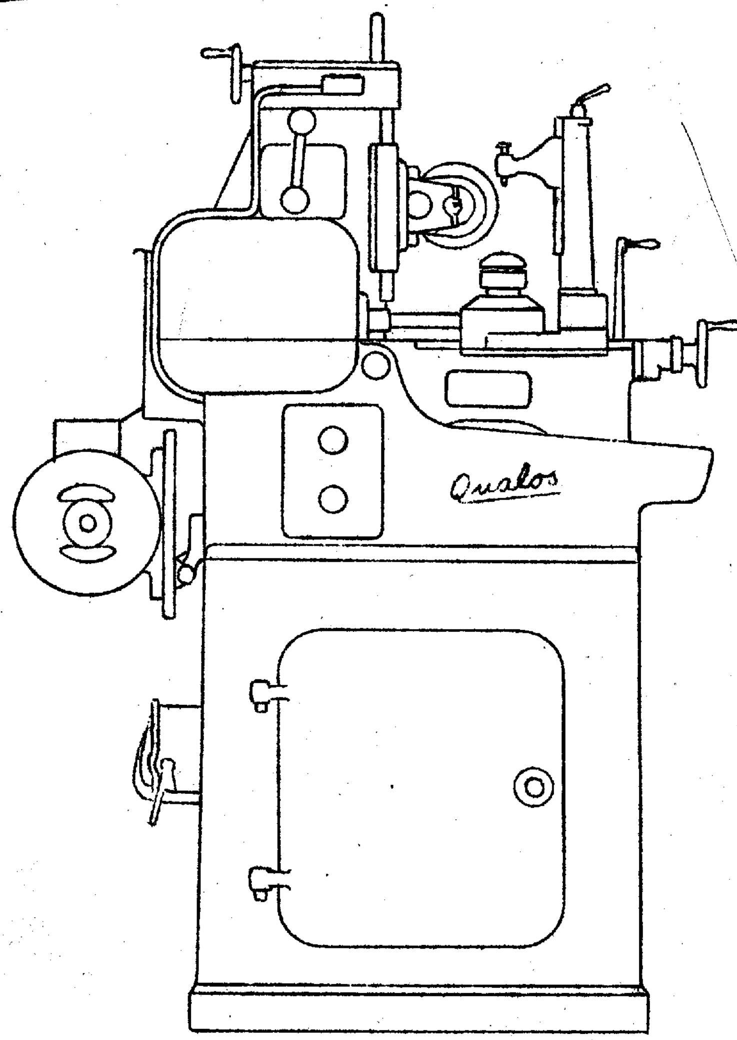
Qualos

PRECISION GEAR HOBBING MACHINE Nº 0.



MANUFACTURED BY

QUALOS MACHINE TOOLS PTY LTD

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AUSTRALIA

OPERATING INSTRUCTIONS

FOR

"QUALOS" No. 0. GEAR HOBBING MACHINE.

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Section 1. Setting the machine in position.

After thoroughly cleaning off all protective packing grease, place the machine on a solid foundation and level up by means of tapered wedges. Using a precision level, place it on the bed slides in both directions and level the machine to within a maximum error of .001" per foot, then it may be bolted down with ½" d. bolts and cemented in position.

Section 2. Lubrication.

a. Column and Main Drive.

The oil reservoir in the column is filled with oil through the opening in the back of the column. After reaching a predetermined level the oil then flows into the main bevel gear drive compartment in the bed. Oil is poured in until the oil sight situated on the front of the machine is completely covered. Approximately 2½ pints of Vactra heavy oil is required.

The column is drained of oil by unscrewing the drain plug in the lead change wheel housing.

The main drive compartment in the bed is drained of oil by unscrewing the drain plug in the index change wheel housing.

There are four oil nipples provided, two on top of the feed pick off gear box at the back of the column, one above the work saddle drive shaft and the other below the micro switch for the lubrication of various bushes.

Another oil nipple is situated above the feed engaging lever for the lubrication of the feed engaging worm and worm wheel.

b. Elevating Gear Box

The elevating gear box which contains three spur gears is mounted on top of the column and is lubricated by one oil nipple on the top cover. Another oil nipple is situated on top of the elevating screw cover. These nipples should be oiled according to the lubrication discs.

c. Hob Head

The hob head contains two compartments to be filled with oil. One compartment which is formed by the hob head and the saddle contains 2 to 1 ratio bevel gears and is kept full of oil by means of the oil nipple located behind the hob. The other compartment is situated at the flywheel end of the hob head and contains two helical drive gears. This compartment is kept full of oil by means of the oil nipple on top of the compartment.

The three remaining nipples lubricate the hob spindle bearing, the spline shaft bevel gear and the hob arbor support bearing.

All the nipples should be oiled according to the lubrication discs placed under the nipples.

d. Work Saddle.

The work saddle which contains the index worm and worm wheel is lubricated by means of a nipple positioned at the front of the work spindle. This saddle is filled with oil until reaching the oil level plug hole located on the front of the index worm housing.

The draining of the saddle may be carried out by means of an oil plug at the back of the saddle.

The remaining nipples at each side of the tail column lubricate the bed ways and should be oiled according to the lubrication discs.

e. Infeed Screw Bearings.

The infeed screw bearing which is located at the end of the bed should be oiled occasionally by unscrewing the grub screw marked "OIL" and giving a few drops of oil.

Section 3. Electrical Connections.

Fig. 1 shows the wiring diagram for the machine. It is only necessary to bring the supply to the isolator switch making certain that the hob runs in a clockwise direction.

Section 4. Coolant System.

The coolant is pumped through a system of pipes to where the hob is cutting, by a centrifugal force pump. The coolant, after passing through a grill in the suds tray to a compartment in the bed, flows through a pipe to a tank inside the pedestal in which the coolant pump is mounted.

Section 5. Running the Machine

These machines have been run as much as possible when being manufactured and tested, but not sufficiently to run them in thoroughly, particularly the feed and differential mechanisms. We advise, therefore, that careful running in be given them until thoroughly free in all respects.

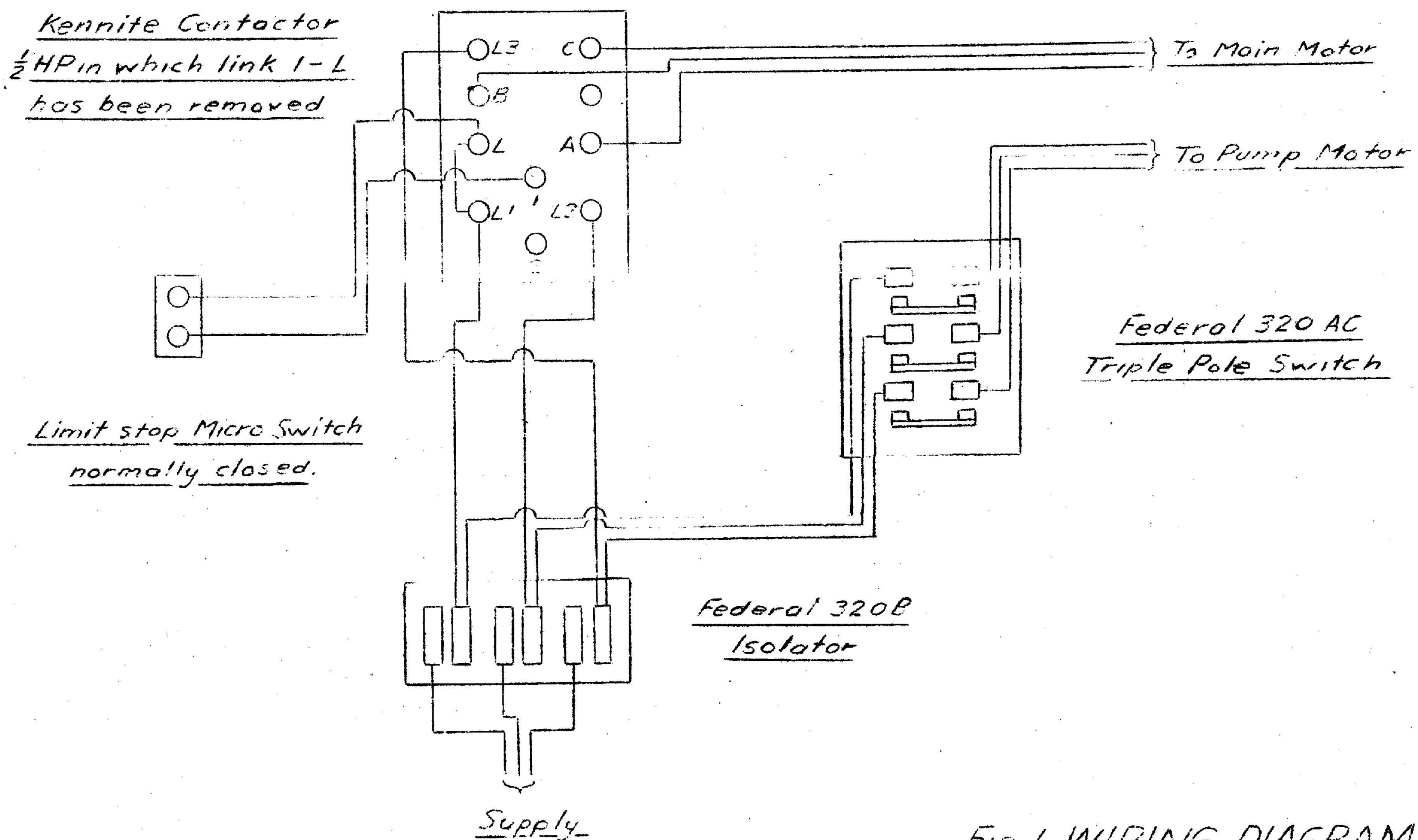


Fig 1. WIRING DIAGRAM

In their manufacture, very close tolerances have been given to all parts with the object of giving longer life, therefore it is understandable that care in lubrication and running in, in the initial stages, be exercised.

