Complete
HOBBING
Service

Operators Hand Book

BARBER-COLMAN

NO. 6-10

Precision Hobbing Machine

Standard Hobbing Machine

BARBER-COLMAN COMPANY, ROCKFORD, ILLINOIS

OPERATOR'S HAND BOOK

FOR

No. 6-10 GEAR HOBBING MACHINE

The No. 6-10 Machine was formerly designated as the No. 3 Hobbing Machine.

SECOND EDITION

BARBER-COLMAN COMPANY
General Offices and Plant, ROCKFORD, ILLINOIS
U. S. A.

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The Barcol OVERdoor Electric Door Operators
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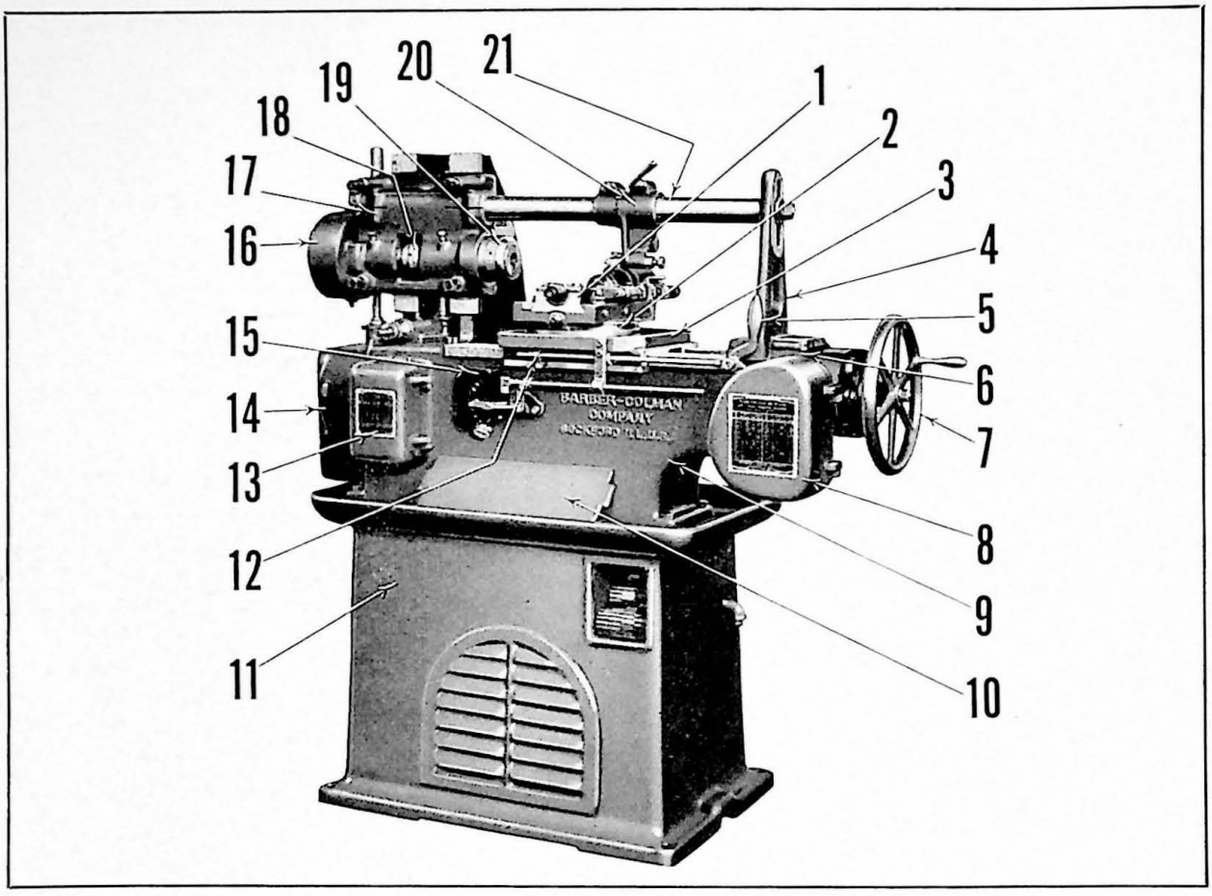
Established 1930

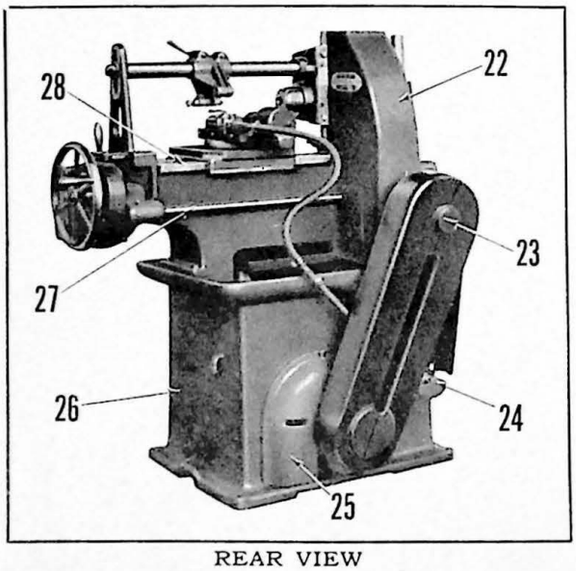
INDEX

No. 6-10 Standard Hobbing Machine

For Generating Spur and Spiral Gears, Spline Shafts, and other Hobbed Forms.
A General-Purpose Machine.



FRONT VIEW



REAR VIEW

This machine is suitable for the smaller hobbing jobs, up to 5″ diameter by 7″ face and 12 pitch or the equivalent. It can be set up quickly and easily for either short-run or production work. The feed and index gear trains have a common power source so that accurate spiral gears and other helical forms can be generated. Short spline shafts can be handled readily. Improvements in materials and design, incorporated into the machine from time to time as their advantages have been proved, insure lasting accuracy and dependability.

For advise concerning application of the machine to a specific job or particular type of work, please write us or call our nearest representative. Our engineering department is always available for thorough consideration of any hobbing problem.

General Description and Features

1 Hob spindle slide.

2 Hob slide swivel.

3 Hob swivel slide.

4 Overarm brace. Rigid upright casting mounted on feed screw drive box. End of overarm clamped in slot.

5 Feed control lever. Engages worm and worm gear drive on feed screw.

6 Feed drive is through spur gear transmission to worm and worm gear on feed screw. Removable cover on feed screw drive box forms convenient tool tray.

7 Large hand wheel. Geared direct to feed screw for positioning hob slide manually.

8 Feed change gear box with etched metal Feeds Chart.

9 Heavy, ribbed, extremely rigid, box-section bed casting.

10 Cover gives access to removable perforated chip pan.

11 Heavy, ribbed, box-section sub-base casting. Open apron around bed to catch oil and coolant drippings. Sub-base has large bosses with holes for floor bolts. Pinch bar slots at both ends.

12 Adjustable stop. Disengages feed automatically at end of cut.

13 Speed change gear box with etched metal Speeds Chart.

14 Index change gear box with etched metal Index Change Gear Chart. Changes in feed, speed, and index effected by setting up suitable spur gear combinations in cast iron hinge-cover boxes. Change gears locked on shafts by nut and quick-removable slotted washer. All necessary sizes of change gears stored in convenient racks in sub-base of machine.

15 Motor controls. On-and-off button switch conveniently located on front of machine controls motor starting box.

16 Index drive for work spindle. Accurately made, hardened and ground steel worm engages bronze worm gear. Reservoir in cast iron case insures constant lubrication. Worm driven by vertical shaft from index change gear box.

17 Work slide. Strong, reinforced casting taper-gibbed to ways for wear adjustment. Positioned vertically by elevating screw with micrometer dial reading to .001". Locked in position by four clamping screws.

18 Work spindle. Forged high-carbon steel, heat treated and accurately ground. Supported in bronze bushings. Front bearing conical, rear bearing straight. Thrust washers and lock nuts provide wear adjustment. Hole through spindle $^{29}/_{32}$" diameter (standard), enlarged to No. 9 B&S taper at nose.

19 Work arbors and collet chucks held in tapered work spindle nose by drawn-in bolt. Collet equipment of various sizes can be furnished to order for clamping work in spindle.

20 Overarm bracket. Supports end of work or work arbor. Quick-clamping handle allows bracket to be moved back and swung out of way easily for reloading. Dowel on bracket engages locater clamped to overarm, to insure accurate return to proper alignment. Bracket furnished with sleeve and adjustable center.

21 Single, steel, cylindrical overarm, accurately aligned with work spindle and bedways and clamped in work slide casting.

22 Upright. Heavy, ribbed, box-section casting integral with bed casting. Has accurately scraped ways for work slide.

23 Main drive shaft with pulley, and belt guard.

24 Belt-driven centrifugal pump. Delivers coolant from reservoir to cutting area through adjustable, valve-controlled flat nozzle.

25 Motor. Mounted on a motor-base and concealed by ventilated cover plates front and rear allowing easy access for lubrication and adjustment.

26 Coolant reservoir. Cast integral with sub-base. Coolant flows slowly over dams and through compartments in reservoir to remove heat and settle out small chips and other sediment.

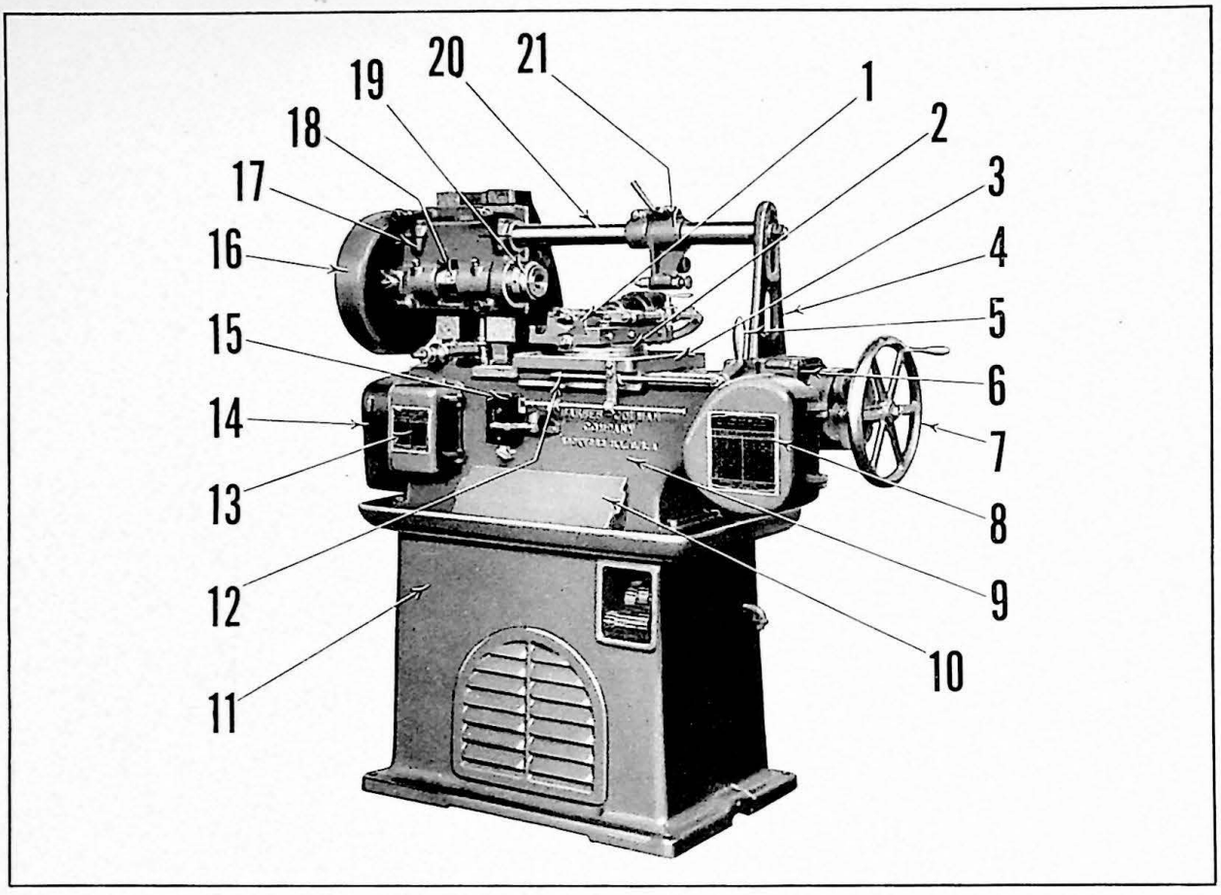
27 Feed drive shaft.

28 Accurately scraped bedways for hob slide.

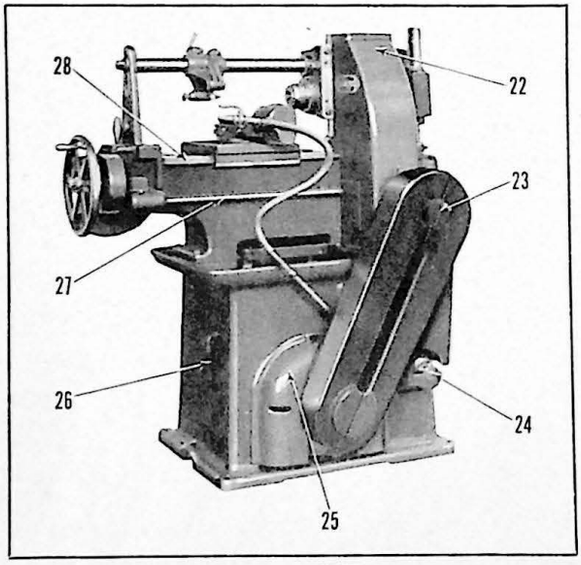
NOTE: — See separate circular "No. 6-10 Hobbing Machine Accessories" for description of units useful for adapting the machines to certain types of special work. Circular sent on request.

No. 6-10 Precision Hobbing Machine

A Machine with Extra Accuracy Throughout for Fine Tool-Room and General Hobbing Work



FRONT VIEW



REAR VIEW

This machine fills the demand for extra accuracy required on many small parts, 12 diametral pitch and finer. *It has a guaranteed accuracy of not more than .00075" accumulative error between non-adjacent teeth on a 4" pitch circle.* It is essentially the same as the standard No. 6-10 Hobbing Machine but selected parts are used throughout and extra accuracy is used in making all fits. An extra large index worm is used to provide additional indexing accuracy.

It can be set up quickly and easily for either short-run or production work. Spiral gears and other helical forms can be generated. For advice concerning application of the machine to a specific job or particular type of work, please write us or call our nearest representative. Our engineering department is always available for thorough consideration of any hobbing problem.

General Description and Features

1 Hob spindle slide.

2 Hob slide swivel.

3 Hob swivel slide.

4 Overarm brace. Rigid upright casting mounted on feed screw drive box. End of overarm clamped in slot. *Extra accuracy in fitting to feed box.*

5 Feed control lever. Engages worm and worm gear drive on feed screw.

6 Feed drive is through spur gear transmission to worm and worm gear on feed screw. Removable cover on feed screw drive box forms convenient tool tray. *Feed screw held to close limits of accuracy.*

7 Large hand wheel. Geared direct to feed screw for positioning hob slide manually.

8 Feed change gear box. *Extra large to accomodate special gears.*

9 Heavy, ribbed, extremely rigid, box-section bed casting.

10 Cover gives access to removable perforated chip pan.

11 Heavy, ribbed, box-section sub-base casting. Open apron around bed to catch oil and coolant drippings. Sub-base has large bosses with holes for floor bolts. Pinch bar slots at both ends.

12 Adjustable stop. Disengages feed automatically at end of cut.

13 Speed change gear box.

14 Index change gear box with etched metal Index Change Gear Charts. Changes in feed, speed, and index effected by setting up suitable spur gear combinations in cast iron hinge-cover boxes. Change gears locked on shafts by nut and quick-removable slotted washer. All necessary sizes of change gears stored in convenient racks in sub-base of machine. *Selected gears.*

15 Motor controls. On-and-off button switch conveniently located on front of machine controls motor starting box.

16 Index drive for work spindle. Accurately made, hardened and ground steel worm engages cast iron worm gear. Reservoir in cast iron case insures constant lubrication. Worm driven by vertical shaft from index change gear box. *Extra large single thread worm gear increases machine ratio. Precision worm. Special accuracy in fitting.*

17 Work slide. Strong, reinforced casting taper-gibbed to ways for wear adjustment. Positioned vertically by elevating screw with micrometer dial reading to .001". Locked in position by four clamping screws. *Extra accuracy in fitting.*

18 Work spindle. Forged high-carbon steel heat treated and accurately ground. Supported in bronze bushings. Front bearing conical, rear bearing straight. Thrust washers and lock nuts provide wear adjustment. Hole through spindle $^{29}/_{32}$" diameter (standard), enlarged to No. 9 B&S taper at nose. *Extra accuracy in fitting bearings.*

19 Work arbors and collet chucks held in tapered work spindle nose by draw-in bolt. Collet equipment of various sizes can be furnished to order for clamping work in spindle.

20 Single, cylindrical overarm, accurately aligned with work spindle and bedways and clamped in work slide casting. *Fitted with extra accuracy.*

21 Overarm bracket. Supports end of work or work arbor. Quick-clamping handle allows bracket to be moved back and swung out of way easily for reloading. Dowel on bracket engages locater clamped to overarm, to insure accurate return to proper alignment. Bracket furnished with sleeve and adjustable center.

22 Upright. Heavy, ribbed, box-section casting integral with bed casting. Has accurately scraped ways for work slide.

23 Main drive shaft with pulley, and belt guard.

24 Belt-driven centrifugal pump. Delivers coolant from reservoir to cutting area through adjustable, valve-controlled flat nozzle.

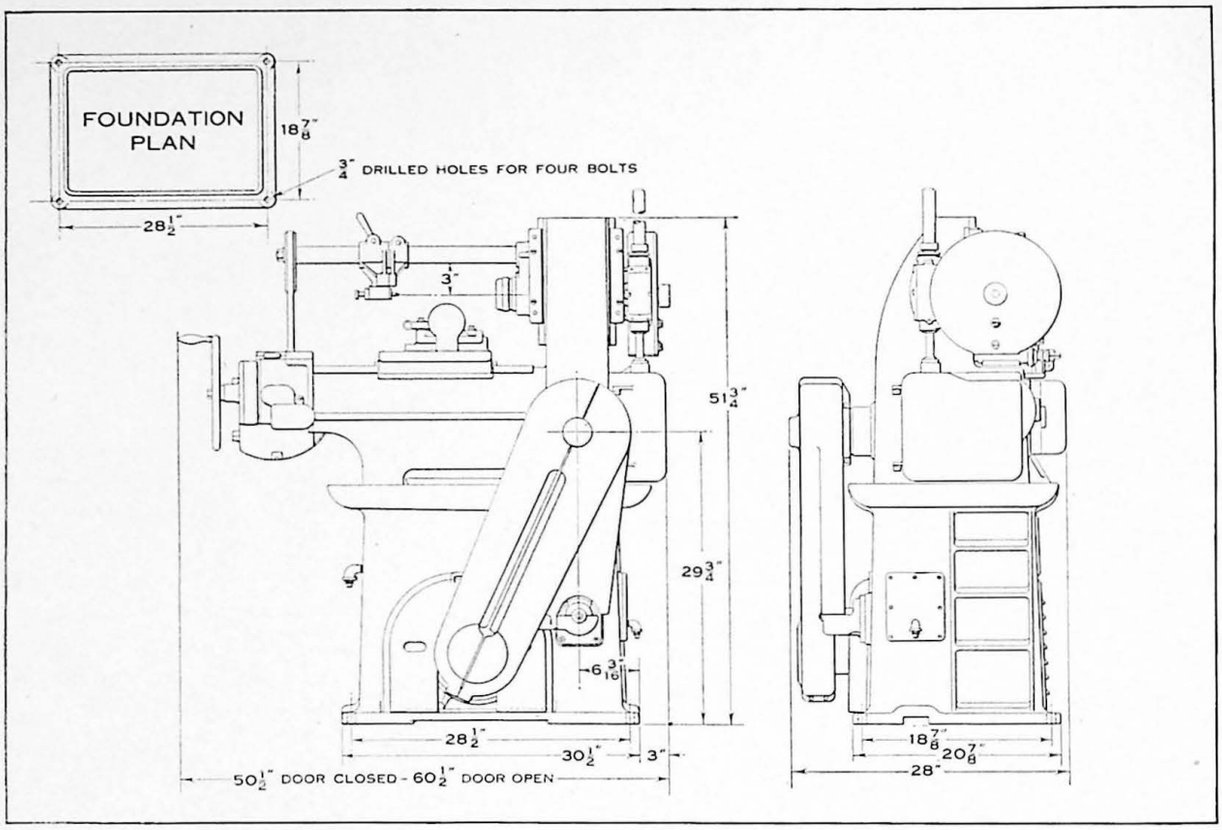
25 Motor. Mounted on a motor-base and concealed by ventilated cover plates front and rear allowing easy access for lubrication and adjustment.

26 Coolant reservoir. Cast integral with sub-base. Coolant flows slowly over dams and through compartments in reservoir to remove heat and settle out small chips and other sediment.

27 Feed drive shaft.

28 Accurately scraped bedways for hob slide.

No. 6-10 Standard and No. 6-10 Precision Hobbing Machines



FLOOR PLAN

DIMENSIONS and SPECIFICATIONS

Capacity, diameter.....5"
face.....7"
diametral pitch, cast iron or steel.....12

(These are average figures. The maximum size work which the machine can accommodate will depend, of course, upon the size of the hob which, in turn, is governed by the diametral pitch of the teeth or the number of splines and by the diameter of the hob spindle. On helical forms, the face capacity is also affected by the angle of the helix, and the helix of the hob. Thus, accurate capacities cannot be given except by an elaborate table involving all these factors. However, the following figures may be helpful for doubtful cases.)

Centerline of work spindle to under side of overarm..3"

Maximum travel of hob slide.....11 9/16"

Maximum distance from centerline of work spindle to centerline of hob spindle.....3 7/8"

Hob diameter, maximum.....2 1/16"

Hob spindle, diameter.....3/4"

Hob spindle speeds (8)
533, 453, 388, 309, 230, 183, 157, 133 r.p.m.

Work spindle, taper in nose.....No. 9 B&S
hole diameter.....29/32"

Feed, maximum, per revolution of work.....150"
minimum, per revolution of work.....015"

Motor, power.....2 h.p.
speed.....1200 r.p.m.

Drive.....V Belt

Floor space, occupied by base.....31" x 21"
required with covers open.....61" x 30"

Weight of machine, net, approximate.....1700 lbs.
shipping, domestic, approximate.....2000 lbs.
shipping, export, approximate.....2250 lbs.

Export shipping case, dimensions.....47" x 38" x 56"
cubic contents.....58 cu. ft.

