table. This groove forms the path for a guide pin, travels only partially through the length of the work, must have parallel sides, and must carry its full depth up to the end.

# INDEX TABLE FOR ANGLES

| Degree of Angle | Turns | Index-Circle | Holes | Degree of Angle | Turns | Index-Circle | Holes | Degree of Angle | Turns | Index-Circle | Holes | Degree of Angle | Turns | Index-Circle | Holes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .... | 81 | 9 | 12½ | 1 | 36 | 14 | 24 | 2 | 81 | 54 | 35½ | 3 | 36 | 34 |
| 1⅓ | .... | 81 | 12 | 12⅔ | 1 | 81 | 33 | 24⅓ | 2 | 81 | 57 | 35⅔ | 3 | 81 | 78 |
| 1½ | .... | 48 | 8 | 13 | 1 | 81 | 36 | 24½ | 2 | 36 | 26 | 36 | 4 | ..... | .... |
| 1⅔ | .... | 81 | 15 | 13⅓ | 1 | 81 | 39 | 24⅔ | 2 | 81 | 60 | 36⅓ | 4 | 81 | 3 |
| 2 | .... | 81 | 18 | 13½ | 1 | 48 | 24 | 25 | 2 | 81 | 63 | 36½ | 4 | 36 | 2 |
| 2⅓ | .... | 81 | 21 | 13⅔ | 1 | 81 | 42 | 25⅓ | 2 | 81 | 66 | 36⅔ | 4 | 81 | 6 |
| 2½ | .... | 36 | 10 | 14 | 1 | 81 | 45 | 25½ | 2 | 48 | 40 | 37 | 4 | 81 | 9 |
| 2⅔ | .... | 81 | 24 | 14⅓ | 1 | 81 | 48 | 25⅔ | 2 | 81 | 69 | 37⅓ | 4 | 81 | 12 |
| 3 | .... | 81 | 27 | 14½ | 1 | 36 | 22 | 26 | 2 | 81 | 72 | 37½ | 4 | 48 | 8 |
| 3⅓ | .... | 81 | 30 | 14⅔ | 1 | 81 | 51 | 26⅓ | 2 | 81 | 75 | 37⅔ | 4 | 81 | 15 |
| 3½ | .... | 36 | 14 | 15 | 1 | 81 | 54 | 26½ | 2 | 36 | 34 | 38 | 4 | 81 | 18 |
| 3⅔ | .... | 81 | 33 | 15⅓ | 1 | 81 | 57 | 26⅔ | 2 | 81 | 78 | 38⅓ | 4 | 81 | 21 |
| 4 | .... | 81 | 36 | 15½ | 1 | 36 | 26 | 27 | 3 | ..... | ..... | 38½ | 4 | 36 | 10 |
| 4⅓ | .... | 81 | 39 | 15⅔ | 1 | 81 | 60 | 27⅓ | 3 | 81 | 3 | 38⅔ | 4 | 81 | 24 |
| 4½ | .... | 48 | 24 | 16 | 1 | 81 | 63 | 27½ | 3 | 36 | 2 | 39 | 4 | 81 | 27 |
| 4⅔ | .... | 81 | 42 | 16⅓ | 1 | 81 | 66 | 27⅔ | 3 | 81 | 6 | 39⅓ | 4 | 81 | 30 |
| 5 | .... | 81 | 45 | 16½ | 1 | 48 | 40 | 28 | 3 | 81 | 9 | 39½ | 4 | 36 | 14 |
| 5⅓ | .... | 81 | 48 | 16⅔ | 1 | 81 | 69 | 28⅓ | 3 | 81 | 12 | 39⅔ | 4 | 81 | 33 |
| 5½ | .... | 36 | 22 | 17 | 1 | 81 | 72 | 28½ | 3 | 48 | 8 | 40 | 4 | 81 | 36 |
| 5⅔ | .... | 81 | 51 | 17⅓ | 1 | 81 | 75 | 28⅔ | 3 | 81 | 15 | 40⅓ | 4 | 81 | 39 |
| 6 | .... | 81 | 54 | 17½ | 1 | 36 | 34 | 29 | 3 | 81 | 18 | 40½ | 4 | 48 | 24 |
| 6⅓ | .... | 81 | 57 | 17⅔ | 1 | 81 | 78 | 29⅓ | 3 | 81 | 21 | 40⅔ | 4 | 81 | 42 |
| 6½ | .... | 36 | 26 | 18 | 2 | ..... | ..... | 29½ | 3 | 36 | 10 | 41 | 4 | 81 | 45 |