Section 6. Description and Operation.

a. General Description.

The Qualos No. 0. Hobbing Machine consists mainly of a bed with a column mounted at one end, so that the slides of each form a right angle. Sliding vertically on the column is the hob head which carries the cutter or hob. On the bed is mounted the work saddle which can slide to and from the column by means of an infeed screw mounted at the opposite end of the bed to the column.

b. Column and Main Drive.

The hob is driven by means of a "Vee" belt and a system of gears and shafts. The selection of hob speeds is obtained by means of the stepped "Vee" belt pulleys at the rear of the machine. The speed used is dependent on the diameter of the hob and the cutting speed of the material of which the gear blank is made.

The feed of the hob is engaged by the lever(1.) Fig. 21 and may be disengaged by the feed pawl (2) Fig. 21. There are nine rates of feed which are selected by means of a pair of pick off gears mounted in the feed housing at the rear of the machine. The pick off gears for the required feed are shown on the fixed machine ratios plate at the front of the machine. The rate of feed is governed by the pitch, the material being cut and the class of gear required. There is a handwheel (3) Fig. 21 for the purpose of hand traversing the hob head either up or down. An adjustable depth stop (4) Fig. 21 mounted on the hob head is used to stop the machine by means of an electric control switch after the required length of blank has been cut.

Incorporated in the rear of the column is the index changewheel housing in which changewheels are mounted for the purpose of synchronising the hob with the table so as to cut the correct number of teeth on the blank.

Should one to one ratio changewheels be mounted the machine automatically cuts 10 teeth provided that a single start hob be used, therefore the formula for index changewheels would be $\frac{10}{NT}$. Similarly if a two start hob be used together with one to one ratio index changewheels the machine would cut 20 teeth, hence the formula :-

$$\text{Index} = \frac{10}{NT} \times \frac{\text{No. of starts in hob}}{1}$$

When cutting helical or spiral gears the work spindle must be either advanced or retarded according to the hand of the spiral. Changewheels mounted in the lead changewheel housing at the front of the machine carry out this movement by virtue of a differential incorporated in the column.

The gearing of the machine is such that if one to one ratio changewheels are connected in the lead housing the machine would cut a 5" lead. In other words the hob head would feed downward 5" and the work spindle would gain or lose one complete turn according to the hand of the spiral being cut. Should we connect one to two ratio changewheels we would cut a 10" lead, similarly with a two to one ratio changewheel train we would cut a $2\frac{1}{2}$" lead. Hence the lead formula is:-

$$\text{Lead} = \frac{5}{\text{Lead req'd.}}$$

By use of this formula the lead of any good commercial helical or spiral gear may be calculated so as not to have an error exceeding .001" per inch of face.

c. Hob Head.

The hob head slides vertically on the column and includes the hob spindle, hob arbor, flywheel, adjustable depth stop (4) Fig. 21 and drive gears. When setting up for cutting a gear the head may be swivelled to the required angle by releasing two clamp bolts and raising or lowering the flywheel end of the head. Also the hob head may be locked in position by the lever (5) Fig. 21 when cutting worm wheels.

A counterweight is incorporated in the design of the machine for the purpose of eliminating any backlash in the elevating feed screw.

d. Work Saddle and End Bearing.

The work saddle is solidly constructed and contains the index worm and worm wheel, which drives the work spindle. The work spindle is designed in such a manner that it is capable of carrying the work mounted on an arbor or alternatively, held by a quick release collet operated by the lever (6) Fig. 21.

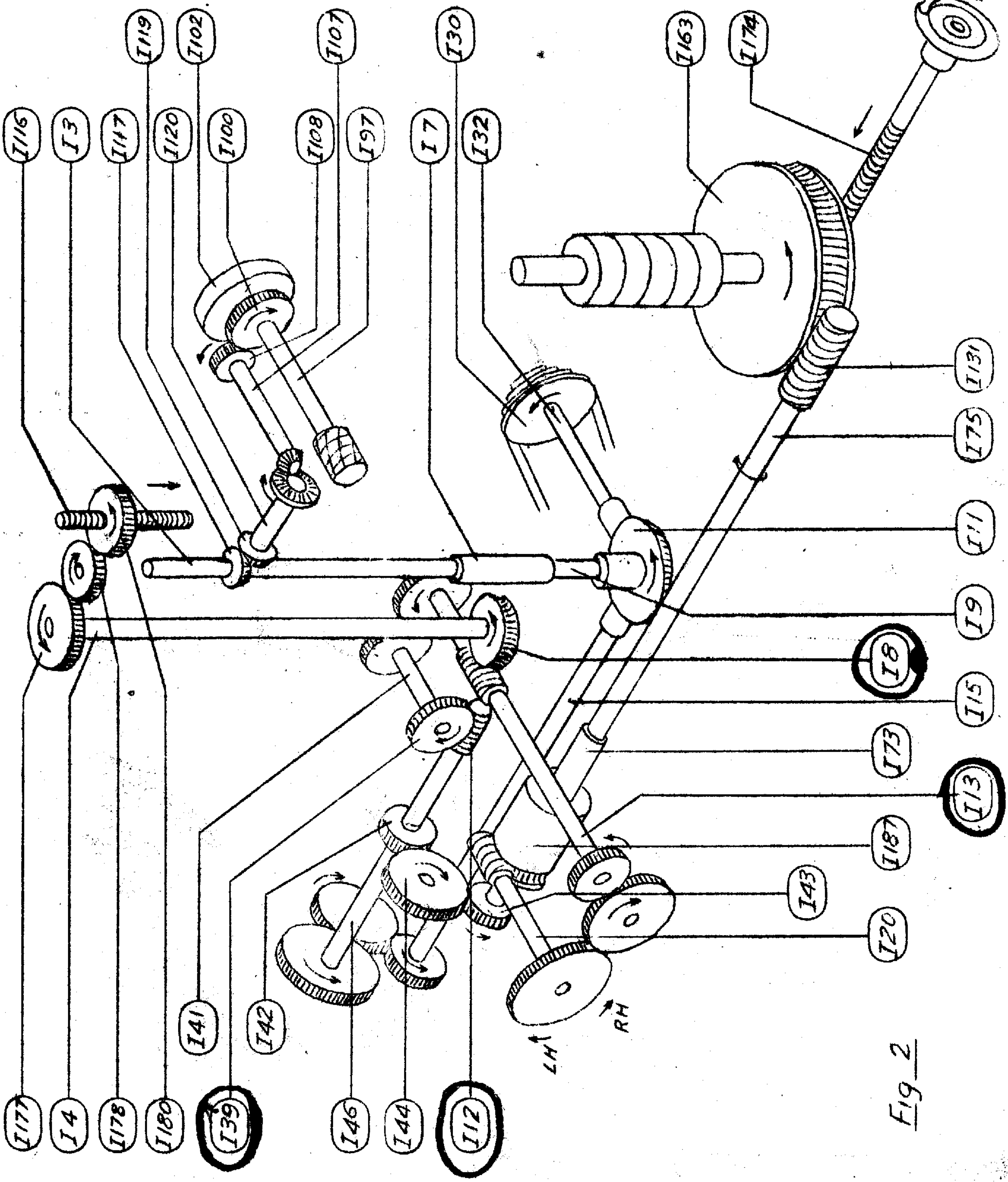
A tail column of rigid design is mounted on the saddle and may be rotated by releasing the lever (7) Fig. 21. Sliding on the tail column is the tail bearing carrying a centre which may be interchanged to suit either male or female centred arbors by slackening the lever (8) Fig. 21.

The work saddle is fed to correct depth by using the end bearing handwheel (9) Fig. 21 in conjunction with the friction loaded micrometer dial, reading to .001". When one off gears are being cut this operation is carried out with the infeed lever (10) Fig. 21 locked in position by the knurled screw (11) Fig. 21. When production of gears or worm wheels is required the saddle is set to correct depth by the infeed screw with the infeed lever held in the forward position. Also after setting the infeed screw must be clamped by the locking screw (12) Fig. 21. The infeed lever may then be used to withdraw the saddle after a cut has been taken and again feed the saddle to correct depth. It is most important that when a bank of gears is being cut the saddle be locked in position by the two locks(13) Fig. 21.

A skeleton diagram of the Qualos No. 0. Hobbing Machine is shown in Fig. 2.

Section 7. Fundamentals of gear Design for Accurate Cutting of Gears on the Hobbing Machine.

One point not realized by the engineer or turner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I3
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I15
I73
I13
I187
I43
I20
RH
LH
I177
I4
I178
I180
I39
I41
I42
I46
I44
I12

Fig 2

I 3	Splined Drive Shaft
I 4	Elevating Feed Shaft
I 7	Driving Sleeve
I 8	Feed Shaft Worm Wheel 40/$\frac{1}{8}$
I 9	Drive Shaft
I11	Main Drive Bevel Gear 48/14
I12	Feed Worm 3/16" 2 St.
I13	Feed Worm Shaft $\frac{1}{8}$" S.S.
I15	Index Bevel Shaft 9/14
I20	Differential Worm Shaft $\frac{1}{8}$" S.S.
I30	Main Drive Pulley
I32	Main Drive Bevel Gear 9/14
I39	Feed Worm Wheel 32/ 3/16"
I41	Feed Shaft
I42	Feed Gear 18/16
I43	Differential Feed Gear 18/16 18/32
I44	Idler Gear 28/16
I46	Shaft
I73	Index Shaft 18/32
I75	Table Drive Shaft
I97	Hob Spindle
I100	Hob Drive Gear 21/12
I102	Flywheel
I107	Cutter Head Bevel Pinion 14/14
I108	Hob Drive Pinion 14/12
I116	Elevating Screw
I117	Splined Bevel Gear 24/14

I119	Cutter Head Bevel Gear 24/14
I120	Cutter Head Bevel Gear 28/14
I131	Table Worm ¼ S.S.
I163	Half Worm Wheel 40/¼"
I174	Infeed Screw
I177	Feed Gear 30/16
I178	Idler Gear 21/16
I180	Elevating Feed Gear 24/16
I187	Differential Housing 40/⅛"

who produces gear blanks to be cut on a hobbing machine or gear generator is, that, gears are most difficult to cut to any greater accuracy than that to which the blanks are turned. This refers particularly to the concentricity of the bore and circumference, parallelism of faces and squareness with bores.