CHAPTER I

CARE AND ADJUSTMENT OF HOBBING MACHINES

Installation

In the installation of the hobbing machine, first attention should be given to its foundation. which should be solid and free from vibration. The machine should be carefully leveled and fastened by bolts or lag screws as shown on the foundation plan furnished with the machine, Clean off slushing compound and any dirt which may have collected in transit, with kerosene, taking especial care to see that all oil holes are clean and covered.

During final inspection, every Barber-Colman hobbing machine is run for twenty hours, ten hours at slow speed, and ten hours at high speed, insuring the proper running in of all bearings and correct adjustments for working conditions. Since a considerable time may elapse during storage or shipment, however, the machine should not be put into service without making sure that any bearings which may have become dry are well lubricated. After oiling a new machine thoroughly, therefore, and before putting it in regular operation, it is advisable to start it up with the slowest set of speed change gears in position, as shown by the table on the door of the speed gear box, and to allow it to run for several hours, gradually increasing the speed by changing the speed gears. Oil frequently during this process, and watch the bearings to see that they do not become overheated. This will allow the oil to work thoroughlv into the bearings before the machine is placed in operation on production work.

Lubrication

The life of the machine will be considerably lengthened if it is oiled regularly and frequently. (See Lubrication Chart page 12). The oil cups provided for the work spindle bearings should be kept well filled, and other oil holes should be filled at least once a day. Do not neglect the oiling points which are reached by removing the feed screw bracket cover, nor those inside the index and feed change gear boxes. The index worm gear case should be filled with a good quality of heavy oil or a mixture of equal parts of Gredag and machine oil, up to the level of the oil hole in the back of the case. Wear on the change gears and other gears which are not enclosed will also be greatly reduced if a few drops of oil are put on the teeth when oiling other parts of the machine. Covers are provided for all exposed oil holes, and it is important that these be kept in place. Dust and fine chips allowed to work through oil holes whose covers are lost or broken off, will quickly ruin bearings.

Adjustments

In order to keep the machine in condition for the high class of work of which it is capable, it is necessary from time to time to take up excessive play caused by wear between moving parts, by means of the adjustments provided for the principal elements. This is particularly necessary in the case of machines which are used for accurate finishing work.

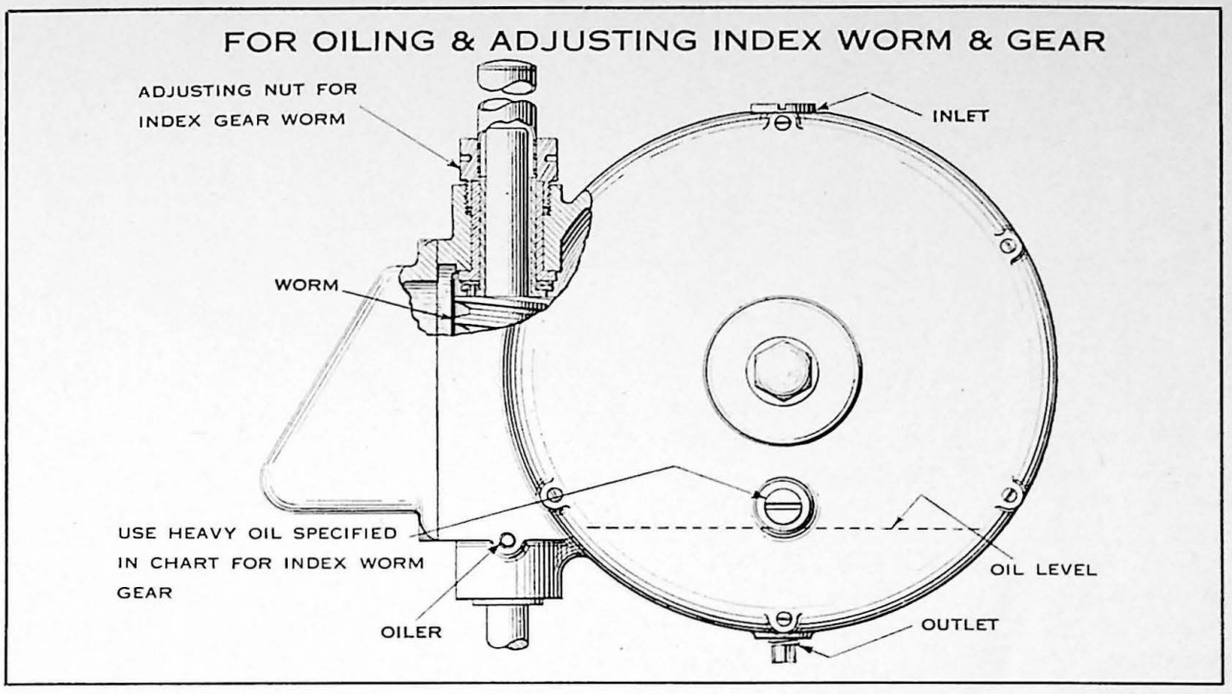
The adjustments of the work spindle and hob spindle bearings are of the greatest importance to the proper operation of the machine, and should be performed only by a competent mechanic. The tightening of the spindle adjusting nuts will also move the index worm gear out of proper relation with the worm. For this reason, before any adjustment is made, the cover of the worm gear case should be removed, an indicator placed on the finished back face of the worm gear, and the relative position of the worm gear and worm shaft carefully noted. Then adjust the work spindle until no end play is evident, lock it in position, and draw up the worm gear on its taper seat on the spindle by means of the worm gear lock nut, until the indicator shows its position relative to the worm shaft to be the same as before.

In cases where considerable wear has developed through long service it is advisable to remove the work spindle and rescrape the bronze bearing and thrust washer until they have a uniform bearing on the spindle. The faces of the steel thrust washer should be reground if necessary to obtain a smooth bearing surface.

In making the adjustment, it is important that the nuts be pulled up just tightly enough to eliminate play, but without causing binding which would force the film of oil out of the bearing and result in "freezing". Frequent adjustment of the work spindle should not be necessary. The bearings are properly adjusted when the machine leaves the factory, and should not be disturbed except when excessive play develops.

The hob spindle runs on bronze bearings, which require proper lubrication and occasional inspection to see that no undue looseness has developed. Wear in the bearing of the No. 6-10 hobbing machine hob spindle may be taken up by means of the adjusting nut and the lock nut at end of the bearing, which are enclosed in the hob drive gear guard.

End thrust of the index worm on its shaft is taken up by tightening the nut at the top of the worm shaft bearing, as shown in the diagram on page 11. Adjustment between the index worm and worm gear is seldom needed, but in case these parts become worn the worm may be moved into closer mesh with the gear. The worm gear case is fastened to the work slide by means of four cap screws, and held in alignment by two keys. Removing the worm gear case cover, the four cap screws may be loosened, and the entire gear case, carrying the worm drawn slightly toward the front of the machine by means of two set screws which are seen at the sides of the case. A movement of .004″ is obtainable in this way, which is ample to compensate for a considerable amount of wear. In the rare cases where it is found necessary to make an adjustment of more than .004″, it will also be necessary to relocate the worm shaft bevel gear bracket which carries the lower end of the index worm shaft. To perform this operation, remove the nut at the lower end of the worm shaft and pull the shaft up out of its bearing in the bracket. Then remove the bevel gear from the front end of the feed drive shaft at the side of the feed screw bracket. Loosening the cap screws which fasten the bevel gear bracket to the bed will now permit the bracket to be removed, carrying the feed drive shaft with it. Drive out the old dowel pins and replace the bracket, worm shaft and bevel gears in their original positions, putting the cap screws loosely in place. Then after moving the worm gear case as directed until the worm and worm gear mesh properly, force the lower bracket in the same direction until the worm shaft is in a vertical position. The correct position of the shaft may be determined by checking it with an indicator until it is exactly parallel with the ways of the upright. Then clamp the bracket firmly with its cap screws, and drill new dowel pin holes to fasten it permanently in place.



Should the work slide become loose on the ways of the upright, it may be tightened by a taper gib, the end of which may be seen at the top of the slide next to the elevating screw. First loosening the beveled clamp gib at the back of the work slide, loosen the lower adjusting screw and tighten the upper one until the slide can just be moved easily by the hand crank.

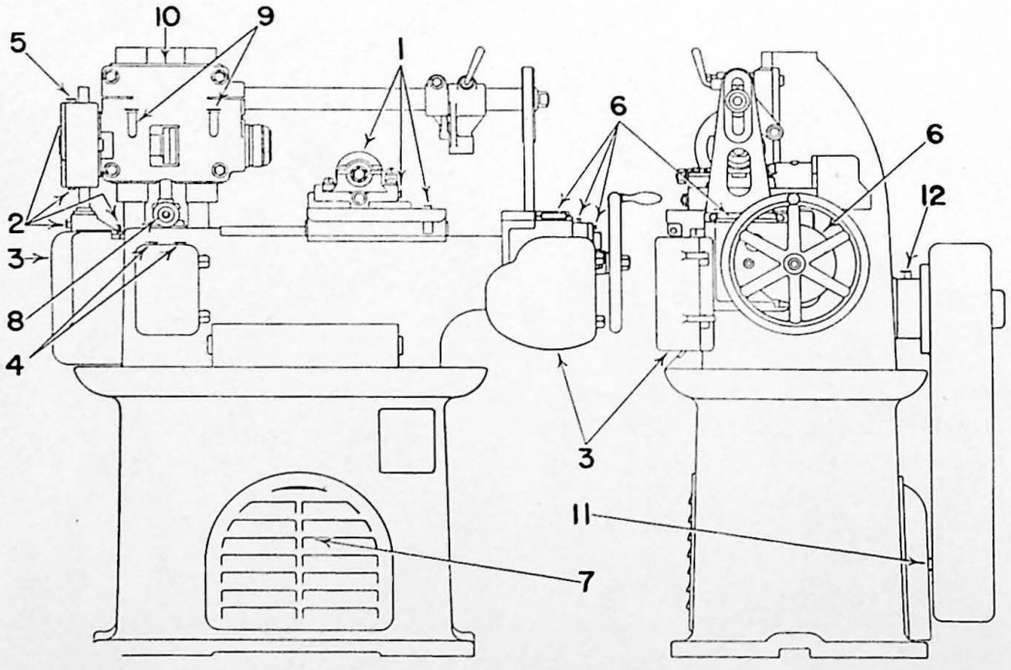
A similar taper gib will be found in the hob swivel slide for taking up wear on the ways of the bed. This will be seen at the front edge of the bed, and two flat clamps are placed underneath the ways to hold the swivel slide to the bed. After adjusting these gibs it should be possible to move the slide freely with the large handwheel, as little sideplay being allowed as consistent with freedom of motion.

LUBRICATION CHART

BARBER-COLMAN
NO. 6-10 HOBBING MACHINE

For lasting accuracy and proper operation, it is IMPORTANT that the No. 6-10 Hobbing Machine be regularly lubricated as this chart shows.

Number	PART	Type of Bearing	Type of Lubricant	Saybolt Universal Viscosity at 210°F. (Approx.)	Type of Oiler	Frequency
1	Hob Swivel Slide Assembly	Plain	High Grade Machine Oil	50	Cap Oiler	Daily
2	Index Worm Gear Drive	Plain (4)	High Grade Machine Oil	50	Cap Oiler	Daily
3	Change Gear Idler Studs	Plain	High Grade Machine Oil	50	Oil Can	Daily
4	Speed Change Gear Case	Plain	High Grade Machine Oil	50	Cap Oiler	Daily
5	Index Worm Gear	Plain	Gear Oil	150	Gear Case	Monthly
6	Feed Box	Plain	High Grade Machine Oil	50	Oil Can	Monthly
7	Motor		As recommended by Motor Manufacturer			Monthly
8	Elevating Shaft	Plain	High Grade Machine Oil	50	Cap Oiler	Weekly
9	Work Spindle	Plain	High Grade Machine Oil	50	Cap Oiler	Daily
10	Elevating Screws	Plain	High Grade Machine Oil	50	Oil Can	Weekly
11	Pump	Plain	High Grade Machine Oil	50	Oil Can	Daily
12	Main Drive	Plain	High Grade Machine Oil	50	Cap Oiler	Daily
	Exposed Joints and Bearings	Plain	High Grade Machine Oil	50	Oil Can	Weekly



CHAPTER II

OPERATION OF THE MACHINE

Change Gears

On the cover of each change gear box is placed, for convenient reference, a table showing a large range of change gear combinations, from which setups for all ordinary commercial spur gear work may be taken without any calculation. The standard No. 6-10 hobbing machine is equipped with a triple thread index worm and worm gear. For special requirements, however, these are sometimes replaced by some other multiple thread which changes the ratio between the work spindle and the hob spindle. When setting up a No. 6-10 machine it is essential to know the correct machine ratio. The tables given cover a machine with Standard index and with either Standard or High Speed Swivel. However, sometimes machines are supplied with different index ratios and also with different hob swivel ratios so that care must be exercised in setting up machine.

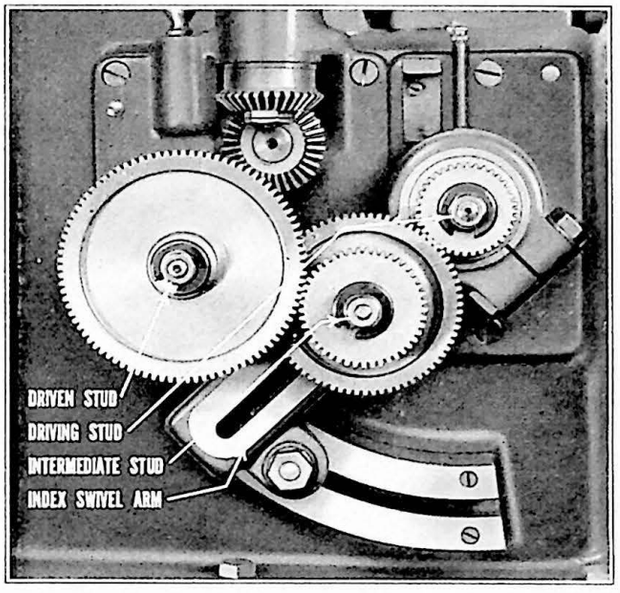


Fig. 1
Index Change Gears

From the index table select the proper change gears corresponding to the number of teeth in the gear to be cut. Before putting them in place make sure that they are clean and free from dirt and chips in the teeth, then place the first driving gear on the driving stud, which is always the stud carrying the change gear swivel arm.

Place the other gears on the intermediate and driven studs as shown by Fig. 1. This illustration shows the proper arrangement

of the combination $\frac{\text{Drivers}}{\text{Driven}} = \frac{40 \times 48}{75 \times 96}$

Before clamping the gears, see that they are adjusted so that they are free to rotate without binding. If meshed too tightly a jerky action is likely to result when the machine is started, which consumes a great deal of unnecessary power and is detrimental to the machine, the work, and to the change gears themselves. Tighten the gears with the nuts and C washers, and lock the change gear swivel arm in position.

It will be noticed when referring to the index change gear table that some

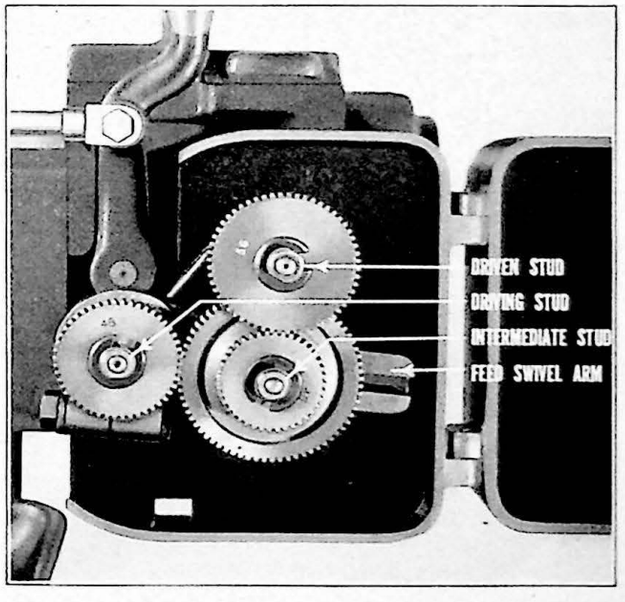


Fig. 2
Feed Change Gears

combinations show only one driver, one driven gear, and an idler, while others require two gears on the intermediate stud, as in Fig. 1. Where an idler is called for, any single gear of convenient size may be used on the intermediate stud. An extra intermediate stud is provided on the change gear swivel arm, which is used for an extra idler in cases where it is necessary to reverse the direction of rotation of the work spindle. When using right hand hobs the work spindle, viewed from the front end, rotates in a counter clockwise direction. When left hand hobs are used, (which as a general rule is only on helical gear work), the rotation must be clockwise, and an extra idler must be placed in the index change gear train. Since this change alone would cause the hob to feed away from the work spindle, it is necessary to insert an idler in the feed gear train also, in order to correct the direction of the feed.

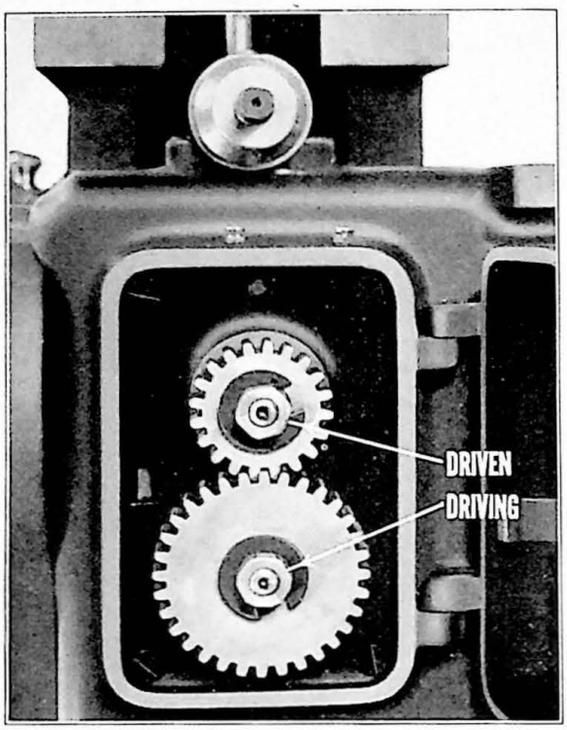


Fig. 3
Speed Change Gears

Next put in position the speed change gears, which control the speed of the hob, and the feed gears, which determine the rate of feed of the hob per revolution of the work, as shown by Figs. 2 and 3, following the same method in adjusting the feed gears as described above. Suggestions for choosing feeds and speeds appropriate for different materials and classes of work are given on page 24. Except when hobbing spiral gears, the index, feed and speed gears may be changed independently of each other; that is, the feed may be altered without any effect on the indexing or the speed of the hob, the speed gears may be changed without changing either the indexing or the feed, and the index gears in turn may be changed for any desired number of teeth with no effect upon either speed or feed.

The Hob and Hob Swivel Assembly

The hob swivel assembly is made up of three units; the Hob Swivel Slide, the Hob Slide Swivel, and the Hob Spindle Slide. Hob swivel slide gibbed to bedways for wear adjustment. Improved felt wipers protect bedways. Right-hand hob slide swivel (standard) adjustable from 60° right to 90° left, to accommodate hobs and spiral settings of various helix angles. Vernier on swivel setting reads to 10″. Left-hand hob slide swivel (optional) adjustable from 60° left to 90° right. Hob spindle slide clamped in swivel with vee-shaped clamp gibs and may be moved lengthwise to obtain several settings of hob. Hardened and ground hob spindle with conical front bearing runs in plain bronze bushings. Feed screw engages adjustable two-piece bronze nut beneath hob swivel slide.

On one end of each gear hob are marked the pitch, the lead angle, the direction or hand of the thread (R.H. or L.H.) and the tooth depth (D + f). These should be carefully noted before putting the hob on the hob spindle. The hob swivel must be swung to an angle to compensate for the lead angle of the hob, that is, to bring the thread of the hob parallel to the direction of the cut. Loosen the hob swivel clamp bolts, swing the drive gear end of the swivel (when using right hand hobs) away from the upright of the machine to the angle marked on the hob and tighten the bolts to clamp the swivel in position. This setting should be checked with the marking on the hob whenever hobs are changed. For accuracy of setting, a vernier reading to 10′ is placed on the side of the swivel, directly under the hob spindle nut.

Then see that the hob spindle, the faces of the hob, and all the filler collars are perfectly clean, and place the hob on the spindle, arranging the collars so that it is approximately in the center of the swivel. Wipe off the bottom of the hob spindle end support and the surface on which it rests, so that they are free from dirt and chips, and slide the steel clamp sleeve and the support over the end of the spindle. Clamp the end support to the hob slide with its two bolts, then tighten the hob spindle nut. The hob is driven by a key, and it is therefore unnecessary to use a hammer in tightening this nut since it can be drawn up tightly enough by hand with the large wrench provided.

In all work where accuracy is an important factor and where ground form hobs are used, the next operation consists of testing the hob for runout with an indicator, as described in detail on page 18. This point is very important in securing accurate gears, and should not be neglected.

The Work and Work Arbor

Wipe the taper hole of the work spindle and the shank of the work arbor clean, put the arbor in place and test it with a dial indicator to see that it runs true. (A convenient place for clamping the indicator stand is afforded by one of the swivel clamp bolts.) If the result of this test is satisfactory, the arbor may be locked securely in position with the draw in bolt. Measure the gear blanks to see that they are of the correct diameter, and place them on the arbor, making sure while doing so that blanks, clamping collars, and the nose of the work spindle are clean. Before tightening the work arbor nut, bring the indicator against the periphery of the blanks and turn them on the arbor by hand to determine whether they are true with the hole within proper limits. Proper preparation of the blanks is very essential in the cutting of accurate gears, and they should be carefully checked to see that faces are parallel with each other and square with the hole, and that the hole is a snug fit on the work arbor. Burrs and dirt on the faces of the blanks cause springing of the arbor when clamped. For this reason the indicator should again be brought into use after the work arbor nut has been tightened, to make sure that the arbor has not been thrown out of true due to improperly machined blanks or to the presence of dirt. Except when testing the first load of gears with the indicator, the overhanging arm bracket should be brought into position to support the end of the arbor, either by the sleeve or a center, as the case may be, and locked with the clamp handle before tightening the work arbor nut.

After the work has been properly mounted, the automatic stop may be set to stop the machine when the cut has been completed. Loosen the work slide clamp bolts and the large nut which clamps the end of the overhanging arm to the brace, and with the power feed thrown out, move the hob swivel slide by the handwheel until the center of the hob is a little past the face of the last blank on the work arbor. Adjust the automatic stop collar to trip switch or belt shift lever as the case may be. In addition to this automatic stop, an auxiliary trip rod is also provided, which may be set to throw out the power feed at any desired position without stopping the machine. When this feed trip rod is not otherwise in use, it is wise to leave it set to act as a safety stop in case the setting of the automatic stop is neglected. This will guard against the possibility of the hob running past the work, into holding equipment or the nose of the work spindle, or of the hob slide running into the upright, which would result in serious damage to the machine.