| 6⅔ | .... | 81 | 60 | 18⅓ | 2 | 81 | 3 | 29⅔ | 3 | 81 | 24 | 41⅓ | 4 | 81 | 48 |
| 7 | .... | 81 | 63 | 18½ | 2 | 36 | 2 | 30 | 3 | 81 | 27 | 41½ | 4 | 36 | 22 |
| 7⅓ | .... | 81 | 66 | 18⅔ | 2 | 81 | 6 | 30⅓ | 3 | 81 | 30 | 41⅔ | 4 | 81 | 51 |
| 7½ | .... | 48 | 40 | 19 | 2 | 81 | 9 | 30½ | 3 | 36 | 14 | 42 | 4 | 81 | 54 |
| 7⅔ | .... | 81 | 69 | 19⅓ | 2 | 81 | 12 | 30⅔ | 3 | 81 | 33 | 42⅓ | 4 | 81 | 57 |
| 8 | .... | 81 | 72 | 19½ | 2 | 48 | 8 | 31 | 3 | 81 | 36 | 42½ | 4 | 36 | 26 |
| 8⅓ | .... | 81 | 75 | 19⅔ | 2 | 81 | 15 | 31⅓ | 3 | 81 | 39 | 42⅔ | 4 | 81 | 60 |
| 8½ | .... | 36 | 34 | 20 | 2 | 81 | 18 | 31½ | 3 | 48 | 24 | 43 | 4 | 81 | 63 |
| 8⅔ | .... | 81 | 78 | 20⅓ | 2 | 81 | 21 | 31⅔ | 3 | 81 | 42 | 43⅓ | 4 | 81 | 66 |
| 9 | 1 | ..... | ..... | 20½ | 2 | 36 | 10 | 32 | 3 | 81 | 45 | 43½ | 4 | 48 | 40 |
| 9⅓ | 1 | 81 | 3 | 20⅔ | 2 | 81 | 24 | 32⅓ | 3 | 81 | 48 | 43⅔ | 4 | 81 | 69 |
| 9½ | 1 | 36 | 2 | 21 | 2 | 81 | 27 | 32½ | 3 | 36 | 22 | 44 | 4 | 81 | 72 |
| 9⅔ | 1 | 81 | 6 | 21⅓ | 2 | 81 | 30 | 32⅔ | 3 | 81 | 51 | 44⅓ | 4 | 81 | 75 |
| 10 | 1 | 81 | 9 | 21½ | 2 | 36 | 14 | 33 | 3 | 81 | 54 | 44½ | 4 | 36 | 34 |
| 10⅓ | 1 | 81 | 12 | 21⅔ | 2 | 81 | 33 | 33⅓ | 3 | 81 | 57 | 44⅔ | 4 | 81 | 78 |
| 10½ | 1 | 48 | 8 | 22 | 2 | 81 | 36 | 33½ | 3 | 36 | 26 | 45 | 5 | ..... | .... |
| 10⅔ | 1 | 81 | 15 | 22⅓ | 2 | 81 | 39 | 33⅔ | 3 | 81 | 60 | ..... | ..... | ..... | .... |
| 11 | 1 | 81 | 18 | 22½ | 2 | 48 | 24 | 34 | 3 | 81 | 63 | ..... | ..... | ..... | .... |
| 11⅓ | 1 | 81 | 21 | 22⅔ | 2 | 81 | 42 | 34⅓ | 3 | 81 | 66 | ..... | ..... | ..... | .... |
| 11½ | 1 | 36 | 10 | 23 | 2 | 81 | 45 | 34½ | 3 | 48 | 40 | ..... | ..... | ..... | .... |
| 11⅔ | 1 | 81 | 24 | 23⅓ | 2 | 81 | 48 | 34⅔ | 3 | 81 | 69 | ..... | ..... | ..... | .... |
| 12 | 1 | 81 | 27 | 23½ | 2 | 36 | 22 | 35 | 3 | 81 | 72 | ..... | ..... | ..... | .... |
| 12⅓ | 1 | 81 | 30 | 23⅔ | 2 | 81 | 51 | 35⅓ | 3 | 81 | 75 | ..... | ..... | ..... | .... |

For indexing the work through any desired angle, or any desired arc. This table is of course based on the Index Table for Divisions, Fig. 15, since one degree represents one of 360 divisions; 45 degrees is the equivalent of one of eight divisions, etc. It is of value in laying off holes in jig work, etc. (See Fig. 36).

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