In blank cutting, should the faces of the finished blanks be turned out of parallel and out of square with the bores, on tightening the arbor nut, the blanks will cause the arbor to bend. When this condition occurs it is impossible to set the arbor in such a position on the machine so that all blanks will run true, with the result that many blanks cut do not run concentric with the bore. It is possible however to produce blanks accurately enough by turning and using care to maintain accuracy when cutting the teeth to run concentric to within .003".

For precision work such as gears for machine tool gear boxes and accurate motions, blanks should be machined and for preference, ground. An alternative method of leaving the bores approximately 1/16" smaller in diameter and the outside diameter 1/32" full before cutting may be used.. To use this method, the hob must be made to correctly clean up the outside diameter to size. The result is that the outside diameter is perfectly concentric with the pitch line and can be used as a reference to set up to for finishing the bore to size. The concentricity of running is then dependent on the accuracy to which the blank is set to the outside diameter when finishing the bore.

This practise is well worth while if quantities of gears are to be produced which have to run at high speeds, or required to be as silent as possible. The more precise the gears are to be, the more accurate the blanks must be and also the more cuts are necessary for elimination of spring and to improve the finish. Most commercial gears are capable of being cut on the Qualos Hobbing Machine with only one cut.

Section 8. Classification of Gears.

Gears may be classified into three classes for the purpose of estimating times of production.

a. "C" Class Gearing.

Commercial gears such as general industrial gears, where centre distance is not fixed or backlash is not important and the speeds are not high, may be cut on the Qualos No. 0. Hobbing Machine up to the maximum pitch for which the machine is recommended and using a reasonably coarse feed rate. High production of "c" class gears of finer pitches may be obtained in one cut by the use of two start hobs, thereby reducing the actual cutting time to half that of the single start hob with the same feed.

b. "B" Class Gearing.

"B" class gears are used for gear boxes in industrial machinery, for changewheels and feed gearing in machine tools. These gears may be cut with one cut, but with finer feeds than "C" class gears. The same gains may be had with two start hobs, although it is preferable to use ground thread hobs to assure that both starts are perfectly identical.

c."A"Class Gearing

"A" class gears are used for the highest application and may be cut using ground thread hobs in one or two or three cuts according to pitch, material and finish required.

All the foregoing recommendations may be varied according to other requirements or circumstances as they are met.

Section 9. Essentials Required in Hobs.

Mention has been made previously regarding the use of one and two start hobs and also the need for ground thread hobs for accurate gear cutting. The chief troubles encountered in hobs are:-

a. Out of concentricity in running.
b. drunkeness of thread.
c. Unequal angles on the sides of the hob teeth.
d. Soft spots in the hob.
e. One start not equal to the others in multi start hobs.

The more gashes a hob has, the more cuts per revolution and the better the finish produced. If a small diameter hob has a lot of gashes then the sharpening life of the hob is reduced. Should the hob diameter be increased to overcome this, then the cutting speed is increased, therefore it is necessary when selecting a hob for general work to strike an average in hob dimensions and number of gashes. (Rules for finding approximate number of gashes or flutes in a hob are contained in Machinery's Handbook.)

Should a hob be running out of concentricity it causes a non uniformity of load and the hob becomes blunt more quickly. The hob should be mounted free from radial and axial play. The free end of the hob arbor must be supported by the outer bearing.

When the teeth of the hob are weak and not capable of conducting away much heat, it is necessary for sufficient coolant to be supplied whilst cutting. Apart from cooling the cutting edges of the teeth the coolant also lubricates and prevents the chips sticking to them.

Frequently in the case of worm wheels it is impossible to use a bored hob as the outside diameter of the hob has to be so small that insufficient material would be left between the bore and the root of the teeth to give necessary strength to the hob, therefore shank hobs are used in such cases. Also when hobbing worm wheels, where the maximum accuracy is desired we suggest that shank hobs be used because of more accurate and positive location on the hob spindle, for with bored hobs a great amount of the accuracy is dependent on the parallelism of the faces, trueness of the bore of the hob and spacing collars etc.

When ordering hobs it is desirable to have the teeth of the hob slightly thin on the pitch line because any drunkeness of thread due to errors in manufacture, mounting or heat treatment all tend to make the hob cut thinner than dimensions of the hob suggest. Therefore if every point is 100% correct such as perfection of the hob and mounting it would be impossible to cut a tooth which is thicker on the pitch line than standard without sacrifice of depth. Perfection of mounting and hob manufacture are remote, therefore the desire to have hobs made with thin teeth so that added depth may be necessary to obtain correct thickness of tooth, with no serious loss in any way except possibly only very slight and negligible reduction of tooth strength.

Section 10. Types of Gears Which May be Cut on the Hobbing Machine.

The types of gears which can be cut on a hobbing machine are:-

a. Straight spur gears and pinions.

b. Helical gears and pinions.

c. Double helical gears and pinions (Under certain circumstances.)

d. Worm wheels

e. Cutting worms using a pinion type cutter.

f. Splines, sprockets, ratchet wheels, hexagons etc

The greatest output attained on the hobbing machine is naturally with blanks that have flat parallel faces which enable them to be banked together so as to form a cylinder on which the teeth may be cut. Spur gears being the simplest form of a gear takes slightly less time for cutting than single helical gears under the same conditions The hobbing machine for production work is the fastest generating machine known, and is equal to any other type of machine including the milling machine for jobbing or for small quantities of any gears which may be cut on the hobbing machine, thus proving this type of machine to be the most universal.

There are of course certain types of gears which cannot be cut on the hobbing machine such as close coupled cluster gears when the blank is made from one piece. Should occasion arise for the use of cluster gears, they can be designed for cutting on the hobbing machine and built up after cutting as illustrated by Fig. 3.

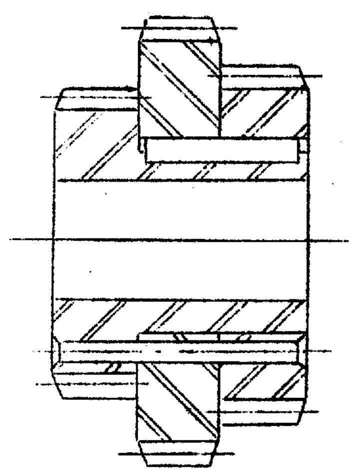


Fig. 3.

Section 11. Machine Setting for Left and Right Hand Hobs.

To facilitate head setting to the desired angle the head has been graduated to read 180° either side of the zero pointer.

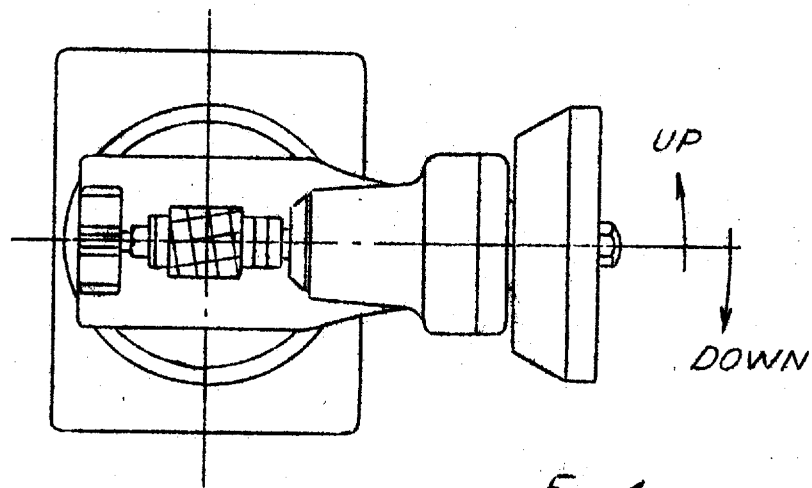


Fig 4.

a. Head Setting for Spur Gears.

When using a right hand hob for cutting spur gears the head must be set down an angle equal to the helix angle of the hob.

Similarly when using a left hand hob for spur gears the head must be set up an angle equal to the helix angle of the hob.

b. Head Setting for Helical and Spiral Gears.

Using Right Hand Hobs.

For right hand helical gears, set the head up. The angle is equal to the helix angle of the gear to be cut minus the helix angle of the hob.

For left hand helical gears, set the head down. The angle is equal to the helix angle of the gear to be cut plus the helix angle of the hob.

Using Left Hand Hobs.

For right hand helical gears set the head up. The angle is equal to the helix angle of the gear to be cut plus the helix angle of the hob.

For left hand helical gears set the head down. The angle is equal to the helix angle of the gear to be cut minus the helix angle of the hob.

Special conditions for Left Hand Spiral Gears.

When cutting a bank of left hand spiral gears it may be necessary to turn the head over to enable the maximum length of work to be cut, thus the directions of the hob, feed and table must be altered accordingly by reversing the direction of the motor. See Fig. 19.

c. Head Setting for Worm Wheels.