The hob slide is then brought back until the hob is directly under the first gear, the machine is started, and the work slide carefully lowered by the hand crank until the hob just grazes the blank. A thin strip of paper may be held between the hob and the work, as a convenient method of telling when the periphery of the blank is reached. As a check against

a possible error in setting the index change gears, it is well to count the marks made by the hob on the circumference of the gear blank. The importance of having the blanks properly trued up is now easily seen if it happens that the hob does not begin to mark uniformly around the entire circumference. The elevating screw micrometer dial should then be set at zero and clamped with its lock nut. This dial is graduated in thousandths of an inch, as an accurate means of setting the hob to depth. After moving the hob slide back from beneath the work, lower the work slide to the proper depth which was found marked on the hob, and clamp it securely. In clamping the work slide, the two clamp bolts nearest to the worm gear case should always be tightened first, followed by those at the right hand side of the slide and the nut at the outer end of the overhanging arm. To start the cut it is only necessary to run the hob up to the edge of the first blank, and throw in the power feed by the lever at the end of the bed.

Hobbing Helical Gears

Helical gears, often improperly termed spiral gears, may be hobbed on Barber-Colman hobbing machines with the same ease and accuracy with which spur gears are produced, and within the range of the machine, no extra mechanisms or attachments are necessary in addition to those employed in spur gear work. There are, however, certain essential differences in the methods of setting up and operation in hobbing helical gears, from those which have been described on preceding pages.

The most fundamental of these differences is in the method of gearing up the machine. Unlike the gearing used in hobbing spur forms, the index and feed change gear combinations must have a definite and fixed relation to each other. The speed gears alone may be changed independently of the others. The helical angle of a hobbed gear is not dependent upon the setting of the hob swivel or the angle of the cutter, but is determined solely by the relation between the index and feed gears. Since these change gear combinations may be calculated to almost any desired degree of accuracy, the exact duplication of any desired angle is assured. Full instructions for figuring proper change gears for hobbing helical gears are given in another part of this handbook beginning with page 27. Tables have also been compiled from which index gearing may be taken directly, without the necessity of performing any calculation. In the case of the occasional gear which does not fall within the range of these tables, a little study of the formula will enable the operator to arrive at the correct result. The feed change gears are determined by a simple calculation, after which the operation of placing the change gears on the machine is the same in every respect as when setting up for hobbing spur gears.

The angle for setting the hob swivel is obtained by subtracting the lead angle of the hob from the helical angle of the gear to be cut. (There is, however, an exception to this rule if the hand of the hob and the gear are not the same; for instance, if a right hand hob is used for cutting a gear of left hand helix angle. In this case the angles of the hob and gear are added instead of subtracted.) The direction in which the hob swivel is swung depends upon the hand of the gear; for right hand gears the end of the swivel towards the operator is swung away from the work spindle; for the left hand gears, toward the work spindle. The diagram which accompanies the instructions for figuring change gears on page 26 illustrates clearly the proper settings.

The power feed should never be thrown out during a cut while hobbing helical gears, without stopping the entire machine, and therefore only the automatic stop should be used. If the feed trip rod is set to stop the feed while the work and the hob continue to rotate, the work will be ruined.

In other respects the procedure of setting up and operation is the same for both spur and helical gear work. The machines are capable of accommodating almost any helical angle

ordinarily encountered in commercial work. The No. 6-10 hobbing machine may be provided with either right hand or left hand hob swivels. Special swivels which have a range of 60° right to 90° left, or 60° left to 90° right, may be provided as optional equipment.

The best results are obtained if right hand hobs are used for hobbing right hand gears, and left hand hobs for left hand gears. While it is quite possible to hob a gear with a hob of the opposite hand of helix, this practice should be avoided wherever possible, since it brings the cutting action of the hob in the wrong direction relative to the rotation of the work, and the results obtained are less satisfactory than where the proper hob is used. This is particularly true where the helix angle of the gear is large.

In cutting gears with large helix angles, it is also advisable to use hobs tapered on the entering end, so that the hob may start the cut gradually, avoiding the shock incident to entering the work at the full depth of cut.

Hobbing Worm Gears

The No. 6-10 hobbing machines may be equipped with power vertical feed attachment for hobbing worm gears, which is carried on top of the upright. The vertical feed attachment is provided with a change gear box by which suitable feeds may be obtained, and with an automatic stop for regulating the depth of cut, which are set in the same manner as the similar equipment used with the horizontal feed.

Worm gear hobs are usually made with a number of threads equal to that in the mating worm, and since provision for the angle of the gear is made in the hob itself, the hob swivel is set at 0° angle.

Hobbing Spline Shafts

The construction of the Barber-Colman hobbing machine renders it particularly adaptable to the great field of work which lies in the hobbing of spline shafts. Special instructions for this class of work, however, come largely under the head of supporting and clamping means for the work, rather than under that of operation. Different types of special holding equipment for spline shafts are illustrated and fully described elsewhere in this book. The methods of operation in other respects are essentially the same as in spur gear work.

Owing to the wide variations in design and shape of spline shaft forms, and in the working limits allowed, the setting depth is not marked on the hob as is the case with gear hobs. Proper setting must therefore be checked by measurement of the shaft with micrometers or special gauges. It is usually possible by measuring the root diameter to determine whether the proper depth has been reached, adjusting the height of the work slide if correction is found necessary.

If the shape of the spline is such that the root diameter cannot be measured, however, or if this dimension is not held to accurate limits, the width of the key must be the determining factor. If the key is found to be tapered, measuring wider at the root than at the outside diameter, it indicates that the cut is too shallow. On the other hand, if the key is undercut, or too wide at the top, corrections may be made by slightly raising the work slide.

Roughing and Finishing

In many classes of work, especially in the heavier pitches, accurate gears are best produced by taking a roughing and finishing cut, which enables the machine to perform the finishing operation while work and equipment are not under the strain of removing large amounts of metal. If gears are being hobbed only in small quantities the usual practice is to take both cuts at the same setting of the work, the hob being set to slightly less than full depth for the roughing cut. Where this method is employed on spur gears, it is unnecessary to relocate the work for finishing, since the hob and the work spindle remain continuously in the proper

relation. Therefore the hob need only be withdrawn to allow the work slide to be lowered to the finishing position, when the power feed may be thrown in after reclamping the work slide. When taking a second cut on helical gears, it is always necessary to reset the gears so that the teeth of the hob will engage centrally with the tooth spaces of the gear. After the setting for depth of tooth is made, the gears are loosened on the arbor and turned so that the hob can be brought partly into mesh with the gear teeth. The same result may sometimes be accomplished more easily by moving the hob or the hob slide endwise instead of changing the position of the work. The power feed should then be engaged before starting the machine. After the hob starts to cut, the setting should be checked by observing whether metal is being removed equally on both sides of the teeth. The amount of stock left to be removed in finishing varies according to the pitch of the gear and other factors, but is usually from .020″ to .030″.

In large quantity production of spur gears it is much more advantageous to perform the roughing and finishing operations separately. Great economies in the time of the roughing operation may be effected in this way by making use of the full power of the machine to remove metal at high speeds and coarse feeds. In finishing the gears the operator is then left free to use speeds and feeds best adapted to producing the accuracy and quality of finish desired. It is usually advisable where possible to reserve certain machines exclusively for finishing work, so that particular attention may be given to keeping them in accurate adjustment. It should not be inferred from this, however, that the care of roughing machines should be neglected, because the accuracy of the finished product is dependent to a large extent upon the character of the preliminary operations. The best results and greatest efficiency in roughing are obtained by using hobs specially designed for this service, which have teeth slightly thinner than the finishing hob, and which whenever practical are made to cut the full depth of the tooth, leaving only a small amount of stock on the sides of the tooth to be removed in the final cut. It is usually possible on gear work to use double or triple thread roughing hobs, which makes possible a further reduction in cutting time.

Important Points in the Use and Care of Hobs

By far the most vital requirement in the equipment of the hobbing machine for the production of accurate work is a hob made to and kept at the highest degree of accuracy. Barber-Colman hobs, both ground and unground, are made on machines specially designed and built for the purpose in our own plant, by methods which have been developed during our long experience in hob manufacture. Unground hobs give results which are satisfactory for the requirements of ordinary practice, but where greater accuracy and uniformity of results are demanded, we recommend ground hobs. In a ground hob the errors and distortions which inevitably result from hardening are removed by grinding the sides and tops of the teeth.

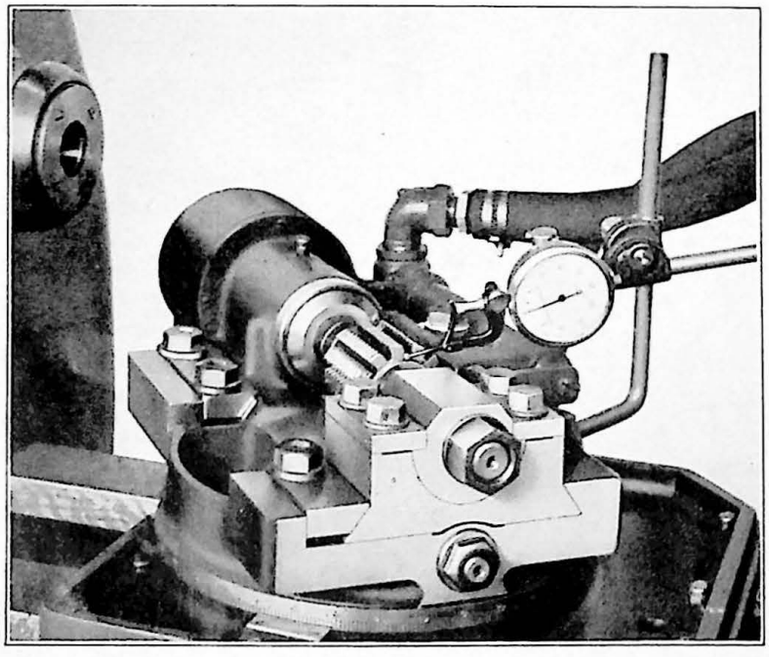


Fig. 4
Testing Hob with Indicator

A hob finished by this process has the accuracy of form and size which is an indispensable requirement in the production of a high class of work.

All Barber-Colman ground hobs are made with hubs at each end, which are ground concentric with the hole and with the pitch line within a limit of .00025". The purpose of these hubs is to afford an accurate means of checking the trueness of the hob when mounted on the hob spindle. In doing accurate finishing work it is essential that the hob run true within a maximum limit of .0005", and it should be possible to maintain this limit of eccentricity unless dirt is present between the faces of the hob, clamping collars, and spindle. To make sure that the runout is not excessive, however, a ground hob should always be tested after being clamped in position, by means of an indicator applied to the hubs. The importance of this precaution can hardly be overemphasized.

The hob should be kept sharp at all times. A hob which is allowed to run afte it has become dull will produce neither accurate work nor a good finish, and will wear more rapidly than one which is kept in proper condition. Barber-Colman hobs are made with uniform relief,

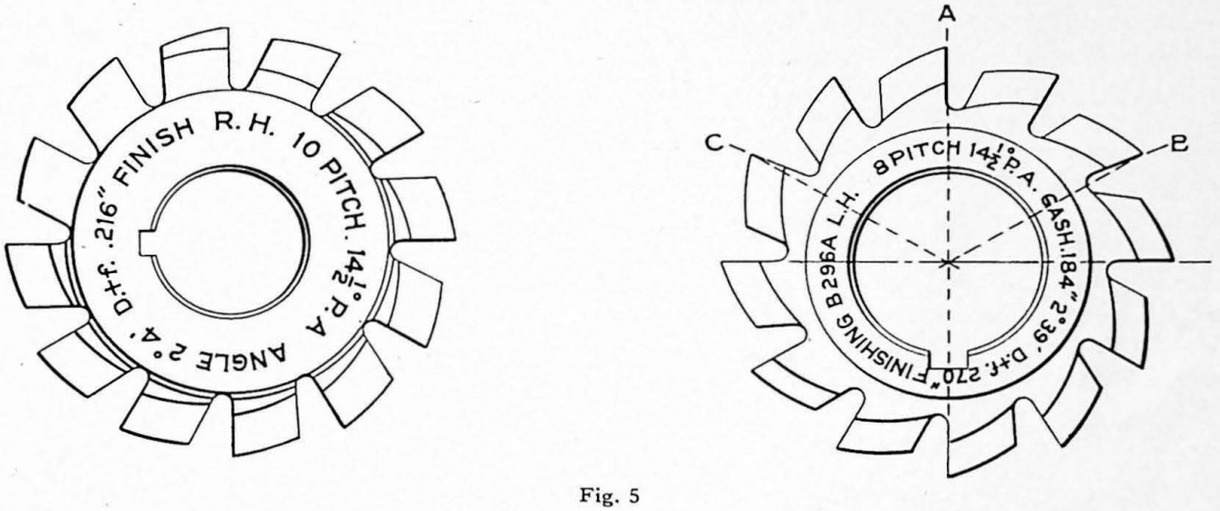


Fig. 5

so that the form, with proper sharpening, remains correct throughout the life of the hob. Fig. 5 shows at A a correctly sharpened hob tooth, which has been ground so that its cutting face is in a plane passing through the axis or center point of the hob. Hobs which are not thus sharpened with faces radial are a common source of trouble and defective work. Two common errors in sharpening are shown in the teeth B and C. The former is ground with an undercut or hooked tooth, and will cause the hob to cut too deep. The tooth at C, whose face is ground back of a radial line, is likely to drag over the surface of the work, giving a shallow cut, and since it does not have a free cutting action, will become dull rapidly. A hob sharpened with either a hooked or a dragging tooth will produce an incorrect form in the gear by changing the pressure angle and may also lead to further irregularity in contour. Care must also be taken in sharpening that the same amount of metal is removed from all the teeth, since if some are ground back further than others, those which are left too high will have to do more than their share of the work. This will prevent uniformity in their cutting action, and will result in an unsymmetrical tooth, in which the form is not the same on both sides. Time given to the correct sharpening of hobs will be amply repaid in the better quality of work obtained thereby.

Hob Sharpening Machines

To meet the needs of plants using a considerable number of hobs, the No's. 4-4, 6-5 and 10-12 Barber-Colman Hob Sharpening Machines were developed.

These machines are automatic in operation and afford a most accurate means for keeping hobs at their highest efficiency. Their ease and rapidity of operation reduce to a minimum the expense incidental to proper hob maintenance. The elimination of troubles arising from

incorrect sharpening, and the increase in the life of hobs make these machines a profitable investment even though they may not be kept in continuous operation.

Provision is made in the hobbing machine for shifting the hob to bring a different set of teeth into action after it has become dull in one position, thus utilizing the entire face of the hob. The hob is made long enough so that several such settings may be obtained before it becomes necessary to remove it from the machine for sharpening. The hob spindle is mounted in an adjustable dovetailed slide which provides a quick means of shifting the hob without disturbing the setting of the work or the hob swivel. Further movement of the hob may be secured if desired, by rearrangement of the hob spindle filler collars.

Cutting Oils and Compounds

Practice in the use of cutting oils and coolants varies considerably in different shops and it is impossible to lay down any hard and fast rules governing the selection of the proper compound.

Suitable cutting compounds may be secured from a large number of reliable sources who can furnish definite information as to the kind of compound required and its preparation for the class of work to be done.

In finishing work, a mineral lard oil usually gives quite satisfactory results, but this is by no means a universal rule. Low carbon steel, for instance, is often so soft that it does not cut freely, and is subject to more or less tearing on the sides of the teeth. Dilution of the oil with about 10 percent of kerosene frequently overcomes this difficulty, and where other expedients fail, the addition of a small quantity of powdered sulphur may prove effective.

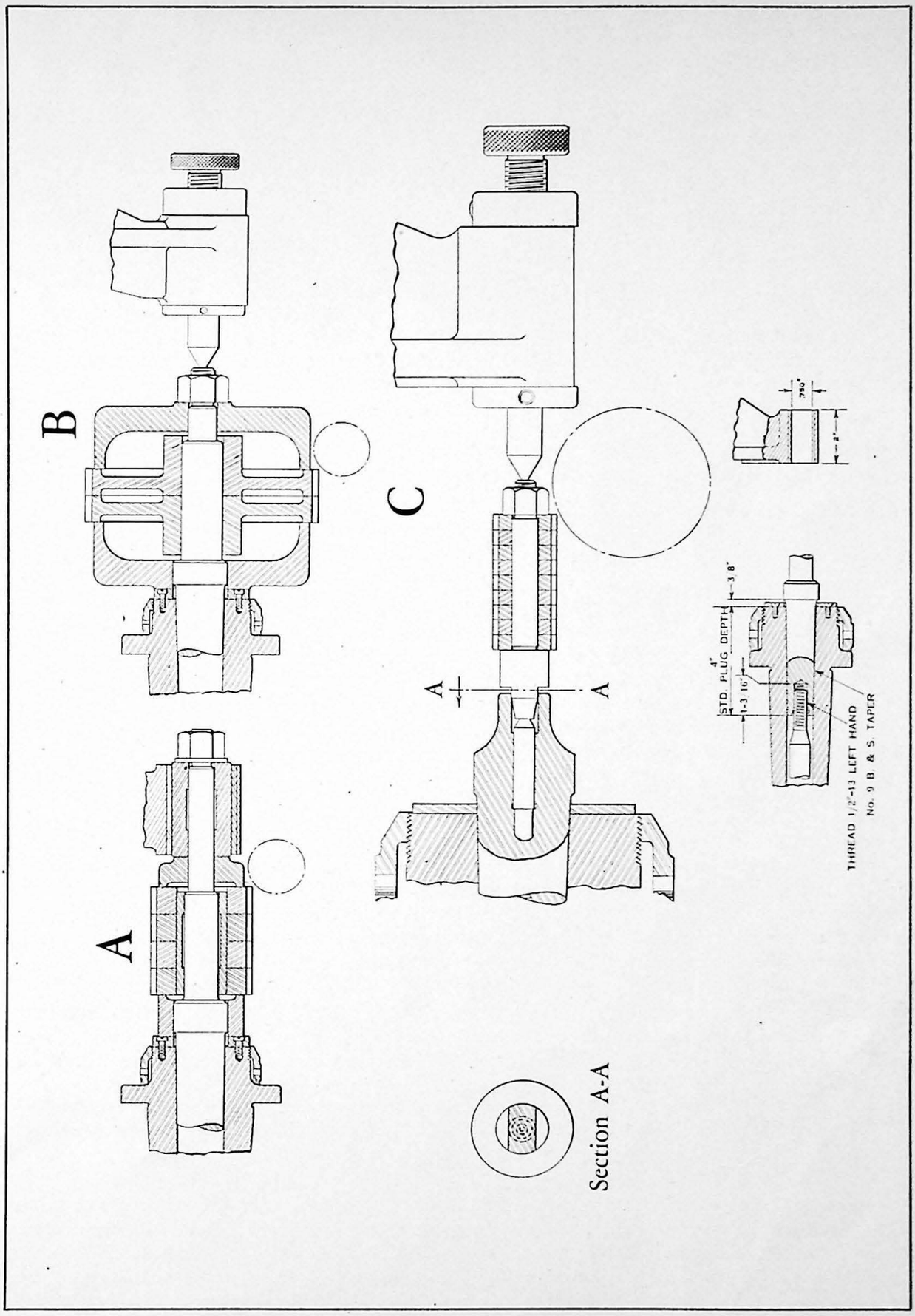
Ordinary brass or bronze as a rule is hobbed without the use of a cutting compound but occasionally a special bronze proves so hard and tough as to require the use of a lubricant in which case a strong solution of soapsuds or a mixture of lard oil and kerosene is suggested. In cutting cast iron a cooling compound is sometimes used for roughing, but is rarely necessary, and the finishing cut is best taken dry.

Hobbing Accurate Gears

Manufacturers in general are more and more coming to appreciate the important contribution toward steady improvement in their products which has been made by better gears. The automobile industry, of necessity, has long realized the importance of maintaining a high degree of accuracy in elements which have such essential functions to perform as the timing and transmission gears of an automobile. The demand in other lines for higher standards, however, is rapidly increasing with a general recognition of the advantages of smooth running, quiet, long wearing gears over those produced by the haphazard methods of former years.

The essential characteristics of a properly cut gear are completely covered by three important requirements—correct size, concentricity, and correct tooth form. These may be attained only by careful attention to every detail of equipment and operation. The cardinal requirements to be observed in the operation of the hobbing machine may be summarized briefly as follows:

1. A machine in proper adjustment.
2. A hob of correct form—correctly sharpened—running true.
3. Properly machined blanks.
4. Rigid and accurate means of supporting the work.


A
B
C
A
A
Section A-A
.750"
4"
STD. PLUG DEPTH
.4"
.3 8"
1-3 16"
THREAD 1,2"-13 LEFT HAND
No. 9 B. & S. TAPER

CHAPTER III

WORK HOLDING EQUIPMENT

In the design of equipment for supporting work on the hobbing machine there are three important considerations to be observed; first, that it must locate the work accurately; second, that it must afford support rigid enough to reduce vibration to a minimum; and third, that it must be conveniently and quickly operated. Accuracy, however, is impossible without rigidity, since if the holding equipment is not substantial enough to resist the thrust of the hob without vibration, the springing of the work will result in eccentricity and incorrect size. Vibration or chatter is both destructive of the finish of the work and detrimental to the hob, which wears much more rapidly under such conditions.

The great majority of gear work, of course, is held by means of work arbors. No standard arbors are furnished with Barber-Colman hobbing machines as regular equipment, since they are primarily production machines, and it is considered that better results are obtained with equipment designed to suit the particular requirements of individual gears. The work spindle of the No. 6-10 machine has a No. 9 B & S taper. All arbors are held in place by a draw-in bolt, which makes it possible to back clamping collars directly against the nose of the work spindle instead of against a shoulder on the arbor, since there is no possibility of pulling the arbor out of its seat in clamping the work. A hardened protector plate attached to the nose of the spindle and ground absolutely square with the taper hole, affords a true surface of large diameter as a bearing for clamping collars. This method of support adds much to the stiffness of the work arbor. Gears which are clamped only by their hubs, especially if they have only a thin web or spokes, are subject to springing and chatter under the thrust of the hob. Work therefore should be supported as near to the root of the teeth as possible, allowing only clearance enough to allow the hob to pass under the collars. A, page 21, shows the use of a bushing to adapt an arbor for gears with different sizes of holes.