When cutting worm wheels on a hobbing machine the head must be set to zero regardless of whether right or left hand worm wheels are being cut.

d. Index Changewheel Settings.

Fig. 5 shows the index changewheel directions when using right hand hobs or cutting right hand worm wheels. Now when using a left hand hob or cutting left hand worm wheels, the direction in which the table revolves must be reversed. Fig. 6 shows the adoption of an intermediate changewheel which carries out this reversing action.

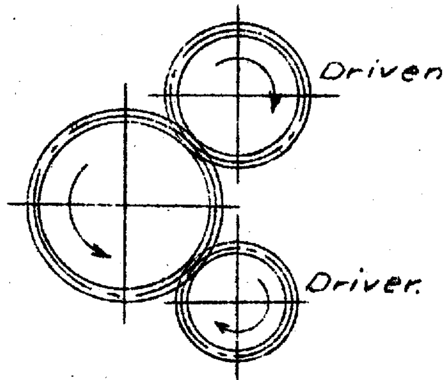


Fig. 5.

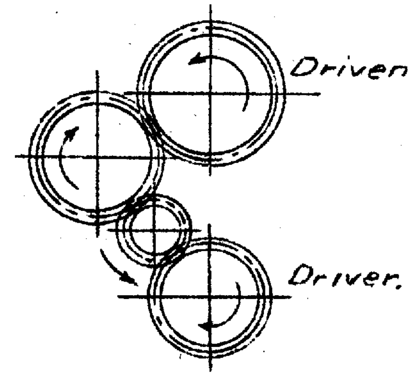


Fig. 6.

Caution.

It is to be noted that when the table is reversed the direction of feed of the hob head is also reversed, therefore, it is necessary to commence the cut at the bottom of the bank, thus causing the hob to climb cut.

e. Lead Changewheel Settings.

When cutting right hand spiral gears, the rotation of the work must be advanced to give the correct spiral. The lead changewheels must be set up as in Fig. 7 to give this advancing motion.

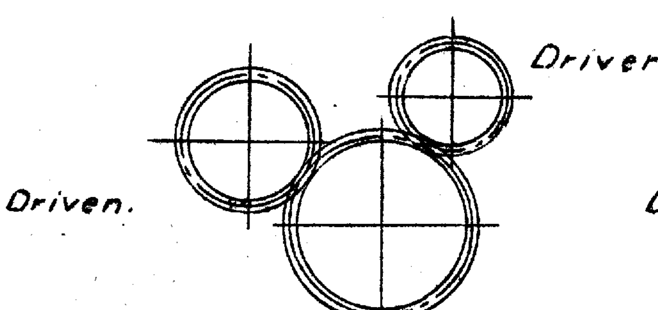


Fig. 7

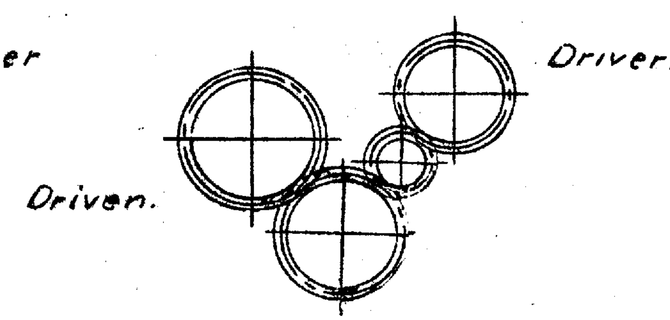


Fig. 8.

For left hand spiral gears the rotation of the work must be retarded by the addition of an intermediate changewheel in the lead changewheel train as shown in Fig. 8.

When cutting prime number gears and the index changewheels are set up to cut less teeth than the number required an intermediate changewheel in the lead changewheel train is required to give the retarding motion required, as in Fig. 8.

If the index changewheels are set up to cut more teeth than the number required, no intermediate changewheel is necessary in the lead changewheel train to give the advancing motion required, as in Fig. 7.

NOTE. When using a left hand hob the direction of rotation of the driving shaft for the lead changewheel train is reversed, therefore the set up is the same regardless of the hand of the hob.

Also when cutting spur gears or worm wheels the driven shaft of the lead changewheel train must be locked by use of the locking collar supplied.

Section 12. Gear Tooth Terms.

Addendum (S) Distance from pitch line to the top of the tooth.

Dedendum (S &F) Distance from pitch line to the root of the tooth.

Clearance (F) Radial distance between the top of a tooth and the bottom of the mating tooth space.

Base Circle. The circle from which an involute tooth curve is developed or generated.

Backlash. The play between mating teeth or the shortest distance between non-driving surfaces of adjacent teeth.

Chordal Thickness. Length of chord subtended by the circular thickness arc. (The dimension obtained when a gear tooth caliper,is used to measure the thickness of tooth at the pitch line.)

Chordal Addendum. Theradial distance from a line representing the chordal thickness at the pitch circle to the top of the tooth.

Face of Tooth. The surface of the tooth which is between the pitch circle and the top of the tooth.

Face Width. Width of pitch surface.

Flank of Tooth. That surface which is between the pitch circle and the bottom land. The flank includes the fillet.

Land. The top land is the top surface of the tooth and the bottom land is the surface of the gear between the flanks of adjacent teeth.

Module. Ratio of the pitch diameter to the number of teeth. Ordinarily module is understood to mean ratio of pitch diameter in millemeters to the number of teeth.

Normal Circular Pitch. The shortest distance on the pitch surface between centres. Applied to helical gearing.

Normal Diametral Pitch. The diametral pitch corresponding to the normal circular pitch and equal to the number of teeth divided by the product of the pitch diameter and the cosine of the helix angle.

Pitch Circle. A circle the radius of which is equal to the distance from the gear axis to the pitch point.

Pitch Point. The point of tangency of the pitch circles or the point where the centre line of the mating gear intersects the circles.

Pitch Diameter. Diameter of the pitch circle. (Generally understood to mean the diameter obtained by dividing the number of teeth by the diametral pitch or the diameter of the pitch circle when the centre to centre distance between mating gears is standard.)

Pressure Angle. The pressure angle of a pair of mating involute gears is the angle between the line of action and a line perpendicular to the centre line of these gears.

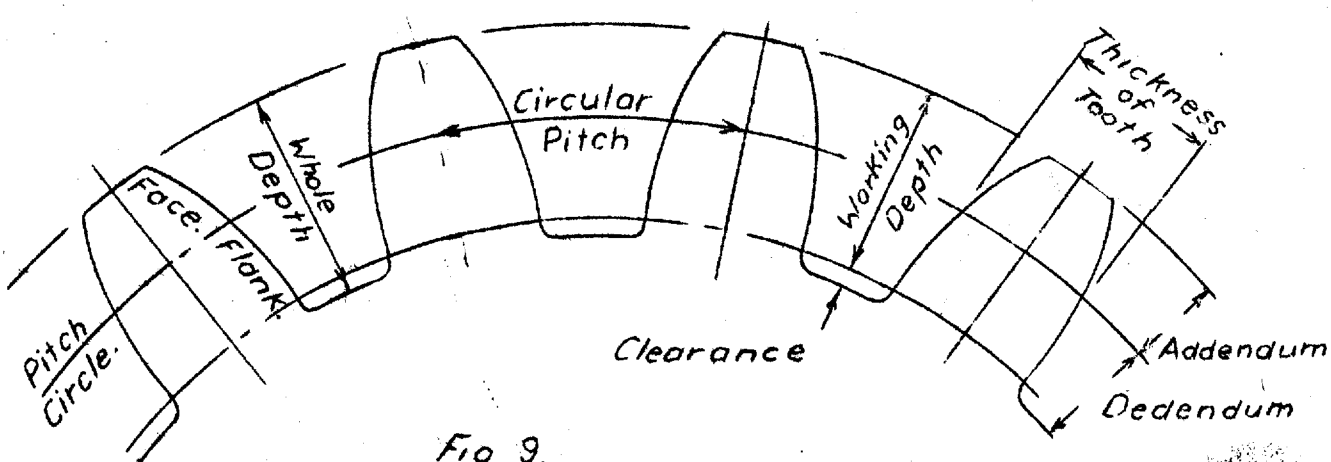


Fig 9.

Whole Depth. Radial dimension between top of the tooth and root circle, also known as total depth.

Working Depth. Depth to which a tooth extends into the tooth space of a mating gear when the centre distance is standard, equals twice the addendum.

Circular Pitch. Length of arc from the centre of one tooth to the centre of the next tooth measured on the pitch circle.

Diametral Pitch. is the number of teeth per inch of diameter of the pitch circle.

Section 13. Spur Gearing.

a. Formula For Spur Gearing.

To Find	Symbol	Rule	Formula
Diametral pitch	DP	Divide 3.1416 by the circular pitch.	$DP = \frac{3.1416}{CP}$
Diametral pitch	DP	Divide number of teeth by pitch diameter	$DP = \frac{NT}{PD}$
Circular pitch	CP	Divide 3.1416 by diametral pitch	$CP = \frac{3.1416}{DP}$
Circular pitch	CP	Multiply pitch diameter by 3.1416 and divide by number of teeth.	$CP = \frac{3.1416 \times PD}{NT}$
Pitch diameter	PD	Divide number of teeth by diametral pitch	$PD = \frac{NT}{DP}$
Pitch diameter	PD	Multiply number of teeth by circular pitch and divide the product by 3.1416	$PD = \frac{NT \times CP}{3.1416}$

To find	Symbol	Rule	Formula
Pitch diameter	PD	Subtract twice the addendum from the outside diameter	$PD = OD - (2xS)$
Outside Diameter	OD	Multiply the sum of the number of teeth plus 2 by the circular pitch and divide the product by 3.1416	$OD = \frac{(NT+2)xCP}{3.1416}$
Outside diameter	OD	Add 2 to the number of teeth and divide the result by diametral pitch	$OD = \frac{NT+2}{DP}$
Outside diameter	OD	Add twice the addendum to the pitch diameter	$OD = PD + (2x\ S)$
Centre distance	C	Add together the pitch diameter of both gears and divide the sum by two	$C = \frac{PDg + PDp}{2}$
Centre distance	C	Add together the number of teeth in both gears and divide the sum by twice the diametral pitch.	$C = \frac{NTg+NTp}{2\ xDP}$
Centre distance	C	Multiply the sum of the number of teeth in both gears by the circular pitch and divide the product by 6.2832	$C = \frac{(NTg+NTp)xCP}{6.2832}$
Addendum	S	Divide 1 by the diametral pitch	$S = \frac{1}{DP}$

To find	Symbol	Rule	Formula
Addendum	S	Divide circular pitch by 3.1416	$S = \frac{CP}{3.1416}$
Clearance	F	Divide .157 by the diametral pitch	$F = \frac{.157}{DP}$
Clearance	F	Divide the circular pitch by 20	$F = \frac{CP}{20}$
Whole depth of Tooth	W	Divide 2.157 by the diametral pitch	$W = \frac{2.157}{DP}$
Whole depth of Tooth	W	Multiply .6866 by the circular pitch	$W = .6866 \times CP$
Tooth thickness	T	Divide circular pitch by 2	$T = \frac{CP}{2}$
Tooth thickness	T	Divide1.5708by diametral pitch	$T = \frac{1.5708}{DP}$
Number of Teeth	NT	Multiply pitch diameter by diametral pitch	$NT = PD \times DP$
Number of Teeth	NT	Multiply pitch diameter by 3.1416 and divide the product by the circular pitch	$NT = \frac{PD \times 3.1416}{CP}$

b. Example of Set Up for Spur Gear Cutting.

To cut a spur gear 24 teeth

1. Mount hob and set hob head to helix angle of hob (See Section 11. a. Page 18)

2. Calculate index changewheels for 24 teeth

$$\frac{\text{Driver}}{\text{Driven}} = \frac{10}{\text{No. of teeth req'd}} \times \frac{\text{No. of starts in hob}}{1}$$

$$= \frac{10}{24} \times \frac{1}{1}$$

$$= \frac{1000}{2400}$$

$$\text{Changewheels} = \frac{20}{60} \times \frac{50}{40}$$

(See section 11.d. Page 19 for index changewheel set up for RH and LH hobs.)

3. Lock differential by using collar supplied in lead changewheel housing.

4. Select suitable feed and mount pick off gears.

5. Set adjustable depth stop(4) Fig.21 to stop machine after cut has been taken.

6. Mount work on suitable arbor.

7. Start machine.

8. Feed work to correct depth and lock work saddle.

9. Engage feed with lever (1) Fig. 21.

10. After cut has been taken withdraw work, disengage feed and wind hob head back to original position by handwheel (3) Fig. 21.

NOTE. If production is required, use of the infeed lever (10) Fig. 21 is recommended. (See section 6.d. Page 7.)

Section 14. To Cut a Prime Number Gear.

Divide the required number of teeth by the number of turns of the blank per one inch of feed, which equals the basic lead per tooth of the difference between the number of teeth for which the index changewheels have been set up and the desired number of teeth. If the difference is greater than one, then divide the basic lead by the difference.

Example

Required to cut a 91 tooth spur gear using 1/64" (.0156) feed.

Calculate index changewheels to cut 90 teeth.

$$\frac{\text{Driver}}{\text{Driven}} = \frac{10}{\text{No.of teeth req'd}} \times \frac{\text{No. of starts in hob}}{1}$$

$$= \frac{10}{90} \times \frac{1}{1}$$

$$\text{Changewheels} = \frac{20}{90} \times \frac{40}{80}$$

(See section 11 d. Page 19 for index changewheel set up for RH and LH hobs.)

Now if we wish to gain 1 tooth over the number set up for, as in this case we must slow the blank down to allow one more tooth to be cut during the blank's revolution. In each revolution the blank makes, the feed takes the hob the basic lead referred to is the gain made by 91 turns of the blank or $\frac{91}{64}$ inches.

This, when expressed in decimals, equals

```
64 ) 91 (1.4218
     64
     270
     256
      140
      128
       120
        64
       560
```

Basic Lead = 1.422"

To calculate the lead changewheels necessary to obtain this lead exactly we would require a 91 tooth changewheel, since this lead exact would always arrive back to the prime number required to be cut. Therefore the nearest possible lead which will factorize to give the required changewheels must be taken, this lead being 1.422 repeated.

Calculate lead changewheels.

$$\frac{\text{Driver}}{\text{Driven}} = \frac{5}{\text{Lead req'd}}$$

$$= \frac{5}{1.422}$$

$$\text{Changewheels} = \frac{90}{80} \times \frac{125}{40}$$

(See section 11 e. Page 20 for lead changewheel setting for prime number gears.)

<u>NOTE</u>. When checking number of teeth, do not disengage feed lever (1) Fig. 21.

When production of prime number gears is required, we suggest that a prime number changewheel be cut so as to eliminate lengthy calculations when future gears may be required, also a prime number changewheel would make the set up similar to spur gears.

Section 15. Helical and Spiral Gears.

a. Formula for Helical and Spiral Gearing.

To find	Symbol	Rule	Formula
Circular pitch	CP	Multiply the secant of the helix angle by 3.1416 and divide by the diametral pitch.	$CP = \frac{Secant HA x 3.1416}{DP}$
Diametral pitch	DP	Multiply the secant of the helix angle by the number of teeth and divide by the pitch diameter.	$DP = \frac{Secant HA X NT}{PD}$
Pitch diameter	PD	Multiply the secant of the helix angle by the number of teeth and divide by the diametral pitch.	$PD = \frac{Secant HA x NT}{DP}$
Outside diameter	OD	Add twice the addendum to the pitch diameter.	$OD = PD + 2S$
Angle of spiral or helix angle.	HA	The secant of the helix angle is equal to the product of the pitch diameter and the diametral pitch divided by the number of teeth.	$SecHA = \frac{PD x DP}{NT}$

To find	Symbol	Rule	Formula
Lead of Spiral	L	The product of secant 90° minus the helix angle, the number of teeth and 3.1416 divided by the diametral pitch	$L = (Sec 90^{\circ} - HA) x NT x 3.1416$
Lead of Spiral	L	The product of the pitch diameter and 3.1416 divided by the tangent of the helix angle.	$L = \frac{3.1416 \times PD}{Tan\ HA}$
Lead for right angle spirals only.	L	Multiply the pitch diameter by 3.1416	$L = 3.1416 \times PD$

b. Relationship of Lead and Helix Angle.

Many gears are described or specified as having a certain helix or spiral angle. This angle is directly related to the lead of the gear.

Referring to Fig. 10 ABCD represents the spiral gear. This spiral gear is then extended in length to form a cylinder and the teeth to form spirals around the circumference The letters EFG represent a triangle that if wrapped around this cylinder, EF would equal the pitch circumference and FG would equal the lead.

Fig. 11 represents the theoretical diagram of helical and spiral gears showing the relation of the helix