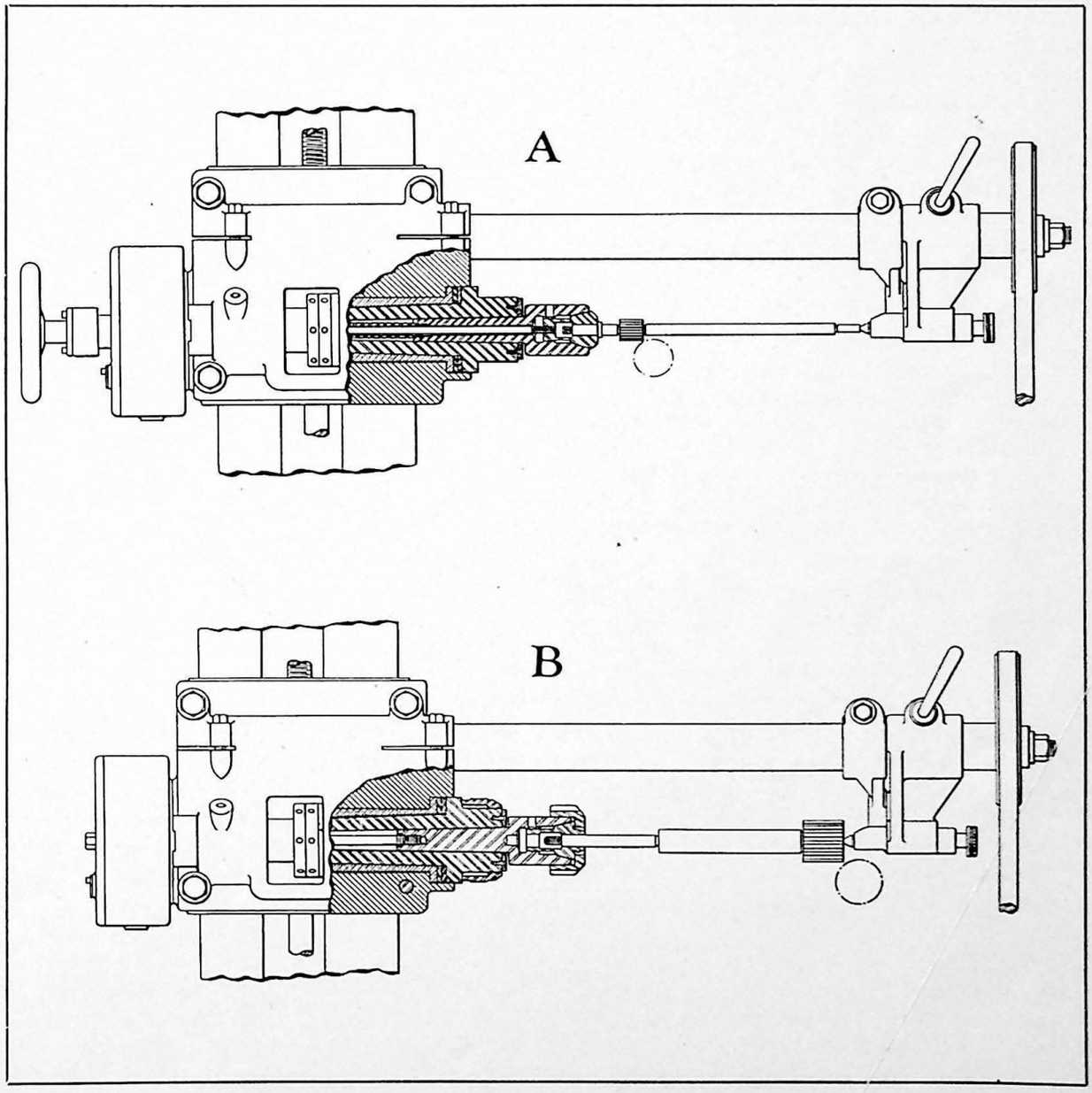
It should be noted that all of these arbors can be supported at the outer end by a long hardened and ground steel sleeve fitting in the overhanging arm bracket. This sleeve, or any bushing used in the hole of a gear, should always be a close sliding fit, with no perceptible shake on the work arbor. An alternative construction is illustrated in the sketch at B, page 21, where a center is used which fits in the overhanging arm bracket in place of the sleeve. This forms a good example of the style of arbor best adapted to the use of a center. The length of the hubs of the gears makes it impractical to hob more than two at a time, so the work is held close to the nose of the work spindle on a short stiff arbor. Where long strings of gears are being cut at high feeds and speeds, as in roughing, it is well to have the additional rigidity afforded by the long bearing of the sleeve in the overhanging arm bracket. A center is furnished with the machine as standard equipment.

Cases are often met with in the small work handled by the No. 6-10 hobbing machines where the actual cutting time for one arbor load of work is very short, and the proportion of time occupied in unloading is therefore high. In such instances a considerable increase in production may be secured by equipment designed to permit more rapid changing of the work. A commonly used design for a simple quick change arbor is shown at C, page 21, where a work arbor shank having a center and a driving slot is used with two short removable arbors, one of which is reloaded while the other load is being hobbed.

Hardened work arbors retain their accuracy much longer and are stiffer than soft arbors, and are always to be preferred except perhaps where temporary equipment is being made for a small quantity of gears. Arbors used for finishing work should run as nearly dead true as possible, with a runout not to exceed .00025". Clamping collars need not be made to fit tightly on the arbor, in fact it is well to make them with holes $\frac{1}{64}$" larger than the arbor size, for

convenience in loading and unloading. The prime requisite for collars is that their faces be machined parallel with each other. It is advisable to harden collars which are to become permanent equipment, although this is not so essential as with the work arbor. We are prepared to n ake suitable arbor equipment where drawings are furnished of the gears to be hobbed, but for the convenience of customers who prefer to make their own, standard work arbor details are shown on page 21.

Where gears or splines are to be cut on shafts, different styles of holding means suited to the design of the shaft must be used. If the work is short enough to be held entirely in front of the work spindle, a chuck held in the taper of the standard spindle is usually employed, two types being illustrated below. The arbor chuck at A is held in position by a threaded tube and a nut at the back of the spindle which is not shown in the drawing, and the spring collet is attached by a draw in rod and handwheel. The collet may also be closed by a nut on the end of the arbor chuck as at B, and a spanner wrench, but the former construction is to be preferred where practicable.



CHAPTER IV

ESTIMATING PRODUCTION

The actual time required for hobbing any piece of work is calculated by the following formula.

$$T = \frac{N \times [L + O]}{F \times R.P.M.}, \text{ in which}$$

T = cutting time in minutes;

N = number of teeth in gear to be cut;

L = distance between the outside faces of the work;

O = overrun of the hob, or the distance traveled from the time it first touches the work until it reaches full depth;
(L + O therefore represents the total distance traveled by the hob while cutting.)

F = feed of the hob in inches per revolution of the work;

R. P. M. = revolutions per minute of the hob.

If a multiple thread hob is used, the number of teeth (N) in this formula must be divided by the number of threads in the hob.

For example, let us assume that we wish to figure the time for hobbing a 45 tooth, 16 pitch gear without hubs, having a face width of 3/4", on the No. 6-10 hobbing machine, holding four gears on the arbor and using a feed of .040" per revolution of the work with a hob speed of 230 R. P. M. The total face of the gears is then 3/4" x 4, or 3", while the overrun of a 16 pitch hob, 1 7/8" in diameter, is approximately 1/2". L + O is therefore equal to 3 1/2".

Then $T = \frac{45 \times 3.5''}{.040'' \times 230}$ = 17 minutes cutting time. If 3/4 minutes are required to remove the finished gears and reload the arbor, the total floor to floor time for four gears is about 17 3/4 minutes, equivalent to a production of approximately 13 1/2 gears per hour.

If the gears have hubs on one or both sides, L must of course include the distance between the faces, in addition to the actual face width of the gears.

Selecting Proper Feeds and Speeds

The conditions governing the choice of appropriate feeds and speeds for hobbing are so many and varied that it is impossible to make any general recommendations which can be relied upon to give the best results in every case.

No recommendations which might be made can have a universal application to all classes of work, or can be followed indiscriminately without careful consideration of the peculiar requirements of each different job. Judgment gained from experience in the operation of the hobbing machine is the best basis for determining suitable feeds and speeds, and may be supplemented where necessary by experiment, until a result is found which gives a satisfactory quality of work combined with the most economical rate of production. The tables suggested feeds and speeds given herewith are therefore offered only as a guide to what may be considered ordinary practice.

Among the factors which should be taken into consideration in connection with the use of these tables, the following may be mentioned as the most important.

1. Character of the material to be hobbed, i.e., its chemical composition and its physical condition with regard to hardness, uniformity of structure, etc.
2. Area of the cut taken by the hob.
3. Material of the hob (high speed or carbon steel).

4. Rated capacity and mechanical condition of the hobbing machine.
5. Design of the work.
6. Stiffness and accuracy of the holding means.
7. Degree of accuracy required.
8. Quality of finish desired.

While a number of these considerations may be considered fixed with a fair degree of certainty for any particular job, it is also evident that some of them are subject to wide variations. For instance, it is not enough to know that a piece of steel is of a certain chemical analysis, without also knowing that it is in the proper condition to be machined freely, since the annealing or other heat treatment to which it may have been subjected may make its machining qualities decidedly different from average conditions.

The accuracy and smoothness of finish are usually the deciding factors in determining whether work is to be roughed and finished, or completed in one cut. The requirements in the way of accuracy and finish depend largely upon the kind of service which the finished product is called upon to perform, and the standards maintained in different plants are more difficult to forecast correctly than any of the other factors mentioned above. It therefore follows that those most familiar with local conditions and standards are generally best qualified to make the final decision as to the production rates to be employed.

The tables of feeds and speeds given herewith represent average conditions applying to spur gears and shafts. With helical gears, the feeds chosen must be modified somewhat according to the size of the helical angle. If the feed which would be selected for a spur gear of corresponding size is multiplied by the cosine of the angle, it will give an approximation of the suitable feed for the helical gear.

TABLE No. 19

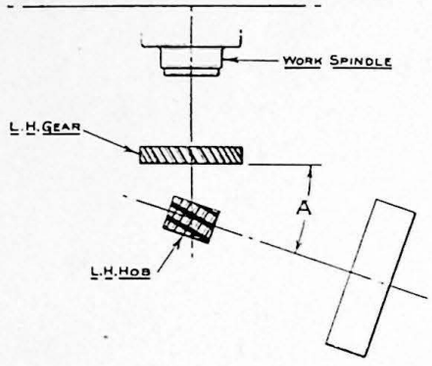
APPROXIMATE
FEEDS AND SPEEDS
FOR HOBBING
SPUR GEARS

No. 6-10 MACHINE

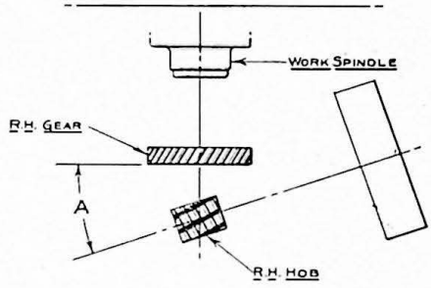
MATERIAL	FINISHING		FINISHING		ROUGHING	
	12 to 32 Diam. Pitch Single Thread Hob		12 to 32 Diam. Pitch Double Thread Hob		12 to 32 Diam. Pitch Double Thread Hob	
	Feed Per Rev. Of Work	Speed (R. P. M.)	Feed Per Rev. Of Work	Speed (R. P. M.)	Feed Per Rev. Of Work	Speed (R. P. M.)
Fibre	.050″—.100″	533	.040″—.070″	453		
Rawhide, Micarta, etc.	.050″—.100″	453	.040″—.070″	388		
Soft Brass	.050″—.080″	388	.040″—.065″	388		
Malleable Iron, Soft Cast Iron	.050″—.070″	309	.040″—.060″	309		
Hard Brass, Bronze	.045″—.065″	309	.035″—.050″	230		
Low Carbon Machinery Steel	.040″—.060″	230	.035″—.045″	183	.060″—.075″	183
.35 — .45 Carbon Steel	.035″—.050″	183			.050″—.065″	157
Case Hardening Alloy Steel	.035″—.050″	183			.050″—.065″	157
.45 — .60 Carbon Steel	.035″—.045″	157			.040″—.055″	133
High Carbon Alloy Steel	.025″—.040″	183			.030″—.045″	133

Directions For Setting Hob Swivel

For Cutting Spur Gears With R.H. Hobs And L.H. Helical Gears With L.H. Hobs.

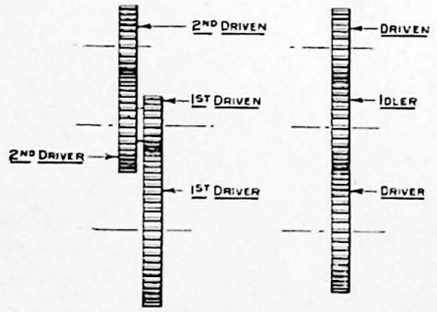


For Cutting Spur Gears With L.H. Hobs. And R.H. Helical Gears With R.H Hobs.

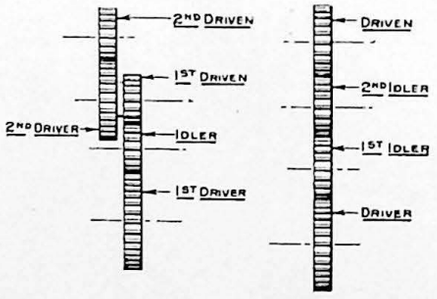


I For Spur Gears A = Lead Angle Marked On Hob.
II For R.H. Helical Gears With R.H. Hobs, Or
L.H. Helical Gears With L.H. Hobs.
A= Helical Angle Minus Lead Angle Marked On Hob.
III For R.H. Helical Gears With L.H. Hobs, Or
L.H. Helical Gears With R.H. Hobs.
A= Helical Angle Plus Lead Angle Marked On Hob.

Directions For Setting Index & Feed Change Gears



For R.H. Hobs



For L.H. Hobs

CHAPTER V

USE OF GEAR TABLES AND FORMULAE

Spur Gears and Worm Gears

On pages 34 to 39 will be found tables from which the proper index, feed and speed change gear combinations may be selected for cutting spur gears or other non-spiral forms. The ratio of each machine is given in the formula at the head of each index table. Thus in the case of the No. 6-10 machine, $\frac{12}{1}$ is the ratio between the work spindle and the hob spindle. The ratio of the index gears for hobbing a given number of teeth is therefore

$$\frac{12}{\text{No. of teeth to be cut}} = \frac{12}{N} = \frac{\text{drivers}}{\text{driven}}$$

For a 27 tooth gear, $\frac{\text{drivers}}{\text{driven}} = \frac{12}{27} = \frac{32}{72}$ index gears.

When using a multiple thread hob, the constant of the machine is multiplied by the number of threads, so that the ratio becomes, in the case of a double thread hob, for example, $\frac{2 \times 12}{N}$ or $\frac{24}{N}$

Helical Gears

Change gears for helical gear cutting may be obtained from the tables and formulae beginning on page 40. Suppose for example that we wish to cut on the No. 6-10 machine a gear of 45 teeth, 16 diametral pitch, 24° helical angle, using a feed of about .040″ per revolution of the work.

Index Change Gears

To find the index change gears, refer first to the table of feed constants for .040″ feed (page 43). Under 16 pitch, and opposite 24° angle, we find the approximate value of C to be 12.

(If the exact pitch or angle in question is not given by the table, use the value of C for the pitch or angle nearest to that desired. The accuracy of the calculation will in no way be affected by this slight variation, the only result being a little change in the amount of the feed.)

Then turn to the table giving the nearest approximate value of C. In this case we use the table on page 50, where C = 13 approximate. Opposite 45 teeth are found the desired index change gears, $\frac{\text{drivers}}{\text{driven}} = \frac{24}{85} \times \frac{70}{74}$. At the right of the index gears, this table also gives the exact constant C for 45 teeth as 14, which is the value now to be used in finding the feed change gears.

Feed Change Gears

STANDARD MACHINE (See Page 28 for formulae for Precision Machine.)

The feed change gears are found by substituting the proper values in the formula:—

$$\frac{\text{Normal circular pitch}}{\text{C x sin angle x .075″}} = \text{the ratio } \frac{\text{drivers}}{\text{driven}} \text{ which we will call R.}$$

Thus: $\frac{.19635}{14 \times .40674 \times .075″} = \frac{.19635}{.427077} = .459752 = R.$

Having found the feed change gear ratio, the next step is to select in the book of decimal equivalents the fraction most nearly equal to this decimal, which in the present example is

$$\frac{40}{87} = .45977.$$

If these particular gears are not available, they may be factored so as to obtain the same ratio with different gears, as follows:

$$\frac{40}{87} = \frac{10 \times 4}{29 \times 3} = \frac{10 \times 4}{29 \times 3} \times \frac{20 \times 3}{30 \times 2} = \frac{30 \times 80}{58 \times 90}$$

If the combination obtained in this way is not considered sufficiently accurate, a closer approximation to the decimal ratio .459752 may be reached by another method.

The decimal .459752 = .4 + .059752. Dropping the first figure (4) in this way, look in the book of decimal equivalents for the fraction nearest to the remaining figures — .59752.

We find $\frac{49}{82} = .59756$

Then $\frac{49}{820} = .059756.$

Now adding the first figure, which was dropped, we have

$$.4 + .059756 = .4 + \frac{49}{820} = \frac{328}{820} + \frac{49}{820} = \frac{377}{820}$$ which is equal to the decimal .459756.

This ratio can be factored to obtain suitable change gears.

$$\frac{377}{820} = \frac{13 \times 29}{10 \times 82} = \frac{39 \times 87}{90 \times 82}$$ feed change gears.

If on reference to the table of composite numbers and factors, however, we found that the fraction $\frac{377}{820}$ cannot be factored, it would therefore be necessary to try another fraction from the table of decimal equivalents. The next nearest to the desired decimal is—

$$\frac{52}{87} = .59770.$$

Proceeding as before,

$$\frac{52}{870} = .05977.$$

$$.4 + .05977 = .4 + \frac{52}{870} = \frac{348}{870} + \frac{52}{870} = \frac{400}{870} = \frac{20 \times 20}{87 \times 10} = \frac{60 \times 60}{87 \times 90}$$

Amount of Feed

For the standard No. 6-10 machine, the actual amount of feed per revolution of the work, given by this gear combination is found by the following formula:

Ratio of feed gears x .075, or
Ratio of feed gears x 3/40 = feed per revolution of work.
In the above example,

$$\frac{39 \times 87 \times 3}{90 \times 82 \times 40} = .034481$$ actual feed.

For the precision No. 6-10 machine the above formula becomes — Ratio of feed gears x 3/20.

Proof Formula

The correctness and accuracy of the above calculations should now be checked as follows:

$$\frac{R}{\text{ratio of feed change gears}} = \frac{R \times \text{driven}}{\text{drivers}} = 1.$$

The result of this formula should be within the limits .9999 and 1.0001.

Substituting the results we have obtained in the above example, we have

$$\frac{.459752 \times 90 \times 82}{39 \times 87} = \frac{3392.97}{3393} = .999991.$$

The speed change gears are chosen from the standard tables and may be changed independently of the index and feed gears.

Basic Formulae

Index gears may also be found by substituting the value C, obtained from the table of feed constants, in the following formulae:

$$\frac{12 \times C}{(N \times C) - 1}$$ **for No. 6-10 machine with standard hob swivel;**

$$\frac{18 \times C}{(N \times C) - 1}$$ **for No. 6-10 machine with high speed hob swivel.**

$$\frac{24 \times C}{(N \times C) - 1}$$ **for No. 6-10 precision machine.**

Table 17, giving approximate values of C, apply only to the No. 6-10 machine with standard hob swivel, and only in cases where the gear to be cut and the hob to be used are of the same hand. For the No. 6-10 machine with high speed swivel, or the precision machine, index change gears must be found by use of the basic formula above.

When a right hand gear is to be cut with a left hand hob, or a left hand gear with a right hand hob, the minus sign in the above formulae must be changed to plus, as for example,

$$\frac{12 \times C}{(N \times C) + 1} = \frac{\text{drivers}}{\text{driven}}$$ for No. 6-10 machine.

To illustrate the use of the basic formula, suppose for example that we wish to cut on the No. 6-10 machine with high speed swivel a gear of 35 teeth, 28 pitch, 20 R. H. helical angle, using a R. H. hob and a feed of about .040″ per revolution of the work. To find the index change gears, refer first to the table of feed constants on page 42 of the handbook. Under 28 pitch, and opposite 20° angle, we find the value of C to be 8.

(If the exact pitch or angle in question is not given by the table, use the nearest value to that desired. The accuracy of the calculation will in no way be affected by this slight variation, the only result being a little change in the amount of the feed.)

The index gears are now found by substituting this value of C in a formula similar to those given above. For the No. 6-10 machine with high speed swivel, this is $\frac{18 \times C}{(N \times C) - 1}$

Making the substitution for C, this becomes $\frac{18 \times 8}{(35 \times 8) - 1} = \frac{144}{280 - 1} = \frac{144}{279}$

Factoring this ratio, we have $\frac{144}{279} = \frac{8 \times 18}{9 \times 31} = \frac{80 \times 36}{90 \times 62}$ index change gears.

In case the ratio obtained cannot be factored, try a slightly different value of C in the formula as before.

Feed change gears are now found by the same method given on page 29, and in the case of this example,

$$\frac{\text{Normal circular pitch}}{\text{C x sin angle x .075}} = \frac{.1122}{8 \times .34202 \times .075} = \frac{.1122}{.20521} = .54675 = R.$$

We then choose from the book of decimal equivalents the fraction most nearly equal to this decimal, which in the present example is $\frac{41}{75} = .54666$.

If these particular gears are not available, they may be factored so as to obtain the same ratio with different gears, as follows:

$$\frac{41}{75} = \frac{41 \times 48}{75 \times 48} = \frac{82 \times 24}{75 \times 48}$$ feed change gears.

The amount of feed given by these change gears is:

Ratio of feed gears x 3/40 = feed per revolution of work.

$$\frac{82 \times 24 \times 3}{75 \times 48 \times 40} = \frac{41}{1000} = .041''$$ actual feed.

To check the accuracy of these calculations,

$$\frac{R \times \text{driven}}{\text{drivers}} = \frac{.54675 \times 75 \times 48}{82 \times 24} = \frac{.54675 \times 75}{41} = 1.0001.$$

In case the hob used is not the same hand as that of the gear, the sign in the index gear formula is changed from minus to plus or $\frac{18 \times C}{(N \times C) + 1}$

TABLES

IMPORTANT

No. 17 Tables giving change gears for approximate "C" Values can only be used for cases where hob and gear are of same hand—when of different hands, use basic formula.