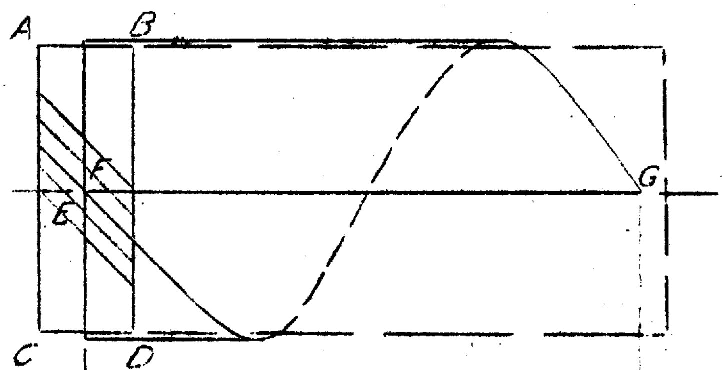


Fig 10

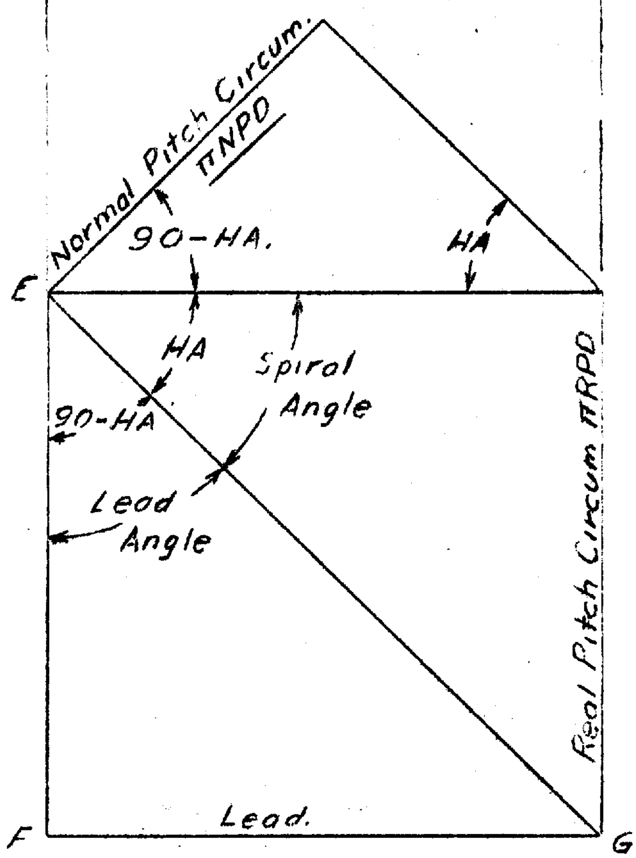


Fig 11

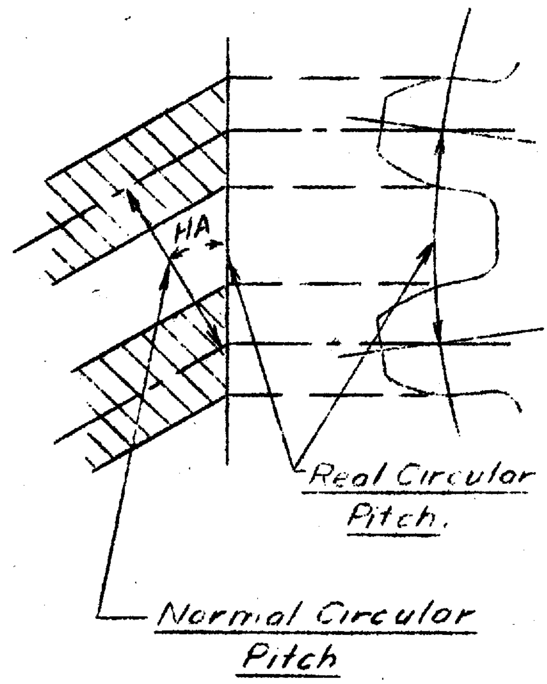


Fig 12

NOTATIONS

L = Lead
HA = Helix or Spiral Angle
NPD = Normal Pitch Diameter
RPD = Real Pitch Diameter.
NT = Number of Teeth.
RCP = Real Circular Pitch.
CP = Circular Pitch.

or spiral angle in relation to the lead.

Fig. 12 illustrates the relation of the normal circular pitch and the real circular pitch.

The gear hobbing machine cuts helical and spiral gears by the lead and not the helix angle. Therefore to obtain a gear of definite and precise helix angle the lead must be accurately calculated and lead changewheels arranged to give this lead as near as possible. The resultant error between the lead obtained from those changewheels and the lead calculated should be no more than .001" per inch of calculated lead. Even this amount of error would give .001" per inch of face, a cross corner bearing.

When calculating for two gears to mesh, try always in selecting lead changewheel trains to err both gear trains the same way. For instance if the lead given by the lead changewheel train for the gear happens to err on the high side of the calculated lead, then the lead given by the lead changewheel train for the pinion should also err the same way.

In designing helical gears for hobbing it is preferable to calculate gears right out for the lead changewheels and then take the lead changewheels for the pinion lead in direct ratio to the gears and pinions being cut.

c. Example of Set Up for Cutting Helical Gears

To cut a gear and pinion of 80 and 20 teeth respectively. The lead for the gear as calculated came to 30.015" RH.

For the Gear

1. Mount hob and set hob head to give required helix angle (See section 11 b. Page 18 .)

2. Calculate index changewheels for 80 teeth.

$$\frac{\text{Driver}}{\text{Driven}} = \frac{10}{\text{No. of teeth req'd}} \times \frac{\text{No. of starts in hob}}{1}$$

$$= \frac{10}{80} \times \frac{1}{1}$$

$$\text{Changewheels} = \frac{25}{80} \times \frac{40}{100}$$

(See section 11. d. Page 19 for index changewheel settings for RH and LH hobs.)

3. Calculate lead changewheels for 30.015" lead.RH.

$$\frac{\text{Driver}}{\text{Driven}} = \frac{5}{\text{Lead req'd}}$$

$$= \frac{5}{30.015}$$

Nearest approximation $= \frac{5}{30}$ or using a 30" lead.

$$\text{Lead changewheels} = \frac{20}{120}$$

(See section 11. e. Page 20 for lead changewheel settings for RH and LH helical gears.)

NOTE. Do not disengage feed lever when checking numbers of teeth.

For the Pinion

1. Mount hob and set hob head to required helix angle (See section 11 b. Page 18 .)

2. Calculate index changewheels for 20 teeth.

$$\frac{\text{Driver}}{\text{Driven}} = \frac{10}{\text{No. of teeth req'd}} \times \frac{\text{No.of starts in hob}}{1}$$

$$= \frac{10}{20}$$

$$\text{Changewheels} = \frac{25}{50}$$

(See section 11. d. Page 19 for index changewheel settings for RH and LH hobs.)

3. Calculate lead changewheels for pinion.

For the lead changewheels fo the pinion, multiply the lead changewheels of the gear by the ratio of the numbers of teeth in the gear and pinion ($\frac{80}{20}$)

$$\text{Driver} = \frac{20}{120} \times \frac{80}{20}$$

$$= \frac{80}{120}$$

$$\text{Lead changewheels} = \frac{20}{30}$$

(See section 11. e. Page 20 for lead changewheel settings for RH and LH helical gears.)

Operations 4 - 10 for spur gears are similar for helical gears.

NOTE. This method of calculation for the lead changewheels of the pinion may not always work out. Then, both gear and pinion lead changewheels would have to be worked out independently.

d. Relationship of Tangent and Secant Formula for Calculation of Leads.

The theoretical diagram Fig. 11 shows the triangles necessary to determine the lead formula.

Fig. 11 $\quad \text{Tan HA} = \dfrac{\pi \times \text{RPD}}{\text{L}}$

$$= \frac{\text{RCP x NT}}{\text{L}}$$

Fig. 12. $\quad \text{Cos HA} = \dfrac{\text{CP}}{\text{RCP}}$

$$\text{RCP} = \frac{\text{CP}}{\text{Cos HA}}$$

$$\text{Tan HA} = \frac{\text{CP x NT}}{\text{Cos HA x L}}$$

$$\text{Now Tan HA} = \frac{\text{Sin HA}}{\text{Cos HA}}$$

$$\frac{\text{Sin HA}}{\text{Cos HA}} = \frac{\text{CP x NT}}{\text{Cos HA x L}}$$

$$\text{Sin HA} = \frac{\text{CosHA xCP NT}}{\text{Cos HA x L}}$$

$$\text{L} = \frac{\text{CP x NT}}{\text{Sin HA}}$$

$$= \frac{\text{CP x NT}}{\text{Cos}(90^\circ - \text{HA})} \quad \left(\text{Sec}\,\theta = \frac{1}{\text{Cos}\,\theta}\right)$$

$$= \text{CP x NT x Sec}(90^\circ - \text{HA})$$

Secant formula for lead $= \dfrac{\text{Sec}(90^\circ - \text{HA})\text{xNTx}\pi}{\text{DP}} \quad \left(\text{CP} = \dfrac{\pi}{\text{DP}}\right)$

Tangent formula for lead $= \frac{\pi \times RPD}{\tan HA}$

The secant formula for calculating the lead is much simpler than the tangent formula, but is only suitable when gears are cut correctly to calculated dimensions and angles so that the lead and angle will match. Should any modification be made, such as increased or decreased addendum or pitch diameter, it will be necessary to use the tangent formula to maintain exact angle from lead. This is due to the fact that the gear hobbing machine cuts helical and spiral gears by lead and not helix angle, in other words, the machine cuts the exact lead that the changewheel train has been set up for.

e. Example Showing Lead Comparison for Modified Gears.

Required to cut right angle spiral gear having 20 teeth 20 DP, and 45° HA.

$$PD = \frac{\text{Secant } 45^\circ \times NT}{DP}$$

$$= \frac{1.4142 \times \not{2}0}{\not{2}0}$$

$$= 1.4142$$

Lead for right hand spiral $= \pi \times PD$

$$= 3.1416 \times 1.4142$$

$$= 4.443''$$

Now should it be necessary to require the same gear with a modified pitch diameter, say.020" smaller, than 20 teeth, 20 DP, 45°HA.

PD = 1.3942"

In this case it is necessary to use the tangent formula.

$$\text{Lead} = \frac{\pi \times PD}{\text{Tan HA}}$$

$$= \frac{3.1416 \times 1.3942}{1}$$

$$\text{Lead} = 4.380$$

Section 16. Worm Gearing

a. Formula for Worms.

To find	Symbol	Rule	Formula
Outside diameter	OD	Add together the pitch diameter and twice the addendum.	OD = PD + 2S
Outside diameter	OD	Multiply the circular pitch by .6366 and add to the pitch diameter.	OD=PD+(.6366 xCP)
Pitch diameter	PD	Subtract twice the addendum from the outside diameter.	PD = OD - 2S
Pitch diameter	PD	Multiply the circular pitch by.6366 and subtract from the outside diameter.	PD=OD-(.6366xCP)

b. Formula for Worm Wheels.