TABLE No. 1

GEAR TOOTH PARTS
DIAMETRAL PITCH

Diametral Pitch	Circular Pitch	Thickness of Tooth on Pitch Line	Addendum	Working Depth of Tooth	Depth of Space Below Pitch Line	Whole Depth of Tooth
1/2	6.2832	3.1416	2.0000	4.0000	2.3142	4.3142
3/4	4.1888	2.0944	1.3333	2.6666	1.5428	2.8761
1	3.1416	1.5708	1.0000	2.0000	1.1571	2.1571
1 1/4	2.5133	1.2566	.8000	1.6000	.9257	1.7257
1 1/2	2.0944	1.0472	.6666	1.3333	.7714	1.4381
1 3/4	1.7952	.8976	.5714	1.1429	.6612	1.2326
2	1.5708	.7854	.5000	1.0000	.5785	1.0785
2 1/4	1.3963	.6981	.4444	.8888	.5143	.9587
2 1/2	1.2566	.6283	.4000	.8000	.4628	.8628
2 3/4	1.1424	.5712	.3636	.7273	.4208	.7844
3	1.0472	.5236	.3333	.6666	.3857	.7190
3 1/2	.8976	.4488	.2857	.5714	.3306	.6163
4	.7854	.3927	.2500	.5000	.2893	.5393
5	.6283	.3142	.2000	.4000	.2314	.4314
6	.5236	.2618	.1666	.3333	.1928	.3595
7	.4488	.2244	.1429	.2857	.1653	.3081
8	.3927	.1963	.1250	.2500	.1446	.2696
9	.3491	.1745	.1111	.2222	.1286	.2397
10	.3142	.1571	.1000	.2000	.1157	.2157
11	.2856	.1428	.0909	.1818	.1052	.1961
12	.2618	.1309	.0833	.1666	.0964	.1798
13	.2417	.1208	.0769	.1538	.0890	.1659
14	.2244	.1122	.0714	.1429	.0826	.1541
15	.2094	.1047	.0666	.1333	.0771	.1438
16	.1963	.0982	.0625	.1250	.0723	.1348
17	.1848	.0924	.0588	.1176	.0681	.1269
18	.1745	.0873	.0555	.1111	.0643	.1198
19	.1653	.0827	.0526	.1053	.0609	.1135
20	.1571	.0785	.0500	.1000	.0579	.1079
22	.1428	.0714	.0455	.0909	.0526	.0980
24	.1309	.0654	.0417	.0833	.0482	.0898
26	.1208	.0604	.0385	.0769	.0445	.0829
28	.1122	.0561	.0357	.0714	.0413	.0770
30	.1047	.0524	.0333	.0666	.0386	.0719
32	.0982	.0491	.0312	.0625	.0362	.0674
34	.0924	.0462	.0294	.0588	.0340	.0634
36	.0873	.0436	.0278	.0555	.0321	.0599
38	.0827	.0413	.0263	.0526	.0304	.0568
40	.0785	.0393	.0250	.0500	.0289	.0539
42	.0748	.0374	.0238	.0476	.0275	.0514
44	.0714	.0357	.0227	.0455	.0263	.0490
46	.0683	.0341	.0217	.0435	.0252	.0469
48	.0654	.0327	.0208	.0417	.0241	.0449
50	.0628	.0314	.0200	.0400	.0231	.0431
56	.0561	.0280	.0178	.0357	.0207	.0385
60	.0524	.0262	.0166	.0333	.0193	.0360

TABLE No. 2

GEAR TOOTH PARTS
CIRCULAR PITCH

Circular Pitch	Threads or Teeth, per inch Linear	Diametral Pitch	Thickness of Tooth on Pitch Line	Addendum	Working Depth of Tooth	Depth of Space Below Pitch Line	Whole Depth of Tooth
6	1–6	.5236	3.0000	1.9098	3.8196	2.2098	4.1196
5 1/2	2–11	.5711	2.7500	1.7506	3.5012	2.0257	3.7763
5	1–5	.6283	2.5000	1.5915	3.1830	1.8415	3.4330
4 1/2	2–9	.6983	2.2500	1.4323	2.8646	1.6674	3.0997
4	1–4	.7854	2.0000	1.2733	2.5466	1.4731	2.7464
3 1/2	2–7	.8976	1.7500	1.1440	2.2880	1.2591	2.4031
3	1–3	1.0472	1.5000	.9549	1.9098	1.1049	2.0598
2 1/2	2–5	1.2566	1.2500	.7957	1.5914	.9208	1.7165
2	1–2	1.5708	1.0000	.6366	1.2732	.7366	1.3732
1 7/8	8–15	1.6755	.9375	.5968	1.1937	.6906	1.2874
1 3/4	4–7	1.7952	.8750	.5570	1.1141	.6445	1.2016
1 5/8	8–13	1.9333	.8125	.5173	1.0345	.5985	1.1158
1 1/2	2–3	2.0944	.7500	.4775	.9549	.5525	1.0299
1 7/16	16–23	2.1855	.7187	.4576	.9151	.5294	.9870
1 3/8	8–11	2.2848	.6875	.4377	.8754	.5064	.9441
1 5/16	16–21	2.3936	.6562	4178	.8356	.4834	.9012
1 1/4	4–5	2.5133	.6250	.3979	7958	.4604	.8583
1 3/16	16–19	2.6456	.5937	.3780	.7560	.4374	.8156
1 1/8	8–9	2.7925	.5625	.3581	.7162	.4143	.7724
1 1/16	16–17	2.9568	5312	.3382	.6764	.3913	.7295
1	1–1	3.1416	.5000	.3183	.6366	.3683	.6866
15/16	16–15	3.3510	4687	.2984	.5968	.3453	.6437
7/8	8–7	3.5904	.4375	.2785	5570	.3223	.6007
13/16	16–13	3.8666	4062	.2586	.5173	.2993	.5579
3/4	4–3	4.1888	.3750	.2387	.4775	.2762	.5150
11/16	16–11	4.5696	.3437	.2189	.4377	.2532	.4720
2/3	3–2	4.7124	.3333	.2122	.4244	.2455	.4577
5/8	8–5	5.0265	.3125	.1989	.3979	.2301	.4291
9/16	16–9	5.5851	.2812	.1790	.3581	.2071	.3862
1/2	2–1	6.2832	.2500	.1592	.3183	.1842	.3433
7/16	16–7	7.1808	.2187	.1393	.2785	.1611	.3003
2/5	5–2	7.8540	.2000	.1273	.2546	.1473	.2746
3/8	8–3	8.3776	.1875	.1194	.2387	.1381	.2575
1/3	3–1	9.4248	.1666	.1061	.2122	.1228	.2289
5/16	16–5	10.0531	.1562	.0995	.1989	1151	.2146
2/7	7–2	10.9956	.1429	.0909	.1819	.1052	.1962
1/4	4–1	12.5664	.1250	.0796	.1591	.0921	.1716
2/9	9–2	14.1372	.1111	.0707	.1415	.0818	.1526
1/5	5–1	15.7080	.1000	.0637	.1273	.0737	.1373
3/16	16–3	16.7552	.0937	.0597	.1194	.0690	.1287
1/6	6–1	18.8496	.0833	.0531	.1061	.0614	.1144
1/7	7–1	21.9911	.0714	.0455	.0910	.0526	.0981
1/8	8–1	25.1327	.0625	.0398	.0796	.0460	.0858
1/9	9–1	28.2743	.0555	.0354	.0707	.0409	.0763
1/10	10–1	31.4159	.0500	.0318	.0637	.0368	.0687
1/16	16–1	50.2655	.0312	.0199	.0398	.0230	.0429

TABLE No. **11**

INDEX TABLE FOR SPUR GEARS
AND OTHER NON-SPIRAL FORMS
STANDARD HOB SWIVEL

No. **6-10** MACHINE

INDEX GEAR FORMULA —— $\frac{12}{N} = \frac{\text{DRIVERS}}{\text{DRIVEN}}$

CHANGE GEARS FURNISHED WITH MACHINE

28 - 29

24(2)—30(2)—32—33—36—39—40—42—45(2)—48—53—56—57—59—60(2)—61—62—67—68—69—70—71
72—73—74—75—76—78—79—80—82—83—84—85—86—87—88—89—90—94—96 -91-120-136

No. of Teeth	Driver	Intermediate Driven	Intermediate Driver	Driven	No. of Teeth	Driver	Intermediate Driven	Intermediate Driver	Driven
3	96	48	72	36	33	32	IDLER		88
4	96	IDLER		32	34	30	IDLER		85
5	72	IDLER		30	35	24	IDLER		70
6	72	IDLER		36	36	30	IDLER		90
7	72	IDLER		42	37	24	IDLER		74
8	72	IDLER		48	38	24	IDLER		76
9	60	IDLER		45	39	24	IDLER		78
10	72	IDLER		60	40	24	IDLER		80
11	48	88	90	45	41	24	IDLER		82
12	90	45	36	72	42	24	IDLER		84
13	90	45	36	78	43	24	IDLER		86
14	48	IDLER		56	44	24	IDLER		88
15	48	IDLER		60	45	24	IDLER		90
16	36	IDLER		48	46	36	69	42	84
17	48	IDLER		68	47	24	IDLER		94
18	40	IDLER		60	48	24	IDLER		96
19	36	IDLER		57	49	60	70	24	84
20	36	IDLER		60	50	36	90	48	80
21	32	IDLER		56	51	24	72	60	85
22	96	48	24	88	52	45	78	36	90
23	36	IDLER		69	53	24	53	48	96
24	30	IDLER		60	54	32	72	48	96
25	36	90	72	60	55	32	88	48	80
26	36	IDLER		78	56	24	80	60	84
27	32	IDLER		72	57	48	76	32	96
28	30	IDLER		70	58	36	87	48	96
29	36	IDLER		87	59	24	59	48	96
30	36	IDLER		90	60	32	80	48	96
31	48	62	40	80	61	24	61	48	96
32	30	IDLER		80	62	24	62	48	96

THIS TABLE CANNOT BE USED FOR HELICAL GEARS

TABLE No. 11 (Continued)

INDEX TABLE FOR SPUR GEARS
AND OTHER NON-SPIRAL FORMS
STANDARD HOB SWIVEL

No. 6-10 MACHINE

No. of Teeth	Driver	Intermediate		Driven	No. of Teeth	Driver	Intermediate		Driven
		Driven	Driver				Driven	Driver	
63	32	84	48	96	92	24	69	36	96
64	30	80	48	96	94	24	94	48	96
65	24	78	48	80	95	24	76	36	90
66	30	90	48	88	96	24	72	36	96
67	36	67	32	96	99	24	88	40	90
68	24	68	45	90	100	24	80	36	90
69	36	69	30	90	102	24	85	40	96
70	24	70	45	90	104	24	78	36	96
71	24	71	48	96	105	24	84	36	90
72	24	72	48	96	108	24	72	32	96
73	24	73	48	96	110	24	88	36	90
74	24	74	48	96	111	24	74	32	96
75	32	80	36	90	112	24	84	36	96
76	24	76	48	96	114	24	76	32	96
77	24	84	48	88	116	24	87	36	96
78	30	78	36	90	117	24	78	32	96
79	24	79	48	96	119	24	84	30	85
80	36	90	30	80	120	24	90	36	96
81	32	90	40	96	123	24	82	32	96
82	24	82	48	96	126	24	84	32	96
83	24	83	48	96	128	24	88	33	96
84	24	84	48	96	129	24	86	32	96
85	24	85	48	96	132	24	88	32	96
86	24	86	48	96	136	24	85	30	96
87	24	87	48	96	141	24	90	30	94
88	24	88	48	96	144	24	90	30	96
89	24	89	48	96					
90	24	90	48	96					

THIS TABLE CANNOT BE USED FOR HELICAL GEARS

TABLE No. 12

INDEX TABLE FOR SPUR GEARS
AND OTHER NON-SPIRAL FORMS
HIGH SPEED HOB SWIVEL

No. 6-10 MACHINE

INDEX GEAR FORMULA —— $\frac{18}{N} = \frac{\text{DRIVERS}}{\text{DRIVEN}}$

CHANGE GEARS FURNISHED WITH MACHINE

24(2)—30(2)—32—33—36—39—40—42—45(2)—48—53—56—57—59—60(2)—61—62—67—68—69—70—71
72—73—74—75—76—78—79—80—82—83—84—85—86—87—88—89—90—94—96

No. of Teeth	Driver	Intermediate		Driven	No. of Teeth	Driver	Intermediate		Driven
		Driven	Driver				Driven	Driver	
3	90	45	72	24	33	48	IDLER		88
4	90	48	72	30	34	36	IDLER		68
5	90	45	72	40	35	36	IDLER		70
6	90	IDLER		30	36	36	IDLER		72
7	84	56	72	42	37	36	IDLER		74
8	90	IDLER		40	38	36	IDLER		76
9	72	IDLER		36	39	36	IDLER		78
10	72	IDLER		40	40	36	IDLER		80
11	60	80	72	33	41	36	IDLER		82
12	36	IDLER		24	42	36	IDLER		84
13	60	80	72	39	43	36	IDLER		86
14	72	IDLER		56	44	36	IDLER		88
15	48	IDLER		40	45	36	IDLER		90
16	45	IDLER		40	46	36	69	60	80
17	72	IDLER		68	47	36	IDLER		94
18	60	IDLER		60	48	36	IDLER		96
19	72	IDLER		76	49	24	84	72	56
20	72	IDLER		80	50	24	80	72	60
21	72	IDLER		84	51	24	IDLER		68
22	72	IDLER		88	52	30	78	72	80
23	72	60	45	69	53	36	53	45	90
24	36	IDLER		48	54	24	IDLER		72
25	72	60	45	75	55	36	60	48	88
26	45	78	72	60	56	36	80	60	84
27	40	IDLER		60	57	24	IDLER		76
28	36	IDLER		56	58	36	80	60	87
29	72	40	30	87	59	36	59	45	90
30	36	IDLER		60	60	24	IDLER		80
31	36	IDLER		62	61	36	61	45	90
32	45	IDLER		80	62	36	62	45	90

THIS TABLE CANNOT BE USED FOR HELICAL GEARS

TABLE No. 12 (Continued)

INDEX TABLE FOR SPUR GEARS
AND OTHER NON-SPIRAL FORMS
HIGH SPEED HOB SWIVEL

No. 6-10 MACHINE

No. of Teeth	Driver	Intermediate		Driven	No. of Teeth	Driver	Intermediate		Driven
		Driven	Driver				Driven	Driver	
63	24	IDLER		84	77	36	77	40	80
64	36	72	45	80	78	36	78	40	80
65	36	78	48	80	79	36	79	40	80
66	24	IDLER		88	80	36	80	40	80
67	36	67	40	80	81	36	80	40	81
68	36	68	40	80	82	36	80	40	82
69	36	69	40	80	83	36	80	40	83
70	36	70	40	80	84	36	80	40	84
71	36	71	40	80	85	36	80	40	85
72	24	IDLER		96	86	36	80	40	86
73	36	73	40	80	87	36	80	40	87
74	36	74	40	80	88	36	80	40	88
75	36	75	40	80	89	36	80	40	89
76	36	76	40	80	90	36	80	40	90

THIS TABLE CANNOT BE USED FOR HELICAL GEARS

TABLE No. 13

FEEDS PER REV. OF WORK
STANDARD OR HIGH SPEED HOB SWIVEL

No. 6-10 MACHINE

FEED GEAR FORMULA —— $\frac{\text{FEED}}{.075} = \frac{\text{DRIVERS}}{\text{DRIVEN}}$

Feeds Per Rev.	Driver	Intermediate		Driven
		Driven	Driver	
.015″	24	60	36	72
.018″	24	60	36	60
.020″	24	60	48	72
.022″	24	60	45	61
.025″	24	IDLER		72
.030″	24	IDLER		60
.035″	30	60	42	45
.040″	30	60	48	45
.045″	36	IDLER		60
.050″	24	IDLER		36
.055″	33	IDLER		45
.060″	48	IDLER		60
.065″	39	IDLER		45
.072″	48	70	56	40
.080″	32	IDLER		30
.085″	68	45	36	48
.090″	36	IDLER		30
.095″	57	IDLER		45
.100″	48	IDLER		36
.115″	69	IDLER		45
.125″	60	IDLER		36
.130″	72	45	39	36
.135″	72	IDLER		40
.140″	56	IDLER		30
.150″	60	IDLER		30

DRIVE SHAFT AT 400 R.P.M.

SURFACE SPEEDS OF HOB

STANDARD HOB SWIVEL

SPEED CHANGE GEARS FURNISHED WITH MACHINE

18—20—22—25—29—32—34—36

Driver	Driven	R. P. M. of Hob	Ft. Per Min. 2 1/16″ Hob	Ft. Per Min. 1 7/8″ Hob	Ft. Per Min. 1 1/2″ Hob
18	36	133	72	65	52
20	34	157	85	77	62
22	32	183	100	90	72
25	29	230	125	113	90
29	25	309	167	152	122
32	22	388	210	190	152
34	20	453	245	223	178
36	18	533	288	277	209

TABLE No. 14

VERTICAL FEEDS PER REV. OF WORK

No. 6-10 MACHINE

FEED GEAR FORMULA —— $\frac{\text{FEED}}{.01875} = \frac{\text{DRIVERS}}{\text{DRIVEN}}$

Vert. Feeds Per Rev.	Driver	Intermediate		Driven
		Driven	Driver	
.002612″	24	68	30	76
.003125″	24	60	30	72
.00375″	24	60	36	72
.005″	24	48	32	60
.00625″	24	IDLER		72
.0075″	24	IDLER		60
.00875″	30	60	42	45
.010″	30	60	48	45
.01125″	36	IDLER		60
.0125″	24	IDLER		36
.01375″	33	IDLER		45
.015″	48	IDLER		60
.018″	48	70	56	40

DRIVE SHAFT AT 400 R.P.M.

SURFACE SPEEDS OF HOB

HIGH SPEED HOB SWIVEL

Driver	Driven	R. P. M. of Hob	Ft. Per Min. $1\frac{1}{4}$″ Hob	Ft. Per Min. $1\frac{1}{16}$″ Hob	
18	36	200	65	56	
20	34	235	76	65	
22	32	276	90	77	
25	29	344	112	96	
29	25	464	151	129	
32	22	580	189	161	
34	20	680	222	189	
36	18	800	261	222	

FEED CONSTANTS — TABLE NO. 15 — FEED = .010" PER REV. OF WORK

N. D. P.	3	4	5	6	7	8	9	10	12	14	16	18	20	24	28	30	32	36	40	48	56	60
N. C. P.	1.0472	.7854	.62832	.52360	.44880	.39270	.34906	.31416	.26180	.22440	.19635	.17453	.15708	.13090	.11220	.10472	.09817	.08726	.07854	.06515	.05610	.05236
3°	2000	1500	1200	1000	855	750	667	600	500	428	375	333	300	250	214	200	187	166	150	125	107	100
5°	1200	900	720	600	516	450	400	360	300	258	225	200	180	150	129	120	113	100	90	75	65	60
7°	860	645	516	430	371	322	285	258	215	186	161	143	129	108	93	86	80	71	65	54	47	43
9°	666	500	400	333	285	250	222	200	166	143	125	111	100	83	72	66	63	55	50	42	36	33
10°	602	451	361	301	258	225	200	180	150	129	112	100	90	75	64	60	56	50	45	38	32	30
11°	549	410	329	275	235	205	183	164	138	117	102	92	82	69	58	55	51	46	41	35	29	28
12°	504	377	301	252	215	189	166	150	126	108	95	83	75	63	54	50	48	41	38	32	27	25
13°	465	348	279	232	200	174	153	140	116	100	87	77	70	58	50	47	44	39	35	29	25	23
14°	432	324	259	216	185	162	144	130	108	93	81	72	65	54	46	43	40	36	33	27	23	22
15°	405	304	243	203	174	152	135	121	100	87	76	68	61	50	43	40	38	34	30	25	22	20
16°	380	284	225	190	162	142	126	114	95	81	71	63	57	48	40	38	36	32	29	24	20	19
17°	357	268	215	180	150	132	119	105	88	77	67	60	53	44	38	35	34	30	27	22	19	18
18°	338	253	203	169	145	126	112	102	85	73	63	56	51	43	36	34	32	28	25	21	18	17
19°	322	240	192	161	138	120	105	97	80	69	60	53	49	40	34	32	30	26	24	20	17	16
20°	306	230	183	153	130	115	102	92	76	65	58	51	46	38	32	31	29	25	23	19	16	15
22°	279	209	166	140	119	106	93	84	70	60	53	47	42	35	30	28	27	24	21	18	15	14
24°	256	196	153	128	112	98	85	77	64	56	49	43	39	32	28	26	25	22	20	16	14	13
26°	238	178	143	119	102	90	80	72	60	51	45	40	35	29	25	24	23	20	18	15	13	12
28°	222	166	133	111	95	83	74	67	56	48	42	37	34	28	24	22	21	19	17	14	12	11
30°	209	156	125	105	89	78	70	63	52	45	39	35	32	26	23	21	20	18	16	13	11	10
35°	182	136	110	91	78	68	61	55	46	39	34	31	28	23	20	18	17	16	14	12	10	9
40°	162	121	97	81	69	61	54	49	40	35	31	27	25	20	18	16	15	14	13	10	9	8
45°	148	111	88	74	63	55	49	44	37	32	28	25	22	19	16	15	14	13	11	9	8	8
50°	136	102	81	68	58	51	46	41	34	29	26	23	21	17	15	14	13	12	10	8	8	7
60°	121	90	72	60	52	45	40	36	30	26	23	20	18	16	13	12	12	10	9	8	7	6
70°	112	84	67	56	48	42	37	34	28	24	21	18	17	14	12	11	11	9	8	7	6	6
80°	106	79	63	53	45	40	35	32	26	23	20	17	16	13	11	11	10	9	8	7	6	6

FEED CONSTANTS — TABLE NO. 15 — FEED = .020″ PER REV. OF WORK

N. D. P.	3	4	5	6	7	8	9	10	12	14	16	18	20	24	28	30	32	36	40	48	56	60
N. C. P.	1.0472	.7854	.62832	.52360	.44880	.39270	.34906	.31416	.26180	.22440	.19635	.17453	.15708	.13090	.11220	.10472	.09817	.08726	.07854	.06545	.05610	.05236
3°	1000	750	600	500	427	375	333	300	250	213	188	166	150	125	107	100	94	83	75	63	53	50
5°	600	450	360	300	258	225	200	180	150	129	112	100	90	75	65	60	56	50	45	38	32	30
7°	430	322	258	215	186	161	143	129	108	93	81	72	65	54	47	43	40	36	33	27	24	21
9°	333	250	200	166	143	125	111	100	83	72	63	56	50	42	36	33	32	28	25	21	18	16
10°	301	225	180	150	129	112	100	90	75	65	56	50	45	38	33	30	28	25	23	19	16	15
11°	275	205	164	138	117	102	92	82	69	59	51	46	41	35	30	27	26	23	21	18	15	13
12°	252	189	150	126	108	95	83	75	63	54	48	42	38	31	27	25	24	21	19	16	14	13
13°	232	174	140	116	100	87	77	70	58	50	44	39	35	29	25	23	22	20	18	15	13	12
14°	216	162	130	108	93	81	72	65	54	47	41	36	33	27	24	22	20	18	17	14	12	11
15°	203	152	121	100	87	76	68	61	50	44	38	34	31	25	22	20	19	17	16	13	11	10
16°	190	142	114	95	81	71	63	57	48	41	36	32	29	24	21	19	18	16	15	12	10	10
17°	180	132	105	88	77	67	60	53	44	38	33	29	27	22	19	18	17	15	14	11	9	9
18°	169	126	102	85	73	63	56	51	43	37	32	28	26	21	18	17	16	14	13	10	9	9
19°	161	120	97	80	69	60	53	49	40	35	30	27	25	20	17	16	15	14	12	10	8	8
20°	153	115	92	76	65	58	51	46	38	33	29	26	23	19	16	15	15	13	11	9	8	8
22°	140	106	84	70	60	53	47	42	35	30	27	24	21	18	15	14	14	12	10	9	8	7
24°	128	98	77	64	56	49	43	39	32	28	25	22	20	16	14	13	13	11	10	8	7	6
26°	119	90	72	60	51	45	40	35	29	25	22	19	18	15	13	12	11	10	9	8	6	6
28°	111	83	67	56	48	42	37	34	28	24	21	18	17	14	12	11	11	9	8	7	6	5
30°	105	78	63	52	45	39	35	32	26	23	20	17	16	13	11	11	10	9	8	6	6	5
35°	91	68	55	46	39	34	31	28	23	20	17	16	14	12	10	9	9	8	7	6	5	4
40°	81	61	49	40	35	31	27	25	20	18	16	14	13	10	9	8	8	7	6	5	4	4
45°	74	55	44	37	32	28	25	22	19	16	14	13	11	9	8	7	7	6	5	5	4	3
50°	68	51	41	34	29	26	23	21	17	15	13	12	11	8	8	7	6	6	5	4	4	3
60°	60	45	36	30	26	23	20	18	16	13	12	11	10	8	7	6	6	5	5	4	3	3
70°	56	42	34	28	24	21	18	17	14	12	11	9	9	7	6	6	5	5	5	4	3	3
80°	53	40	32	26	23	20	17	16	13	11	10	8	8	7	6	5	5	4	4	4	3	2

FEED CONSTANTS — TABLE NO. 15 — FEED = .030′ PER REV. OF WORK

N. D. P.	3	4	5	6	7	8	9	10	12	14	16	18	20	24	28	30	32	36	40	48	56	60
N. C. P.	1.0472	.7854	.62832	.52360	.44880	.39270	.34906	.31416	.26180	.22440	.19635	.17453	.15708	.13090	.11220	.10472	.09817	.08726	.07854	.06545	.05610	.05236
3°	667	500	400	333	285	250	222	200	166	143	125	111	100	83	72	67	62	55	50	42	36	33
5°	400	300	240	200	172	150	133	120	100	86	75	67	60	50	43	40	38	34	30	25	22	20
7°	285	215	172	143	124	108	95	86	72	62	54	47	43	36	31	29	27	24	22	18	15	15
9°	222	166	134	111	95	83	74	67	56	48	42	37	33	28	24	22	21	19	17	14	12	11
10°	200	150	120	100	86	75	67	60	50	43	38	33	30	25	22	20	19	17	15	12	11	10
11°	183	138	110	92	78	69	61	55	46	39	35	30	27	23	20	18	17	15	14	11	10	9
12°	166	126	100	83	72	63	55	50	42	36	31	27	25	21	18	17	15	14	13	10	9	9
13°	153	116	92	77	67	58	51	46	39	33	29	25	23	20	17	15	14	13	12	10	9	8
14°	144	108	86	72	62	54	48	43	36	31	27	24	22	18	16	14	14	12	11	9	8	7
15°	135	100	82	68	58	50	45	41	34	29	25	22	20	17	15	13	13	11	10	9	8	7
16°	126	95	76	63	54	48	42	38	32	27	24	21	19	16	14	13	12	10	9	8	7	6
17°	119	88	71	60	51	44	40	35	29	25	22	19	18	15	13	12	11	10	9	8	6	6
18°	112	85	68	56	48	43	38	34	28	24	21	19	17	14	12	11	11	9	8	7	6	5
19°	105	80	64	53	46	40	35	32	27	23	20	17	16	14	11	11	10	9	8	7	6	5
20°	102	76	62	51	43	38	34	31	26	21	19	17	15	13	10	10	10	8	7	6	5	5
22°	93	70	56	47	40	35	31	28	24	20	18	15	14	12	10	9	9	8	7	6	5	4
24°	85	64	52	43	37	32	28	26	22	19	16	14	13	11	9	9	8	7	6	6	5	4
26°	80	60	47	40	34	29	26	23	19	17	15	13	12	10	9	8	7	6	6	5	5	4
28°	74	56	44	37	31	28	24	22	18	16	14	12	11	9	8	7	7	6	5	5	4	4
30°	70	52	42	35	30	26	23	21	17	15	13	12	10	9	7	7	6	6	5	4	4	3
35°	61	46	36	31	26	23	20	18	16	13	12	10	9	8	6	6	6	5	5	4	3	3
40°	54	40	32	27	23	20	18	16	14	12	10	9	8	7	6	5	5	5	4	4	3	3
45°	49	37	30	25	21	19	16	15	13	11	9	8	7	7	5	5	5	4	4	3	3	2
50°	46	34	28	23	19	17	15	14	12	10	8	8	7	6	5	5	4	4	3	3	2	2
60°	40	30	24	20	18	16	14	13	11	9	8	7	6	6	5	4	4	4	3	3	2	2
70°	37	28	22	18	16	14	12	12	9	8	7	6	6	5	4	4	4	3	3	3	2	2
80°	35	26	21	17	15	13	11	11	8	7	7	6	6	4	4	4	3	3	3	2	2	2

FEED CONSTANTS — TABLE NO. 15 — FEED = .040″ PER REV. OF WORK

N. D. P.	3	4	5	6	7	8	9	10	12	14	16	18	20	24	28	30	32	36	40	48	56	60
N. C. P.	1.0472	.7854	.62832	.52360	.44880	.39270	.34906	.31416	.26180	.22440	.19635	.17453	.15708	.13090	.11220	.10472	.09817	.08726	.07854	.06545	.05610	.05236
3°	500	375	300	250	213	188	166	150	125	106	94	83	75	63	53	50	47	42	38	31	27	25
5°	300	225	180	150	129	112	100	90	75	65	56	50	45	38	33	30	28	25	23	19	16	15
7°	215	161	129	108	93	81	72	65	54	47	40	36	32	27	24	22	20	18	16	14	12	11
9°	166	125	100	83	72	63	56	50	42	36	31	28	25	21	18	17	15	14	13	11	9	9
10°	150	112	90	75	65	56	50	45	38	33	28	25	23	19	16	15	14	13	11	10	8	8
11°	138	102	82	69	59	51	46	41	35	30	26	23	21	17	15	14	13	12	10	9	8	7
12°	126	95	75	63	54	48	42	38	31	27	24	21	19	16	14	13	12	11	10	8	7	6
13°	116	87	70	58	50	44	39	35	29	25	22	20	17	15	13	12	11	10	9	7	6	6
14°	108	81	65	54	47	41	36	33	27	24	20	18	16	14	12	11	10	9	8	7	6	6
15°	100	76	61	50	44	38	34	31	25	22	19	17	15	13	11	10	10	8	8	6	6	5
16°	95	71	57	48	41	36	32	29	24	21	18	16	14	12	10	10	9	8	7	6	5	5
17°	88	67	53	44	38	33	29	27	22	19	17	15	13	11	10	9	9	7	7	6	5	5
18°	85	63	51	43	37	32	28	26	21	18	16	14	13	11	9	9	8	7	6	5	5	4
19°	80	60	49	40	35	30	27	25	20	17	15	14	12	10	8	8	7	7	6	5	4	4
20°	76	58	46	38	33	29	26	23	19	16	14	13	12	10	8	8	7	6	6	5	4	4
22°	70	53	42	35	30	27	24	21	18	15	13	12	11	9	7	7	6	6	5	4	4	4
24°	64	49	39	32	28	25	22	20	16	14	12	11	10	8	7	7	6	6	5	4	3	3
26°	60	45	35	29	25	22	19	18	15	12	11	10	9	7	6	6	6	5	5	4	3	3
28°	56	42	34	28	24	21	18	17	14	12	11	9	9	7	6	6	5	5	4	3	3	3
30°	52	39	32	26	23	20	17	16	13	11	10	9	8	7	5	5	5	4	4	3	3	3
35°	46	34	28	23	20	17	16	14	12	10	9	8	7	6	5	5	5	4	4	3	2	2
40°	40	31	25	20	18	16	14	13	10	9	8	7	6	5	4	4	4	3	3	2	2	2
45°	37	28	22	19	16	14	13	11	9	8	7	7	6	5	4	4	4	3	3	2	2	2
50°	34	26	21	17	15	13	12	11	8	7	7	6	5	4	3	3	3	3	3	2	2	2
60°	30	23	18	16	13	12	11	10	8	7	6	6	5	4	3	3	3	3	2	2	2	2
70°	28	21	17	14	12	11	9	9	7	6	5	5	4	3	3	3	3	2	2	2	1	1
80°	26	20	16	13	11	10	8	8	7	6	5	4	4	3	3	3	2	2	2	2	1	1

FEED CONSTANTS — TABLE NO. 15 — FEED = .050″ PER REV. OF WORK

N. D. P.	3	4	5	6	7	8	9	10	12	14	16	18	20	24	28	30	32	36	40	48	56	60
N. C. P.	1.0472	.7854	.62832	.52360	.44880	.39270	.34906	.31416	.26180	.22440	.19635	.17453	.15708	.13090	.11220	.10472	.09817	.08726	.07854	.06545	.05610	.0523€
3°	400	300	240	200	172	150	133	120	100	86	75	67	60	50	43	40	38	33	30	25	22	20
5°	240	180	144	120	102	90	80	72	60	52	45	40	36	30	26	24	23	20	18	15	13	12
7°	172	129	102	86	74	65	57	52	43	37	32	29	26	22	19	17	16	14	13	11	9	9
9°	134	100	80	67	57	50	45	40	33	29	25	23	20	17	14	13	13	11	10	8	7	7
10°	120	90	73	60	52	45	40	36	30	26	23	20	18	15	13	12	11	10	9	8	7	6
11°	110	82	66	55	47	41	37	33	27	24	21	19	17	14	12	11	10	9	8	7	6	6
12°	100	75	61	50	43	38	33	30	25	22	19	17	15	13	11	10	10	8	7	6	5	5
13°	92	70	56	46	40	35	31	28	23	20	17	16	14	12	10	9	9	8	7	6	5	5
14°	86	65	52	43	37	33	29	26	22	19	16	15	13	11	9	9	8	7	6	6	5	4
15°	82	61	49	41	35	31	27	25	20	18	15	14	12	10	9	8	8	7	6	5	4	4
16°	76	57	45	38	33	29	25	23	19	16	14	13	12	10	8	8	7	6	6	5	4	4
17°	71	53	43	35	30	27	24	21	18	15	13	12	11	9	8	7	7	6	5	5	4	4
18°	68	51	41	34	29	26	23	20	17	15	13	12	11	9	7	7	6	6	5	4	4	3
19°	64	49	39	32	28	25	21	19	16	14	12	11	10	8	7	6	6	5	5	4	3	3
20°	62	46	37	31	26	23	21	18	15	13	12	11	10	8	6	6	6	5	5	4	3	3
22°	56	42	34	28	24	21	19	17	14	12	11	10	9	7	6	6	5	5	4	3	3	3
24°	52	39	31	26	23	20	17	16	13	11	10	9	8	7	6	5	5	4	4	3	3	3
26°	48	35	28	23	20	18	16	14	12	10	9	8	7	6	5	5	5	4	4	3	2	2
28°	44	34	27	22	19	17	15	14	11	9	9	8	7	6	5	4	4	4	3	3	2	2
30°	42	32	25	21	18	16	14	13	10	9	8	7	7	6	4	4	4	3	3	3	2	2
35°	36	28	22	18	16	14	12	11	9	8	7	6	6	5	4	4	4	3	3	2	2	2
40°	32	25	19	16	14	13	11	10	8	7	6	6	5	4	4	3	3	3	3	2	2	2
45°	30	22	18	15	13	11	10	9	7	7	6	5	5	4	3	3	3	2	2	2	2	1
50°	28	21	17	14	12	11	9	8	7	6	5	5	4	4	3	3	3	2	2	2	1	1
60°	24	18	15	13	11	10	8	8	6	6	5	4	4	3	3	3	2	2	2	2	1	1
70°	22	17	14	12	10	9	7	7	6	5	4	4	4	3	3	2	2	2	2	1	1	1
80°	21	16	13	11	9	8	7	7	6	5	4	4	4	3	2	2	2	2	2	1	1	1

FEED CONSTANTS — TABLE NO. 15 — FEED = .060" PER REV. OF WORK

N. D. P.	3	4	5	6	7	8	9	10	12	14	16	18	20	24	28	30	32	36	40	48	56	60
N. C. P.	1.0472	.7854	.62832	.52360	.44880	.39270	.34906	.31416	.26180	.22440	.19635	.17453	.15708	.13090	.11220	.10472	.09817	.08726	.07854	.06545	.05610	.05236
3°	333	250	200	166	143	125	111	100	83	72	63	56	50	42	36	33	31	28	25	21	18	16
5°	200	150	120	100	86	75	67	60	50	43	38	33	30	25	21	20	19	17	15	13	11	10
7°	143	108	86	72	62	54	47	43	36	31	27	24	22	18	16	14	14	12	11	9	8	7
9°	111	83	67	56	48	42	37	33	28	23	21	19	17	14	12	11	10	9	8	7	6	6
10°	100	75	60	50	43	38	33	30	25	22	19	17	15	13	11	10	9	8	8	6	5	5
11°	92	69	55	46	39	35	30	27	23	20	17	15	14	12	10	9	9	8	7	6	5	4
12°	83	63	50	42	36	31	27	25	21	18	16	14	13	11	9	8	8	7	6	5	4	4
13°	77	58	46	39	33	29	25	23	20	16	15	13	12	10	8	8	7	6	6	5	4	4
14°	72	54	43	36	31	27	24	22	18	15	14	12	11	9	8	7	7	6	6	5	4	4
15°	68	50	41	34	29	25	22	20	17	14	13	11	10	9	7	7	6	6	5	4	4	3
16°	63	48	38	32	27	24	21	19	16	13	12	11	10	8	7	6	6	5	5	4	3	3
17°	60	44	35	29	25	22	19	18	15	13	11	10	9	8	6	6	6	5	5	4	3	3
18°	56	43	34	28	24	21	19	17	14	12	11	10	9	7	6	6	5	5	4	3	3	3
19°	53	40	32	27	23	20	17	16	14	11	10	9	8	7	6	5	5	4	4	3	3	3
20°	51	38	31	26	21	19	17	15	13	10	10	9	8	7	5	5	5	4	4	3	3	2
22°	47	35	28	24	20	18	15	14	12	10	9	8	7	6	5	5	4	4	3	3	2	2
24°	43	32	26	22	19	16	14	13	11	9	8	7	7	6	5	4	4	4	3	3	2	2
26°	40	29	23	19	17	15	13	12	10	8	7	6	6	5	4	4	4	3	3	2	2	2
28°	37	28	22	18	16	14	12	11	9	8	7	6	6	5	4	4	3	3	3	2	2	2
30°	35	26	21	17	15	13	12	10	9	7	7	6	6	5	4	3	3	3	3	2	2	2
35°	31	23	18	16	13	12	10	9	8	6	6	5	5	4	3	3	3	3	2	2	2	1
40°	27	20	16	14	12	10	9	8	7	6	5	5	4	4	3	3	3	2	2	2	1	1
45°	25	19	15	13	11	9	8	7	7	5	5	4	4	3	2	2	2	2	2	2	1	1
50°	23	17	14	12	10	8	8	7	6	5	4	4	4	3	2	2	2	2	2	1	1	1
60°	20	16	13	11	9	8	7	6	6	5	4	4	3	3	2	2	2	2	2	1	1	1
70°	18	14	12	9	8	7	6	6	5	4	3	3	3	3	2	2	2	2	1	1	1	1
80°	17	13	11	8	7	7	6	6	4	4	3	3	3	2	2	2	2	1	1	1	1	1

FEED CONSTANTS — TABLE NO. 15 — FEED = .080″ PER REV. OF WORK

N. D. P.	3	4	5	6	7	8	9	10	12	14	16	18	20	24	28	30	32	36	40	48	56	60
N. C. P.	1.0472	.7854	.62832	.52360	.44880	.39270	.34906	.31416	.26180	.22440	.19635	.17453	.15708	.13090	.11220	.10472	.09817	.08726	.07854	.06545	.05610	.05236
3°	250	188	150	125	106	94	83	75	63	53	47	42	38	32	26	25	24	21	19	16	13	12
5°	150	112	90	75	65	56	50	45	38	32	28	25	23	19	16	15	14	13	11	9	8	8
7°	108	81	65	54	47	40	36	32	27	23	20	18	16	14	12	11	10	9	8	7	6	5
9°	83	63	50	42	36	31	28	25	21	18	16	14	13	11	9	8	8	7	6	5	5	4
10°	75	56	45	38	33	28	25	23	19	16	14	13	12	10	8	8	7	6	6	5	4	4
11°	69	51	41	35	30	26	23	21	17	15	13	12	11	9	7	7	6	6	5	4	4	3
12°	63	48	38	31	27	24	21	19	16	14	12	11	10	8	7	6	6	5	5	4	3	3
13°	58	44	35	29	25	22	20	17	15	13	11	10	9	7	6	6	6	5	4	4	3	3
14°	54	41	33	27	24	20	18	16	14	12	10	9	8	7	6	5	5	5	4	3	3	3
15°	50	38	31	25	22	19	17	15	13	11	10	9	8	6	6	5	5	4	4	3	3	2
16°	48	36	29	24	21	18	16	14	12	10	9	8	7	6	5	5	4	4	4	3	3	2
17°	44	33	27	22	19	17	15	13	11	10	8	8	7	6	5	4	4	4	3	3	2	2
18°	43	32	26	21	18	16	14	13	11	9	8	7	7	5	5	4	4	3	3	3	2	2
19°	40	30	25	20	17	15	14	12	10	9	8	7	6	5	4	4	4	3	3	3	2	2
20°	38	29	23	19	16	14	13	12	10	8	7	7	6	5	4	4	3	3	3	2	2	2
22°	35	27	21	18	15	13	12	11	9	8	7	6	6	5	4	4	3	3	3	2	2	2
24°	32	25	20	16	14	12	11	10	8	7	6	6	5	4	3	3	3	3	2	2	2	2
26°	29	22	18	15	12	11	10	9	7	6	6	5	5	4	3	3	3	2	2	2	2	1
28°	28	21	17	14	12	11	9	9	7	6	5	5	4	4	3	3	3	2	2	2	1	1
30°	26	20	16	13	11	10	9	8	7	6	5	5	4	3	3	3	2	2	2	2	1	1
35°	23	17	14	12	10	9	8	7	6	5	4	4	4	3	2	2	2	2	2	1	1	1
40°	20	16	13	10	9	8	7	6	5	5	4	4	3	3	2	2	2	2	2	1	1	1
45°	19	14	11	9	8	7	7	6	5	4	4	3	3	2	2	2	2	2	1	1	1	1
50°	17	13	11	8	7	7	6	5	4	4	3	3	3	2	2	2	2	1	1	1	1	1
60°	16	12	10	8	7	6	6	5	4	3	3	3	3	2	2	1	1	1	1	1	1	1
70°	14	11	9	7	6	5	5	4	3	3	3	3	2	2	1	1	1	1	1	1	1	1
80°	13	10	8	7	6	5	4	4	3	3	3	2	2	2	1	1	1	1	1	1	1	1

FEED CONSTANTS — TABLE NO. 15 — FEED = .100" PER REV. OF WORK

N. D. P.	3	4	5	6	7	8	9	10	12	14	16	18	20	24	28	30	32	36	40	48	56	60
N. C. P.	1.0472	.7854	.62832	.52360	.44880	.39270	.34906	.31416	.26180	.22440	.19635	.17453	.15708	.13090	.11220	.10472	.09817	.08726	.07854	.06545	.05610	.05236
3°	200	150	120	100	86	75	67	60	50	43	38	34	30	25	22	20	19	17	15	12	11	10
5°	120	90	72	60	52	45	40	36	30	26	23	20	18	15	13	12	11	10	9	7	6	6
7°	86	65	52	43	37	32	29	27	22	19	16	15	13	11	9	9	8	7	7	5	5	4
9°	67	50	40	33	29	25	23	20	17	15	13	12	10	9	7	7	6	6	5	4	4	3
10°	60	45	36	30	26	23	20	18	15	13	12	10	9	8	6	6	6	5	4	4	3	3
11°	55	41	33	27	24	21	19	17	14	12	11	10	9	7	6	6	5	5	4	3	3	3
12°	50	38	30	25	22	19	17	15	13	11	10	9	8	7	6	5	5	4	4	3	3	3
13°	46	35	28	23	20	17	16	14	12	10	9	8	7	6	5	5	4	4	4	3	2	2
14°	43	33	26	22	19	16	15	13	11	10	8	8	7	6	5	4	4	4	3	3	2	2
15°	41	31	25	20	18	15	14	12	10	9	8	7	6	5	4	4	4	3	3	3	2	2
16°	38	29	23	19	16	14	13	12	10	8	7	7	6	5	4	4	3	3	3	2	2	2
17°	35	27	21	18	15	13	12	11	9	8	7	6	6	5	4	4	3	3	3	2	2	2
18°	34	26	20	17	15	13	12	11	9	8	7	6	5	4	4	3	3	3	2	2	2	2
19°	32	25	19	16	14	12	11	10	8	7	6	6	5	4	3	3	3	3	2	2	2	2
20°	31	23	18	15	13	12	11	10	8	7	6	5	5	4	3	3	3	2	2	2	2	1
22°	28	21	17	14	12	11	10	9	7	6	6	5	5	4	3	3	3	2	2	2	1	1
24°	26	20	16	13	11	10	9	8	7	6	5	5	4	4	3	3	2	2	2	2	1	1
26°	23	18	14	12	10	9	8	7	6	5	5	4	4	3	2	2	2	2	2	2	1	1
28°	22	17	14	11	9	9	8	7	6	5	4	4	4	3	2	2	2	2	2	1	1	1
30°	21	16	13	10	9	8	7	7	6	5	4	4	4	3	2	2	2	2	2	1	1	1
35°	18	14	11	9	8	7	6	6	5	4	4	3	3	3	2	2	2	2	1	1	1	1
40°	16	13	10	8	7	6	6	5	4	4	3	3	3	2	2	2	2	1	1	1	1	1
45°	15	11	9	7	7	6	5	5	4	4	3	3	3	2	2	2	1	1	1	1	1	1
50°	14	11	8	7	6	5	5	4	4	3	3	3	2	2	2	1	1	1	1	1	1	1
60°	13	10	8	6	6	5	4	4	3	3	3	2	2	2	2	1	1	1	1	1	1	1
70°	12	9	7	6	5	4	4	4	3	3	2	2	2	2	1	1	1	1	1	1	1	1
80°	11	8	7	6	5	4	4	4	3	3	2	2	2	2	1	1	1	1	1	1	1	1