To find	Symbol	Rule	Formula
Pitch diameter	PD	Divide the number of teeth by the diametral pitch.	$PD = \frac{NT}{DP}$
Pitch diameter	PD	Multiply the circular pitch by the number of teeth and divide by 3.1416	$PD = \frac{CP \times NT}{3.1416}$
Throat diameter	TD	Add twice the addendum to the pitch diameter	$TD = PD + 2S$
Throat diameter	TD	Multiply the circular pitch by .6366 and add to the pitch diameter	$TD = PD + (.6366 \times CP)$
Throat curvature	r.	Subtract the circular pitch divided by 3.1416 from half the pitch diameter of the worm	$r = \frac{PD \text{ of worm}}{2} - \frac{CP}{3.1416}$
Outside diameter (across corners)	ODc	Multiply throat curvature by cosine of half the face angle and subtract from throat curvature. Multiply the remainder by 2 and add to the throat diameter	$ODc = 2(r - r\cos\frac{\theta}{2}) + TD$
Outside diameter (across flats)	ODf	Multiply the number of teeth plus three by the circular pitch and divide by 3.1416	$ODf = \frac{(NT+3) \times CP}{3.1416}$

To find	Symbol	Rule	Formula
Width of flat	Y	Multiply twice the tangent of half the face angle by the centre distance minus half the outside diameter across flats.	$Y = 2 \times Tan \frac{\theta}{2} \times (C - \frac{OD_f}{2})$

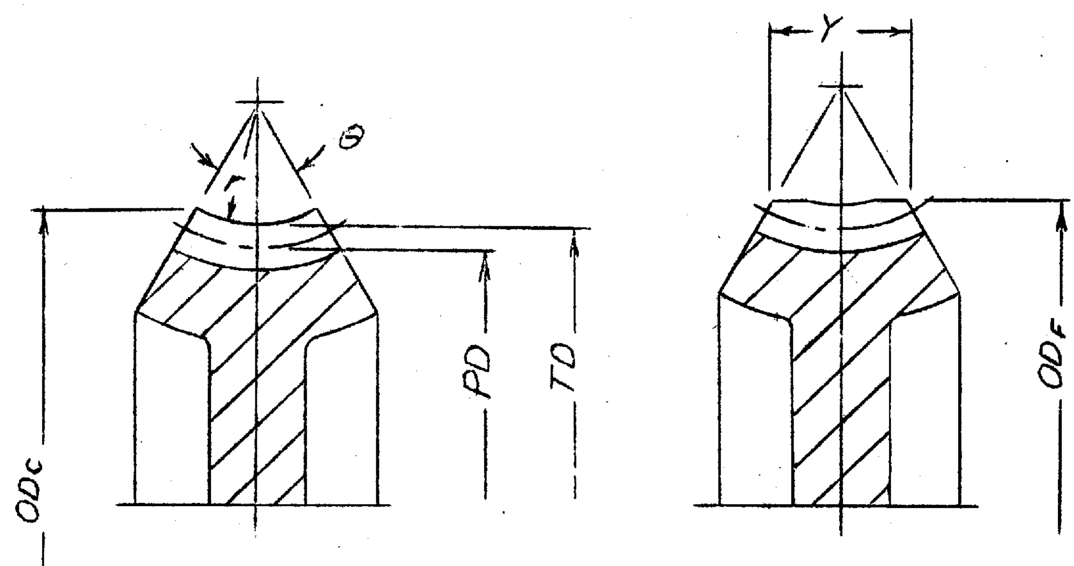


Fig 13.

c. Worm Wheel Hobs.

Hobs for worm wheels have to be specially made, because practically every worm wheel hob has to be shaped differently in this way that the outside diameter and the root diameter of the worm wheel hob are greater than those of the worm by the amount of clearance.

d. Example of Set Up for Hobbing Worm Wheel.

To cut a worm wheel 26 teeth, driven by 2 start worm.

1. Mount hob and set head to zero. (See section 11. c. Page 19 .)

2. Calculate index changewheels for 26 teeth.

$$\frac{\text{Driver}}{\text{Driven}} = \frac{10}{\text{No. of teeth req'd}} \times \frac{\text{No. of starts in hob}}{1}$$

$$= \frac{10}{26} \times \frac{2}{1}$$

$$= \frac{10}{13}$$

$$\text{Changewheels} = \frac{50}{65}$$

(See section 11. d. Page 19 for index changewheel setting for RH and LH hobs.)

3. Lock differential by using collar supplied, in lead changewheel housing.

4. Mount work on suitable arbor

5. Set hob head to correct height and lock in position.

6. Start machine.

7. Bring work up to hob, then feed slowly to correct depth.

8. Allow hob to cut around circumference, then return work to original position.

NOTE. If production is required, use of the infeed lever (10) Fig. 21 is recommended. (See section 6 d. Page 7 .)

Section 17. Formulas for Production.

a. Cutting Time for Spur Gears and Helical Gears.

Let T = Cutting time in minutes

N = Number of teeth

L = Distance between faces

O = Overrun of hob.

F = Feed of hob

RPM = Revs. per minute of hob.

$$T = \frac{N \times (L + O)}{F \times RPM}$$

If a multi start hob is used the number of teeth N, in this formula must be divided by the number of starts in the hob.

Example. Find the time required for cutting 6 gears of 16 teeth, $\frac{1}{2}''$ face, the hob speed being 169 RPM and at 1/64 feed.

$$T = \frac{N \times (L + O)}{F \times RPM}$$

$$= \frac{16 \times (3 + 1)}{1/64 \times 169}$$

$$= \frac{16 \times 64 \times 4}{169}$$

$$= 24.2 \text{ minutes.}$$

NOTE For costing purposes the machine setting time plus gear blank setting time must be added to the cutting time.

b. Cutting time for Worm Wheels

No formula can be given for the cutting time for worm wheels because they are hand fed, therefore, times must be arrived at through practice.

Section 18. Machine Adjustments.

Hob Head.

The accuracy of the hob head slides is maintained by adjusting the pair of tapered strips at the back of the 90° "Vee" slides.

Work Saddle

Adjustment of the tapered gib strip at the back of the work saddle maintains the accuracy of the work saddle slides.

Adjustment for wear of the index worm and worm wheel is made by means of the worm wheel, which is split and locked together by three set screws. See Fig. 14.

The work spindle bearing is adjusted by means of two locking rings. See Fig. 14.

Adjustment for height of the worm wheel when the work spindle bearing wears , is made by the addition of shims under the work spindle bearing bush. See Fig. 14.

The quick release collet is adjusted by the locking collar screwed on to the end of the draw bar. See Fig.14.

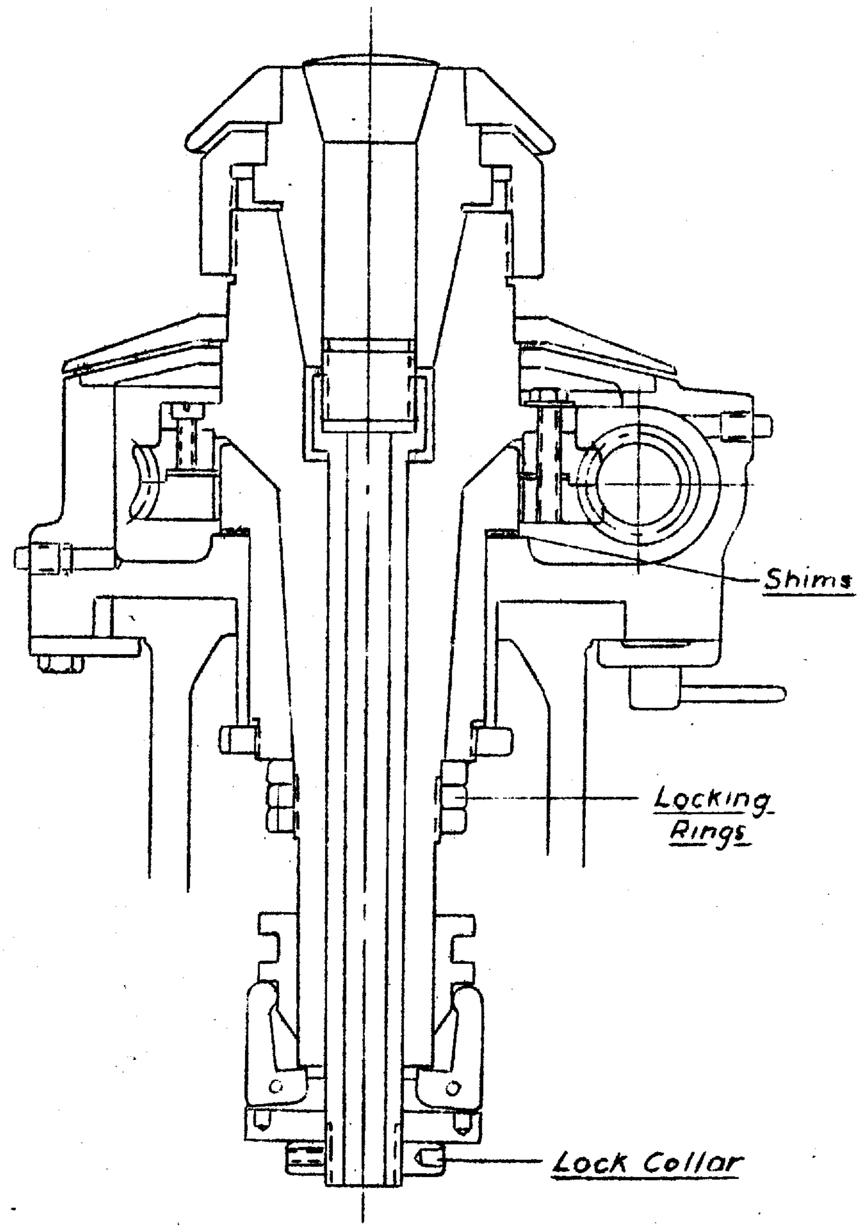


Fig 14.

Section 19. List of Don'ts

a. Don't disengage feed when checking number of teeth when cutting prime number gears, helical or spiral gears.

b. Don't forget to lock differential when cutting spur gears.

c. Don't tighten hob and work arbor unless supported by outer bearings.

d. Don't forget to lock work saddle before proceeding to cut when not infeeding.

e. Don't forget to set the depth stop before taking cut.

f. Don't forget when using left hand hobs to add extra intermediate on the index changewheel train as illustrated in Fig. 6 to reverse the direction of the table.

g. Don't forget when using left hand hobs to begin cut from the bottom of the bank.

Section 20. Hints for Gear Cutting

When using the collets for cutting gears on shafts, it may be necessary to put a rubber washer around the shaft to stop the cuttings from falling into the slots of the collet.

To cut gear segments it may be necessary to make a fixture to mount them on the machine, as shown in Fig. 15.