FEED CONSTANTS — TABLE NO. 15 — FEED = .120″ PER REV. OF WORK

N. D. P.	3	4	5	6	7	8	9	10	12	14	16	18	20	24	28	30	32	36	40	48	56	60
N. C. P.	1.0472	.7854	.62832	.52360	.44880	.39270	.34906	.31416	.26180	.22440	.19635	.17453	.15708	.13090	.11220	.10472	.09817	.08726	.07854	.06545	.05610	.05236
3°	166	125	100	83	72	63	56	50	42	36	32	28	25	21	18	17	16	14	12	10	9	8
5°	100	75	60	50	43	38	33	30	25	22	19	17	15	13	11	10	10	8	7	6	5	5
7°	72	54	43	36	31	27	24	22	18	16	14	12	11	9	8	7	7	6	6	5	4	4
9°	56	42	33	28	23	21	19	17	14	11	11	9	9	7	6	6	6	5	5	3	3	3
10°	50	38	30	25	22	19	17	15	13	11	10	9	8	6	6	5	5	4	4	3	3	3
11°	46	35	27	23	20	17	15	14	12	10	9	8	7	6	5	5	4	4	3	3	2	2
12°	42	31	25	21	18	16	14	13	11	9	8	7	7	6	4	4	4	3	3	3	2	2
13°	39	29	23	20	16	15	13	12	10	8	7	7	6	5	4	4	4	3	3	2	2	2
14°	36	27	22	18	15	14	12	11	9	8	7	6	6	5	4	4	3	3	3	2	2	2
15°	34	25	20	17	14	13	11	10	9	7	6	6	5	5	3	3	3	3	3	2	2	2
16°	32	24	19	16	13	12	11	10	8	7	6	6	5	4	3	3	3	3	2	2	2	2
17°	29	22	18	15	13	11	10	9	8	6	6	5	5	4	3	3	3	3	2	2	2	2
18°	28	21	17	14	12	11	10	9	7	6	5	5	4	4	3	3	3	2	2	2	1	1
19°	27	20	16	14	11	10	9	8	7	6	5	5	4	4	3	3	2	2	2	2	1	1
20°	26	19	15	13	10	10	9	8	7	5	5	4	4	4	3	2	2	2	2	2	1	1
22°	24	18	14	12	10	9	8	7	6	5	5	4	4	3	2	2	2	2	2	2	1	1
24°	22	16	13	11	9	8	7	7	6	5	4	4	4	3	2	2	2	2	2	1	1	1
26°	19	15	12	10	8	7	6	6	5	4	4	3	3	3	2	2	2	2	1	1	1	1
28°	18	14	11	9	8	7	6	6	5	4	4	3	3	3	2	2	2	1	1	1	1	1
30°	17	13	10	9	7	7	6	6	5	4	3	3	3	3	2	2	2	1	1	1	1	1
35°	16	12	9	8	6	6	5	5	4	3	3	3	3	2	2	1	1	1	1	1	1	1
40°	14	10	8	7	6	5	5	4	4	3	3	2	2	2	1	1	1	1	1	1	1	1
45°	13	9	7	7	5	5	4	4	3	3	2	2	2	2	1	1	1	1	1	1	1	1
50°	12	8	7	6	5	4	4	4	3	3	2	2	2	2	1	1	1	1	1	1	1	1
60°	11	8	6	6	5	4	4	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1
70°	9	7	6	5	4	3	3	3	3	2	2	2	2	1	1	1	1	1	1	1	1	1
80°	8	7	6	4	4	3	3	3	2	2	2	2	2	1	1	1	1	1	1	1	1	1

Table No. 17 — C = 8 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	80	60	72	39	8	53	30	90	64	94	8
6	88	78	72	40	11	54	36	80	48	97	9
7	96	33	45	75	8	55	24	76	54	78	9
8	80	42	60	75	8	56	28	85	60	92	7
9	72	40	60	80	9	57	24	65	52	91	8
10	40	IDLER		33	10	58	30	75	42	81	7
11	32	IDLER		29	8	59	24	85	65	90	6.5
12	72	57	48	60	8	60	27	65	42	87	6.3
13	56	IDLER		60	7	61	35	71	36	90	7
14	80	74	72	90	8	62	32	88	48	90	8
15	90	51	32	70	8	63	36	88	42	90	7
16	56	IDLER		74	7	64	24	73	48	84	8
17	32	IDLER		45	8	65	27	73	48	96	9
18	96	52	32	88	8	66	24	85	60	93	8
19	72	60	45	85	9	67	24	84	54	86	9
20	32	IDLER		53	8	68	26	84	52	91	6.5
21	42	IDLER		73	7	69	27	90	54	93	9
22	96	70	32	80	8	70	30	74	36	85	9
23	32	IDLER		61	8	71	27	87	48	88	9
24	32	86	81	60	9	72	24	75	48	92	8
25	45	70	60	80	9	73	27	82	45	90	9
26	32	IDLER		69	8	74	30	70	36	95	9
27	72	60	32	86	8	75	30	67	34	95	8.5
28	48	78	56	80	7	76	34	86	36	90	8.5
29	32	88	80	70	8	77	32	82	36	90	8
30	48	76	56	88	7	78	24	84	48	89	8
31	32	76	72	78	8	79	27	71	36	90	9
32	32	IDLER		85	8	80	30	71	32	90	8
33	36	74	60	80	9	81	27	78	36	84	9
34	30	70	72	87	6	82	30	84	39	95	6.5
35	32	62	60	90	8	83	28	85	40	91	8
36	32	70	60	82	8	84	34	93	36	92	8.5
37	32	59	54	90	8	85	32	84	36	97	8
38	32	88	81	93	9	86	27	73	34	90	8.5
39	42	68	45	90	7	87	27	76	35	90	7
40	36	87	64	88	8	88	30	74	32	95	8
41	36	69	45	80	9	89	30	79	32	90	8
42	32	67	48	80	8	90	24	73	39	96	6.5
43	42	75	45	90	7	91	30	87	36	94	7.5
44	36	79	48	80	9	92	28	70	32	98	8
45	41	80	48	92	8.2	93	27	88	40	95	9
46	26	59	54	91	9	94	28	73	32	96	7
47	32	75	48	80	8	95	28	83	36	96	7
48	36	67	42	90	7	96	24	75	36	92	6
49	30	69	48	85	8	97	24	75	36	93	8
50	36	78	48	92	6	98	24	87	40	90	8
51	24	74	64	88	8	99	27	89	36	90	9
52	24	75	60	83	8	100	27	87	36	93	9

Table No. 17 — C = 13 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	78	IDLER		32	13	53	39	86	45	90	13
6	78	70	80	44	13	54	27	78	54	84	13.5
7	78	IDLER		45	13	55	30	84	52	85	13
8	72	57	60	50	12	56	28	90	60	87	14
9	78	IDLER		58	13	57	36	74	39	90	13
10	52	IDLER		43	13	58	36	85	45	92	13.5
11	56	IDLER		51	14	59	24	75	56	88	14
12	78	60	48	62	13	60	39	82	40	95	13
13	39	IDLER		42	13	61	24	72	52	88	13
14	56	IDLER		65	14	62	32	70	39	92	13
15	32	88	84	38	14	63	36	59	30	96	15
16	52	IDLER		69	13	64	32	59	36	104	12
17	39	IDLER		55	13	65	36	82	40	95	12
18	72	45	36	86	12	66	28	71	42	91	14
19	52	IDLER		82	13	67	36	87	39	90	13
20	48	84	78	74	13	68	24	75	53	96	13.25
21	39	IDLER		68	13	69	26	70	45	96	13
22	78	57	30	75	13	70	24	88	56	89	14
23	72	55	30	75	12	71	24	74	48	92	12
24	42	67	60	75	14	72	26	85	48	88	13
25	91	63	24	72	13	73	30	79	39	90	13
26	32	88	84	66	14	74	30	84	40	88	12.5
27	39	70	60	75	13	75	27	87	48	93	12
28	78	66	32	88	13	76	26	91	52	94	13
29	39	IDLER		94	13	77	27	75	39	90	13
30	30	88	80	68	12.5	78	32	85	36	88	12
31	26	IDLER		67	13	79	30	81	39	95	13
32	30	83	78	75	13	80	27	83	42	91	13.5
33	32	79	72	80	12	81	27	69	36	95	13.5
34	36	63	52	84	13	82	26	71	36	90	13
35	24	82	81	69	13.5	83	26	98	48	88	13
36	36	60	54	97	13.5	84	24	75	42	94	14
37	24	80	78	72	13	85	24	82	42	87	14
38	24	87	78	68	13	86	27	80	36	87	13.5
39	24	88	78	69	13	87	24	79	40	88	10
40	24	86	84	78	14	88	30	78	33	93	13.75
41	24	84	78	76	13	89	25	85	39	85	13
42	32	94	74	88	12⅓	90	24	83	42	91	12
43	30	62	52	90	13	91	28	67	30	95	14
44	24	82	70	75	14	92	28	78	32	88	14
45	24	85	70	74	14	93	31	90	36	96	10⅓
46	24	93	81	80	13.5	94	24	92	48	98	12
47	30	69	50	85	12.5	95	30	89	36	96	15
48	39	84	48	89	13	96	28	79	36	102	14
49	26	53	48	96	13	97	25	85	40	95	10
50	30	78	50	80	12.5	98	30	88	32	89	10
51	36	69	42	93	14	99	30	85	33	96	11
52	24	75	65	90	13	100	27	71	30	95	13.5

Table No. 17 — C = 18 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	96	64	76	47	19	53	34	75	45	90	17
6	96	34	60	84	20	54	33	89	54	90	16.5
7	81	75	72	45	18	55	30	87	57	90	19
8	96	88	72	52	18	56	33	71	42	91	16.5
9	80	70	81	69	18	57	27	75	48	82	18
10	76	90	80	56	19	58	36	67	37	96	18.5
11	76	80	90	78	19	59	27	84	57	90	19
12	96	80	72	86	18	60	33	86	48	92	16.5
13	51	IDLER		55	17	61	34	74	36	84	17
14	68	IDLER		79	17	62	34	78	40	90	17
15	57	IDLER		71	19	63	28	91	57	92	19
16	60	70	72	82	18	64	24	81	57	90	19
17	54	61	72	90	18	65	34	69	36	96	17
18	48	68	72	76	18	66	36	86	40	92	15
19	48	93	81	66	18	67	28	71	40	88	17.5
20	56	82	74	84	18.5	68	32	70	34	88	17
21	48	87	81	78	18	69	30	73	36	85	18
22	54	79	72	90	18	70	34	82	36	87	17
23	96	59	27	84	18	71	32	67	34	96	17
24	38	70	72	78	19	72	25	71	45	95	18.75
25	45	79	76	90	19	73	34	80	36	93	17
26	36	68	76	87	19	74	32	76	37	96	18.5
27	54	90	72	97	18	75	30	71	36	95	18
28	95	59	24	90	19	76	32	81	36	90	16
29	34	IDLER		82	17	77	27	82	45	95	16.2
30	72	49	24	88	18	78	24	86	48	87	16
31	40	70	57	84	19	79	27	75	38	90	19
32	48	75	54	92	18	80	30	85	37	87	18.5
33	45	78	60	95	15	81	36	93	36	94	18
34	38	86	72	90	19	82	24	69	40	95	16
35	30	74	72	85	18	83	34	90	36	94	17
36	34	65	60	94	17	84	24	79	40	85	16
37	38	78	60	90	19	85	30	84	36	91	15
38	34	75	60	86	17	86	30	80	35	94	17.5
39	32	74	57	80	19	87	30	74	32	94	20
40	32	69	57	88	19	88	30	81	35	95	17.5
41	30	80	68	87	17	89	24	65	38	104	19
42	36	92	68	93	17	90	27	78	37	96	18.5
43	32	73	51	80	17	91	24	72	38	96	19
44	24	72	68	83	17	92	30	75	31	95	15.5
45	26	61	57	91	19	93	27	79	34	90	17
46	76	72	24	97	19	94	27	89	40	95	18
47	34	84	60	95	17	95	24	82	38	88	19
48	24	59	56	91	16	96	24	91	46	97	18.4
49	34	78	45	80	17	97	28	78	30	87	17.5
50	36	87	54	93	18	98	27	82	32	86	18
51	38	77	42	88	19	99	27	79	33	93	19.8
52	24	85	72	88	18	100	28	82	32	91	16

Table No. 17 — C = 23 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	92	IDLER		38	23	53	36	82	48	93	24
6	72	65	80	44	24	54	25	95	60	71	25
7	69	IDLER		40	23	55	24	79	69	96	23
8	92	IDLER		61	23	56	32	78	46	88	23
9	72	30	48	86	24	57	30	80	50	89	25
10	88	IDLER		73	22	58	33	75	40	85	22
11	46	IDLER		42	23	59	30	67	45	99	25
12	80	70	72	82	24	60	30	71	45	95	22.5
13	88	IDLER		95	22	61	24	77	60	95	24
14	72	60	48	67	24	62	24	90	69	95	23
15	69	IDLER		86	23	63	36	88	41	88	24.6
16	88	45	30	78	22	64	32	67	33	84	22
17	46	IDLER		65	23	65	24	72	46	83	23
18	40	70	69	59	23	66	25	97	60	85	25
19	60	70	48	65	24	67	24	70	46	88	23
20	92	68	32	72	23	68	24	65	44	92	22
21	90	69	36	82	22.5	69	32	74	33	82	22
22	72	62	32	68	24	70	32	73	36	92	24
23	69	64	32	66	23	71	24	68	46	96	23
24	32	76	69	58	23	72	24	76	47	89	23.5
25	48	82	69	84	23	73	25	72	45	95	25
26	64	56	36	89	24	74	24	81	46	84	23
27	69	62	32	80	23	75	24	68	44	97	22
28	36	61	64	88	24	76	26	85	47	91	23.5
29	66	49	28	91	22	77	26	87	48	92	26
30	45	66	47	80	23.5	78	32	70	33	98	22
31	36	72	69	89	23	79	30	84	40	94	25
32	38	49	46	95	23	80	26	84	48	99	26
33	36	75	66	87	22	81	30	95	46	98	23
34	32	71	69	88	23	82	28	85	40	90	28
35	32	67	69	96	23	83	27	80	36	84	27
36	42	65	47	91	23.5	84	24	65	36	93	24
37	32	80	69	85	23	85	32	84	33	89	22
38	32	72	69	97	23	86	24	76	42	95	21
39	69	64	24	84	23	87	24	83	42	88	21
40	54	87	45	93	22.5	88	32	86	33	90	22
41	66	53	24	102	22	89	24	88	46	93	23
42	60	53	24	95	24	90	27	78	37	96	18.5
43	30	78	69	95	23	91	32	87	33	92	22
44	30	86	72	92	22.5	92	24	90	46	94	23
45	24	94	92	88	23	93	24	92	48	97	24
46	24	96	94	90	23.5	94	25	87	40	90	25
47	24	96	92	90	23	95	24	82	38	88	19
48	24	98	94	92	23.5	96	32	94	36	98	24
49	25	90	75	85	25	97	29	74	30	95	29
50	24	61	58	95	23.2	98	25	79	36	93	25
51	30	78	60	98	25	99	24	75	36	95	24
52	36	86	48	87	24	100	25	85	40	98	25

Table No. 17 — C = 28 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	81	67	72	36	27	53	27	65	48	88	27
6	90	70	72	46	27	54	27	94	72	93	27
7	90	60	54	47	27	55	36	85	50	97	30
8	76	95	81	43	27	56	36	73	40	92	30
9	72	33	54	88	27	57	29	59	42	98	29
10	48	62	84	54	28	58	29	82	48	82	29
11	87	53	48	72	29	59	24	76	58	90	29
12	84	60	48	67	28	60	29	74	48	94	29
13	45	90	87	47	29	61	29	68	42	91	29
14	84	68	48	69	28	62	30	71	44	96	27.5
15	48	84	87	62	29	63	29	83	48	88	29
16	57	84	72	65	28.5	64	25	82	56	91	25
17	56	75	72	76	28	65	30	84	45	87	25
18	60	97	81	75	27	66	24	80	57	94	28.5
19	84	59	32	72	28	67	24	98	60	82	30
20	48	86	84	78	28	68	39	93	40	95	26
21	72	68	40	74	30	69	27	95	60	98	27
22	32	82	84	60	28	70	33	74	35	91	27.5
23	87	72	32	74	29	71	24	84	58	98	29
24	32	88	84	61	28	72	28	65	36	93	28
25	32	88	78	59	26	73	29	69	36	92	29
26	54	74	57	90	28.5	74	29	65	36	99	29
27	87	68	24	69	29	75	36	88	36	92	27
28	24	87	84	54	28	76	24	79	52	100	26
29	87	60	24	84	29	77	29	90	45	93	29
30	32	88	87	79	29	78	30	67	33	96	27.5
31	40	68	56	85	28	79	28	67	36	99	28
32	48	77	53	88	26.5	80	26	84	48	99	26
33	28	91	84	71	28	81	25	88	48	92	25
34	27	88	76	66	28.5	82	28	85	40	90	28
35	32	89	84	88	28	83	27	80	36	84	27
36	40	53	42	95	28	84	24	65	36	93	24
37	36	69	56	90	28	85	29	88	39	91	29
38	27	75	72	82	27	86	28	83	36	87	28
39	36	67	47	82	28.2	87	29	65	30	97	29
40	36	78	54	83	27	88	27	75	36	95	27
41	27	79	72	84	27	89	29	86	36	90	29
42	28	94	72	75	28	90	24	67	35	94	35
43	27	87	72	80	27	91	30	75	31	94	31
44	32	80	58	85	29	92	30	89	36	93	30
45	36	71	50	95	30	93	24	77	41	99	27 1/3
46	28	66	56	91	28	94	25	87	40	90	25
47	40	82	44	84	27.5	95	29	81	30	85	29
48	40	79	42	85	28	96	32	94	36	98	24
49	29	71	48	80	29	97	29	74	30	95	29
50	29	69	48	84	29	98	25	79	36	93	25
51	27	72	54	86	27	99	24	83	39	93	26
52	27	61	48	92	27	100	25	85	40	98	25

Table No. 17 — C = 34 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	70	IDLER		29	35	53	36	76	44	92	33
6	88	29	51	77	34	54	24	67	54	87	36
7	85	79	72	45	34	55	32	84	51	89	34
8	80	62	70	60	35	56	24	65	54	93	36
9	72	61	68	60	34	57	33	90	54	94	33
10	88	28	36	94	33	58	34	73	40	90	34
11	70	IDLER		64	35	59	40	86	42	96	35
12	72	74	68	66	34	60	24	82	67	98	33.5
13	68	49	60	90	34	61	28	97	60	88	35
14	51	75	72	57	34	62	32	98	51	86	34
15	88	52	36	76	33	63	25	95	63	87	35
16	88	68	54	93	33	64	34	75	36	87	34
17	88	56	36	80	33	65	32	94	51	94	34
18	68	52	48	94	34	66	24	75	54	95	36
19	30	83	84	48	35	67	32	66	34	92	34
20	68	56	48	97	34	68	28	61	40	104	35
21	68	62	48	92	34	69	25	71	42	85	35
22	48	72	68	83	34	70	28	79	45	93	35
23	48	88	68	71	34	71	28	72	40	92	35
24	32	91	84	59	32	72	33	75	36	95	33
25	84	69	30	76	35	73	33	84	36	86	33
26	72	66	36	85	36	74	29	65	36	99	29
27	30	96	84	59	35	75	30	82	42	96	35
28	30	89	84	66	35	76	32	82	34	84	34
29	42	65	50	78	35	77	28	75	38	91	38
30	36	69	66	86	33	78	33	83	36	93	33
31	32	78	68	72	34	79	28	81	40	91	40
32	32	88	64	62	32	80	33	87	36	91	33
33	24	95	85	59	34	81	24	79	40	82	40
34	32	88	68	70	34	82	31	77	32	88	31
35	48	87	51	82	34	83	24	91	51	93	34
36	32	70	54	74	36	84	25	67	36	94	37.5
37	66	61	24	80	33	85	24	83	42	86	42
38	36	81	64	90	32	86	24	75	41	94	41
39	40	62	42	88	35	87	29	65	30	97	29
40	28	86	71	77	35.5	88	28	75	38	104	33.25
41	27	78	77	91	33	89	28	73	32	91	32
42	32	85	60	79	32	90	24	67	35	94	35
43	36	68	48	91	36	91	30	79	33	95	33
44	32	67	48	84	32	92	24	74	35	87	35
45	37	78	45	80	37	93	27	86	37	90	37
46	24	74	66	82	33	94	24	71	34	90	34
47	33	75	54	93	33	95	29	81	30	85	29
48	24	92	70	73	35	96	24	67	37	106	37
49	32	74	51	90	34	97	27	80	33	90	33
50	36	68	44	97	33	98	32	88	32	95	32
51	33	87	54	87	33	99	24	71	33	92	33
52	36	70	44	98	33	100	24	86	40	93	40

Table No. 17 — C = 42 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	82	IDLER		34	41	53	36	75	42	89	42
6	82	70	72	42	41	54	36	75	44	95	44
7	82	66	72	52	41	55	36	67	39	96	39
8	84	60	72	67	42	56	36	83	43	87	43
9	82	72	81	69	41	57	33	69	48	109	44
10	86	78	72	66	43	58	30	77	51	96	42.5
11	86	59	72	96	43	59	36	78	41	93	41
12	72	84	83	71	41.5	60	36	87	44	91	44
13	86	62	54	81	43	61	30	69	43	95	43
14	87	76	72	96	43.5	62	35	75	39	94	45.5
15	84	51	36	74	42	63	29	68	42	94	40.6
16	84	61	36	66	42	64	31	70	36	85	46.5
17	84	62	48	92	42	65	30	74	41	90	41
18	82	66	36	67	41	66	29	82	54	105	43.5
19	86	68	36	72	43	67	36	87	42	97	42
20	82	63	36	78	41	68	32	82	38	84	38
21	82	60	36	86	41	69	36	89	40	93	40
22	84	71	36	78	42	70	31	75	39	94	40.3
23	86	65	30	76	43	71	32	80	41	97	41
24	84	53	30	95	42	72	27	55	36	106	40.5
25	82	64	36	96	41	73	30	85	41	88	41
26	82	71	32	80	41	74	32	70	33	93	44
27	86	58	27	90	43	75	27	78	43	93	43
28	82	74	36	93	41	76	31	92	45	96	38.75
29	36	89	86	84	43	77	28	75	38	91	38
30	30	80	79	74	39.5	78	32	73	33	94	44
31	30	90	86	74	43	79	24	78	40	81	40
32	84	68	24	79	42	80	32	92	44	102	44
33	32	83	84	89	44.8	81	24	79	40	82	40
34	89	72	24	84	44.5	82	36	89	38	105	38
35	86	64	24	94	43	83	24	82	42	85	42
36	86	68	24	91	43	84	30	83	34	86	42.5
37	27	96	75	65	45	85	24	83	42	86	42
38	43	71	48	92	43	86	24	75	41	94	41
39	24	94	82	68	41	87	32	86	33	89	44
40	24	92	84	73	42	88	28	91	43	97	43
41	27	84	82	90	41	89	27	77	35	91	45
42	27	68	54	75	40.5	90	28	89	39	92	45.5
43	43	77	45	90	43	91	30	89	36	92	45
44	36	61	43	93	43	92	24	82	37	83	37
45	37	78	54	96	37	93	27	86	37	90	37
46	37	81	48	84	37	94	24	71	34	90	34
47	37	79	48	88	37	95	24	93	47	96	47
48	36	65	42	93	42	96	24	82	44	103	44
49	40	78	43	90	43	97	24	86	47	106	47
50	34	59	40	96	42.5	98	24	73	38	102	38
51	36	74	45	93	45	99	28	97	42	100	49
52	25	77	64	90	40	100	24	86	40	93	40

Table No. 17 — C = 50 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	75	83	80	30	50	53	30	78	53	90	53
6	75	69	72	39	50	54	36	75	44	95	44
7	51	89	90	30	51	55	24	87	72	91	48
8	80	70	75	57	50	56	32	71	39	82	52
9	84	49	53	68	53	57	25	74	48	77	50
10	97	88	72	66	48.5	58	26	67	48	90	52
11	54	84	85	50	51	59	30	80	51	94	51
12	51	78	72	47	51	60	35	67	36	94	52.5
13	64	88	75	59	50	61	32	83	49	96	49
14	72	46	51	93	51	62	32	70	36	85	48
15	48	82	78	57	52	63	25	67	48	94	50
16	75	51	48	94	50	64	28	88	56	95	49
17	42	78	84	64	49	65	26	82	53	91	53
18	48	87	75	62	50	66	32	73	39	94	52
19	48	78	75	73	50	67	24	81	52	86	52
20	48	74	75	81	50	68	24	71	47	90	47
21	54	67	66	93	49.5	69	32	77	36	86	48
22	48	59	51	76	51	70	24	83	51	86	51
23	47	IDLER		90	47	71	24	78	50	91	50
24	48	50	49	94	49	72	24	79	45	82	45
25	52	68	49	78	49	73	25	82	48	89	50
26	48	68	53	81	53	74	34	77	36	98	51
27	32	76	75	71	50	75	27	78	43	93	43
28	78	60	32	97	52	76	33	74	34	96	46.75
29	32	84	75	69	50	77	24	82	49	92	49
30	63	53	33	98	49.5	78	34	82	36	97	51
31	36	79	68	80	51	79	24	86	49	90	49
32	32	78	75	82	50	80	24	86	50	93	50
33	75	68	32	97	50	81	27	93	49	96	49
34	39	76	64	93	52	82	24	87	52	98	52
35	32	53	50	88	50	83	27	69	34	92	51
36	48	82	49	86	49	84	30	89	39	92	48.75
37	48	82	51	92	51	85	25	82	44	95	55
38	24	79	78	75	52	86	24	93	53	98	53
39	27	71	68	84	51	87	33	91	35	92	55
40	32	63	52	88	52	88	26	61	32	100	52
41	30	55	51	95	51	89	27	77	35	91	45
42	36	75	53	89	53	90	28	89	39	92	45.5
43	36	78	49	81	49	91	30	89	36	92	45
44	32	74	53	84	53	92	26	90	42	93	45.5
45	36	74	51	93	51	93	24	92	47	95	47
46	40	75	46	94	46	94	30	93	38	96	47.5
47	24	81	75	87	50	95	24	93	47	96	47
48	36	94	64	98	48	96	30	94	38	97	47.5
49	36	80	49	90	49	97	28	88	35	90	49
50	36	79	49	93	49	98	25	71	32	92	50
51	27	75	51	78	51	99	28	97	42	100	49
52	32	71	42	82	56	100	31	87	32	95	49.6

Table No. 17 — C = 59 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	90	49	59	45	59	53	31	73	48	90	62
6	96	73	61	40	61	54	30	79	48	82	60
7	90	71	61	45	61	55	28	86	61	91	61
8	80	60	62	55	62	56	24	78	62	89	62
9	72	60	59	53	59	57	27	84	57	87	57
10	72	57	59	62	59	58	36	71	40	98	60
11	59	IDLER		54	59	59	24	80	59	87	59
12	96	68	61	86	61	60	29	71	48	98	58
13	80	60	61	88	61	61	24	80	61	93	61
14	64	50	59	88	59	62	28	89	56	91	56
15	60	52	59	85	59	63	27	93	63	96	63
16	72	69	59	82	59	64	33	79	44	98	60.5
17	60	70	61	74	61	65	31	79	40	85	62
18	54	83	80	78	60	66	29	86	48	89	58
19	60	70	59	80	59	67	36	83	38	92	57
20	48	53	61	92	61	68	28	81	48	94	56
21	63	80	61	84	61	69	31	91	48	94	62
22	48	68	58	75	58	70	36	89	39	92	58.5
23	32	86	87	62	58	71	27	86	49	91	63
24	48	76	61	77	61	72	36	85	37	94	55.5
25	48	67	59	88	59	73	29	83	40	85	58
26	48	73	59	84	59	74	24	90	59	97	59
27	65	53	33	91	55	75	33	98	48	101	66
28	36	92	80	73	60	76	24	94	60	97	60
29	42	63	59	95	59	77	30	73	33	87	55
30	36	61	59	87	59	78	34	82	36	97	51
31	36	63	61	90	61	79	28	76	40	97	70
32	40	74	59	85	59	80	31	87	40	95	62
33	36	60	57	94	57	81	27	93	49	96	49
34	87	73	24	81	58	82	33	80	33	93	60.5
35	36	72	59	86	59	83	31	70	32	98	62
36	27	78	79	82	59.25	84	33	97	42	100	57.75
37	76	68	27	93	57	85	25	82	44	95	55
38	32	72	59	83	59	86	26	81	40	92	65
39	36	75	59	92	59	87	33	91	35	92	55
40	24	67	62	74	62	88	29	81	32	84	58
41	24	62	59	78	59	89	24	100	59	105	59
42	25	71	69	85	57.5	90	27	84	39	94	58.5
43	32	76	61	92	61	91	21	68	41	96	57.4
44	24	58	60	91	60	92	26	77	34	88	55.25
45	30	70	61	98	61	93	27	87	42	101	63
46	27	89	80	93	60	94	29	79	32	92	58
47	32	84	59	88	59	95	27	85	35	88	63
48	32	74	48	83	64	96	30	94	38	97	47.5
49	24	68	59	85	59	97	28	88	35	90	49
50	36	74	38	77	57	98	34	106	42	110	59.5
51	30	80	59	94	59	99	27	91	38	93	57
52	24	67	58	90	58	100	26	84	38	98	61.75

Table No. 17 — C = 68 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	88	56	72	47	66	53	39	82	40	84	65
6	72	74	68	33	68	54	37	85	48	94	74
7	68	25	60	95	68	55	32	65	43	97	68.8
8	88	34	54	93	66	56	24	94	68	81	68
9	68	78	72	47	68	57	24	83	67	92	67
10	69	78	72	53	69	58	24	99	70	82	70
11	67	92	72	48	67	59	26	71	50	90	65
12	72	74	71	69	71	60	24	94	76	97	76
13	72	84	69	64	69	61	34	67	38	98	64.6
14	66	78	72	71	66	62	24	94	69	91	69
15	92	47	36	88	69	63	27	93	63	96	63
16	48	68	67	63	67	64	32	91	48	90	64
17	64	88	68	70	68	65	24	96	65	88	65
18	48	68	69	73	69	66	36	98	50	101	75
19	40	80	67	53	67	67	24	88	67	102	67
20	90	71	36	76	67.5	68	32	67	34	92	68
21	67	57	36	74	67	69	27	84	46	85	69
22	36	69	68	65	68	70	28	71	40	92	70
23	67	55	36	84	67	71	27	79	46	93	69
24	48	92	70	73	70	72	33	98	50	101	68.75
25	28	88	80	53	70	73	26	71	44	98	71.5
26	48	93	68	76	68	74	32	78	34	86	68
27	45	49	46	95	69	75	33	98	48	101	66
28	36	75	67	75	67	76	32	77	38	100	76
29	32	72	68	73	68	77	27	83	46	96	69
30	67	49	24	82	67	78	27	84	45	94	67.5
31	68	49	24	86	68	79	28	76	40	97	70
32	48	87	51	75	68	80	32	74	34	98	68
33	30	85	67	65	67	81	26	84	45	94	65
34	32	88	67	69	67	82	27	85	47	102	70.5
35	68	61	28	91	68	83	32	76	34	99	68
36	33	95	72	75	66	84	23	61	36	95	69
37	67	59	28	98	67	85	32	74	32	98	64
38	32	84	68	82	68	86	26	81	40	92	65
39	36	93	66	83	66	87	29	81	42	109	67⅔
40	36	93	69	89	69	88	23	70	44	106	63.25
41	28	92	76	79	66.5	89	25	71	36	94	75
42	36	97	67	87	67	90	21	88	57	102	66.5
43	24	79	68	74	68	91	21	83	49	94	68.6
44	26	79	63	76	68.25	92	28	61	27	95	63
45	28	67	60	94	70	93	27	87	42	101	63
46	24	78	67	79	67	94	24	77	34	83	68
47	24	71	68	90	68	95	27	85	35	88	63
48	24	86	69	77	69	96	21	83	42	85	73.5
49	36	65	46	104	69	97	24	73	35	93	70
50	24	91	71	78	71	98	24	83	36	85	72
51	30	86	56	83	70	99	25	89	41	95	68⅓
52	24	86	67	81	67	100	26	84	38	98	61.75

Table No. 17 — C = 78 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	96	68	75	44	75	53	24	85	77	96	77
6	96	42	57	65	76	54	27	74	53	87	79.5
7	80	60	76	59	76	55	42	73	33	87	77
8	80	82	77	50	77	56	33	94	58	95	79.75
9	79	71	72	60	79	57	32	94	60	97	80
10	78	38	48	82	78	58	24	94	77	95	77
11	79	56	48	62	79	59	63	79	25	98	75
12	78	66	72	85	78	60	76	94	24	97	76
13	77	75	72	80	77	61	27	78	54	95	81
14	79	78	72	85	79	62	44	74	28	86	77
15	79	74	60	80	79	63	33	75	42	97	77
16	78	58	48	86	78	64	31	76	40	87	77.5
17	79	61	48	88	79	65	32	81	43	92	86
18	78	61	36	69	78	66	36	98	50	101	75
19	79	75	48	80	79	67	36	95	52	110	78
20	77	57	40	90	77	68	32	78	37	86	74
21	80	73	48	92	80	69	33	83	42	96	77
22	75	85	60	97	75	70	28	71	40	92	70
23	88	59	28	80	77	71	24	67	42	89	84
24	81	67	36	87	81	72	33	98	50	101	68.75
25	79	70	40	94	79	73	26	71	44	98	71.5
26	77	87	48	92	77	74	30	61	31	94	77.5
27	75	88	48	92	75	75	25	74	45	95	75
28	72	59	26	74	78	76	24	67	41	93	82
29	77	80	40	93	77	77	33	78	35	95	77
30	54	74	51	93	76.5	78	24	77	39	79	78
31	79	68	30	90	79	79	28	76	40	97	70
32	30	67	62	74	77.5	80	32	74	34	98	68
33	36	87	80	91	80	81	27	80	36	82	81
34	38	82	64	84	76	82	24	67	38	93	76
35	36	82	75	96	75	83	28	71	33	90	77
36	45	84	61	98	76.25	84	24	71	41	97	82
37	42	89	66	96	77	85	32	92	41	101	82
38	66	65	28	90	77	86	30	68	31	98	77.5
39	66	79	35	95	77	87	29	86	36	88	87
40	79	78	24	81	79	88	24	87	44	89	88
41	57	70	32	89	76	89	25	71	36	94	75
42	24	85	83	82	83	90	24	71	43	109	86
43	45	78	45	93	75	91	21	83	49	94	68.6
44	78	73	24	94	78	92	24	91	46	93	92
45	28	67	60	94	70	93	24	73	42	107	84
46	62	81	30	88	77.5	94	28	97	46	104	80.5
47	35	67	44	90	77	95	24	71	37	99	74
48	33	86	58	89	79.75	96	22	87	44	89	80 2/3
49	66	82	28	92	77	97	26	85	36	89	78
50	60	86	32	93	80	98	24	83	36	85	72
51	78	82	24	97	78	99	28	86	35	94	81 2/3
52	51	82	36	97	76.5	100	27	89	36	91	81

Table No. 17 — C = 88 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	89	IDLER		37	89	53	43	93	48	98	86
6	60	85	88	31	88	54	24	71	48	73	96
7	72	82	88	45	88	55	29	78	54	92	87
8	72	74	88	57	88	56	35	71	40	92	87.5
9	60	80	89	50	89	57	32	94	60	97	80
10	72	87	90	62	90	58	32	81	44	84	88
11	48	86	90	46	90	59	40	89	43	95	86
12	54	82	76	50	85.5	60	42	104	53	107	92.75
13	89	51	45	85	89	61	25	90	68	96	85
14	89	50	40	83	89	62	38	100	54	106	85.5
15	54	87	89	69	89	63	24	61	46	95	92
16	48	84	88	67	88	64	34	74	40	98	85
17	88	65	36	69	88	65	32	81	43	92	86
18	24	91	86	34	86	66	27	91	57	93	85.5
19	42	91	89	65	89	67	29	93	54	94	87
20	48	94	87	74	87	68	29	65	36	91	87
21	36	83	87	66	87	69	28	73	39	86	91
22	48	90	88	86	88	70	27	68	38	88	85.5
23	87	50	24	80	87	71	24	67	42	89	84
24	89	61	24	70	89	72	24	67	47	101	94
25	34	90	75	59	85	73	34	88	40	94	85
26	91	55	24	86	91	74	32	84	43	101	86
27	36	95	88	75	88	75	23	85	55	93	84⅓
28	24	94	89	53	89	76	31	79	33	82	85.25
29	89	60	24	86	89	77	33	78	35	95	77
30	48	87	66	91	88	78	20	83	53	83	88⅓
31	86	65	24	82	86	79	24	75	47	99	94
32	89	73	24	78	89	80	27	71	43	109	96.75
33	36	70	58	82	87	81	27	82	45	100	81
34	43	74	48	79	86	82	24	71	42	97	84
35	40	59	43	85	86	83	29	76	36	95	87
36	90	79	24	82	90	84	24	83	42	85	84
37	24	93	88	70	88	85	31	76	36	104	93
38	24	98	89	69	89	86	24	85	43	87	86
39	24	94	88	73	88	87	29	86	36	88	87
40	40	69	44	85	88	88	24	87	44	89	88
41	24	96	89	76	89	89	29	79	36	98	87
42	30	86	68	83	85	90	30	89	36	91	90
43	24	97	88	78	88	91	28	90	39	92	91
44	24	98	88	79	88	92	24	91	46	93	92
45	24	91	89	88	89	93	31	92	36	94	93
46	40	71	44	95	88	94	27	82	38	98	85.5
47	29	73	63	98	87	95	24	79	42	101	84
48	38	94	60	97	95	96	24	95	48	97	96
49	31	67	45	85	93	97	26	85	36	89	78
50	32	73	46	84	92	98	30	87	38	107	95
51	36	95	59	95	88.5	99	28	86	35	94	81⅔
52	32	61	44	100	88	100	27	89	36	91	81

Table No. 17 — C = 100 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	81	57	66	39	99	53	33	61	36	86	99
6	96	52	51	47	102	54	24	71	48	73	96
7	96	31	51	92	102	55	25	78	64	94	100
8	80	29	49	90	98	56	28	59	42	93	98
9	72	29	50	93	100	57	33	91	54	93	99
10	66	86	72	46	99	58	24	65	51	91	102
11	97	39	36	82	97	59	33	73	45	100	99
12	98	47	36	75	98	60	20	57	61	107	101⅔
13	96	58	48	86	96	61	40	93	43	94	107.5
14	97	59	48	92	97	62	27	105	67	89	100.5
15	90	89	57	72	95	63	30	68	38	88	95
16	50	82	80	65	100	64	30	79	40	81	100
17	66	58	54	87	99	65	30	67	40	97	100
18	96	86	49	82	98	66	30	76	41	89	102.5
19	66	94	72	80	99	67	30	77	40	87	100
20	96	63	26	66	104	68	34	73	36	95	102
21	36	93	96	65	96	69	24	71	53	103	106
22	97	79	36	81	97	70	30	76	43	99	107.5
23	36	70	68	67	102	71	24	69	52	107	104
24	54	95	66	75	99	72	28	83	42	85	98
25	25	85	80	49	100	73	33	89	47	106	103.4
26	54	93	66	83	99	74	24	81	52	95	104
27	97	68	24	77	97	75	27	58	33	96	99
28	32	82	78	71	104	76	35	79	36	101	105
29	36	70	66	82	99	77	35	86	36	94	105
30	30	86	78	68	97.5	78	32	81	37	95	98⅔
31	27	78	66	59	99	79	27	85	44	92	99
32	36	74	64	83	96	80	27	71	43	109	96.75
33	36	92	66	71	99	81	30	89	40	91	100
34	27	84	67	61	100.5	82	29	73	35	95	101.5
35	34	86	72	83	102	83	27	78	33	79	99
36	43	106	60	73	107.5	84	34	87	34	93	96⅓
37	28	92	97	91	97	85	30	92	42	97	105
38	28	85	70	73	98	86	27	89	46	100	103.5
39	48	82	51	97	102	87	20	91	59	94	98⅓
40	30	93	80	86	100	88	23	61	34	94	97.75
41	48	78	49	103	98	89	27	73	35	96	105
42	36	82	69	106	103.5	90	30	83	38	103	95
43	27	76	66	84	99	91	28	90	39	92	91
44	26	61	64	100	104	92	27	89	43	100	96.75
45	39	89	56	92	91	93	31	92	36	94	93
46	25	73	64	84	100	94	29	90	42	106	101.5
47	24	106	97	86	97	95	26	74	32	89	104
48	33	59	38	85	104.5	96	32	95	36	97	96
49	25	71	64	92	100	97	28	71	32	102	112
50	28	71	56	92	98	98	24	97	49	99	98
51	36	110	64	89	96	99	27	98	44	100	99
52	40	69	43	108	107.5	100	24	99	50	101	100

Table No. 17 — C = 110 APPROXIMATE — No. 6-10 Machine

No. of Teeth	Driver	Intermediate		Driven	C	No. of Teeth	Driver	Intermediate		Driven	C
		Driven	Driver					Driven	Driver		
5	96	61	55	36	110	53	27	59	48	97	108
6	74	70	72	38	111	54	24	59	53	97	106
7	80	29	56	90	112	55	25	85	69	93	115
8	96	44	53	77	106	56	31	75	42	81	108.5
9	88	46	60	86	110	57	36	73	38	89	114
10	91	46	51	84	110.5	58	34	72	39	89	110.5
11	84	53	62	90	108.5	59	30	96	69	106	115
12	81	70	64	74	108	60	26	67	50	97	108 1/3
13	72	51	53	81	106	61	24	69	56	99	112
14	88	57	45	81	110	62	27	89	67	105	100.5
15	74	64	54	78	111	63	37	92	45	95	111
16	54	75	74	71	111	64	27	67	47	101	105.75
17	74	69	54	82	111	65	33	84	47	100	103.4
18	84	65	48	93	112	66	33	74	42	103	115.5
19	74	62	45	85	111	67	35	84	46	107	115
20	76	53	36	86	114	68	27	83	51	94	114.75
21	92	68	30	71	115	69	28	78	47	97	109 2/3
22	88	59	30	82	110	70	30	76	43	99	107.5
23	74	58	36	88	111	71	24	69	52	107	104
24	88	58	30	91	110	72	28	83	42	85	98
25	36	76	74	73	111	73	33	89	47	106	103.4
26	32	82	84	71	112	74	30	82	43	97	107.5
27	92	64	30	97	115	75	27	58	33	96	99
28	64	88	56	95	112	76	33	84	41	102	112.75
29	80	59	29	95	116	77	35	86	36	94	105
30	81	79	32	82	108	78	27	82	50	107	112.5
31	74	80	36	86	111	79	27	85	44	92	99
32	88	69	25	85	110	80	26	74	38	89	123.5
33	73	85	36	85	109.5	81	34	80	38	109	107 2/3
34	74	77	36	98	111	82	33	84	38	102	104.5
35	56	73	38	85	106.4	83	36	94	37	98	111
36	74	85	36	94	111	84	35	87	38	107	110 5/6
37	81	85	32	94	108	85	30	92	42	97	105
38	27	96	73	65	109.5	86	29	70	32	95	116
39	46	90	56	93	107 1/3	87	28	90	47	106	109 2/3
40	48	94	57	97	114	88	32	73	28	90	112
41	37	75	54	91	111	89	27	73	35	96	105
42	27	78	71	86	106.5	90	25	86	50	109	104 1/6
43	53	93	48	98	106	91	28	79	32	86	112
44	29	81	64	84	116	92	35	96	39	109	113.75
45	29	78	66	92	106 1/3	93	33	87	33	97	121
46	40	82	46	86	115	94	29	90	42	106	101.5
47	29	79	64	92	116	95	22	81	40	86	110
48	42	94	61	109	106.75	96	31	91	40	109	103 1/3
49	28	59	48	93	112	97	28	71	32	102	112
50	40	78	44	94	110	98	25	104	54	106	112.5
51	31	63	44	92	113 2/3	99	21	93	51	95	119
52	40	69	43	108	107.5	100	24	99	50	101	100