When large quantities of gears are required, two arbors may be made so that one may have gear blanks mounted on it while the other is in the machine being cut.

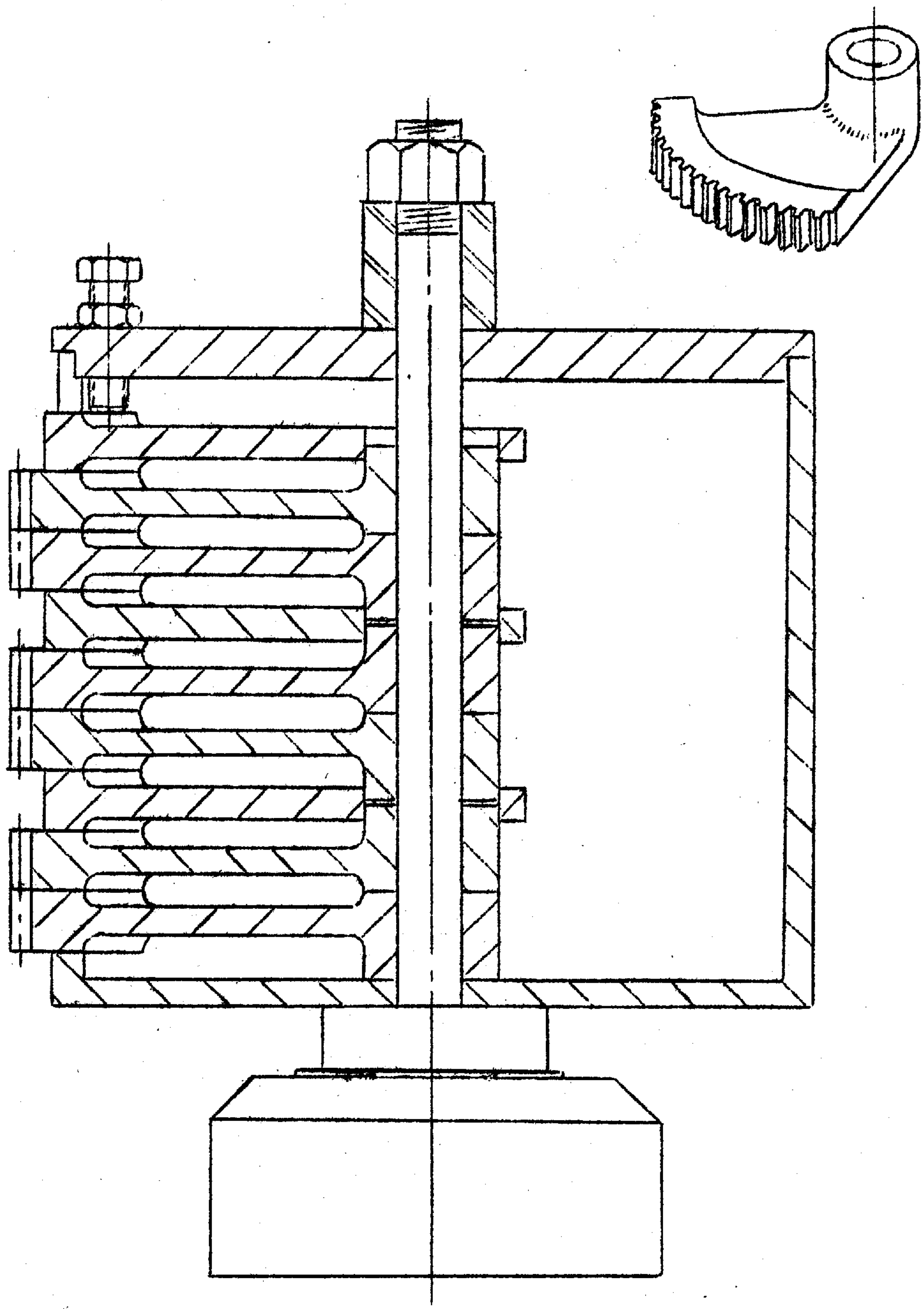


Fig. 15.

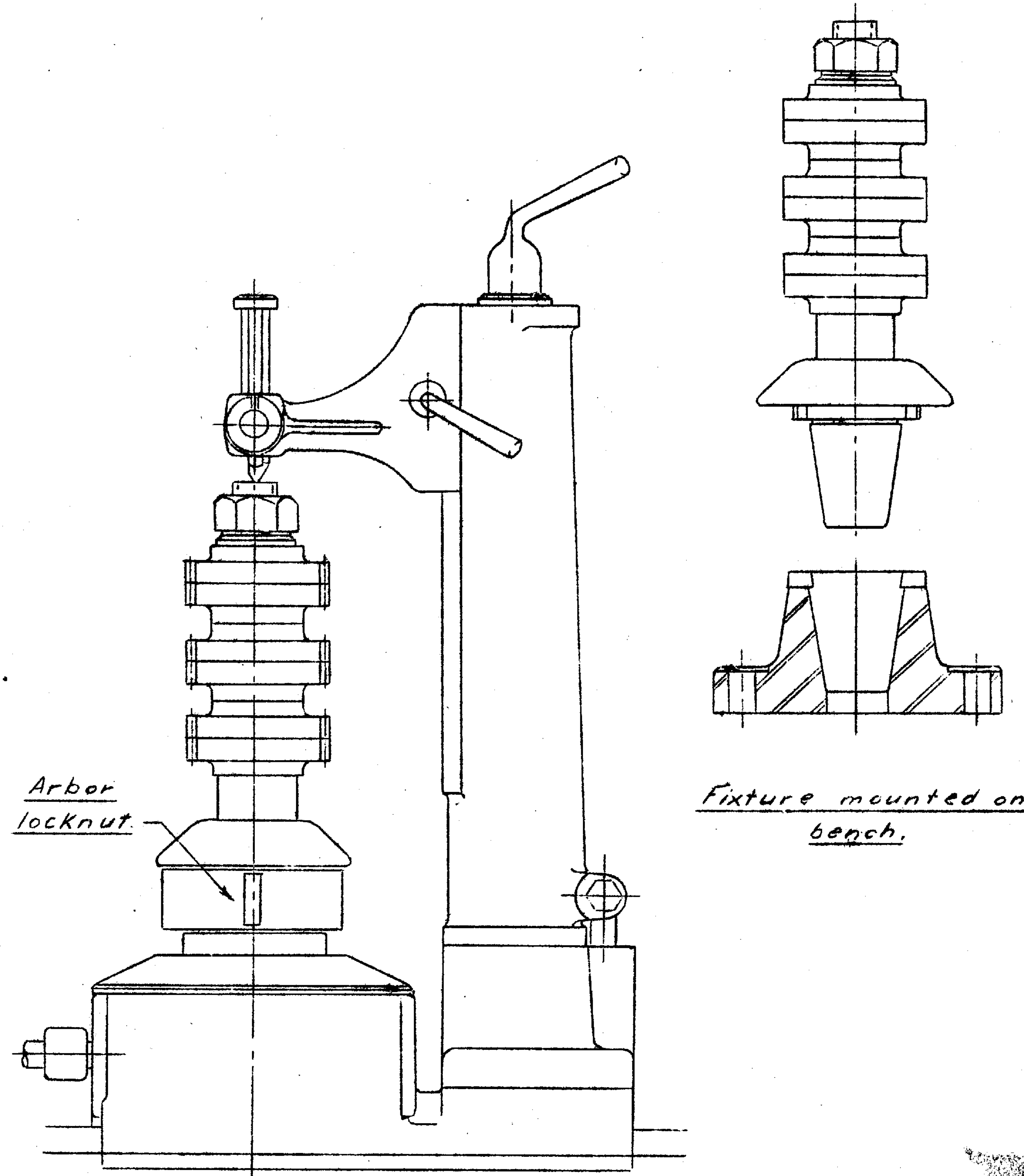


Fig 16.

A fixture with a No. 30 Milling machine taper in it may be bolted to the bench so as to be able to tighten the arbor nut. After a cut has been taken, the tail bearing can be swung out of the way, then the arbor locknut released and the arbors interchanged. See. Fig. 16.

Section 21. Specifications for Qualos No.0 Hobbing Machine

Largest diameter gear cut	5" d.
Largest diametral pitch cut	16 DP.
Greatest width of face of bank of spur gears cut. (See Fig. 17 for hob head movement)	$3\frac{3}{8}$"
Greatest width of face of bank of RH or LH spiral gears. (See Figs. 18,19 and 20 for hob head movement.)	Varies according to diameter of gear.
Hole in work spindle	$\frac{5}{8}$" d.
Diameter of hob arbor	$\frac{3}{8}$" d.
Maximum diameter of hob	$1\frac{1}{4}$" d.
Speeds of hob in RPM.	104,169,254,360
Feed of hob per rev. of table	.0067", .0084", .0104" .0128", .0156", .0191" .0234", .0290", .0364"
Size of collets supplied	$\frac{1}{2}$, $\frac{3}{8}$", $\frac{1}{4}$", $\frac{1}{8}$".
Size of collets available	1/16", 3/32", $\frac{1}{8}$", 5/32" 3/16", 7/32", $\frac{1}{4}$" 9/32" 5/16", 11/32", $\frac{3}{8}$", 13/32" 7/16", 15/32" $\frac{1}{2}$"
Size of work arbors supplied	$\frac{1}{4}$", $\frac{3}{8}$", $\frac{1}{2}$", $\frac{5}{8}$", $\frac{3}{4}$"
Horsepower of motor	$\frac{1}{2}$ HP.
Speed of motor	1440 RPM
Weight of machine	$8\frac{1}{2}$ cwt.
Space occupied by machine	3'2" x 1'7"

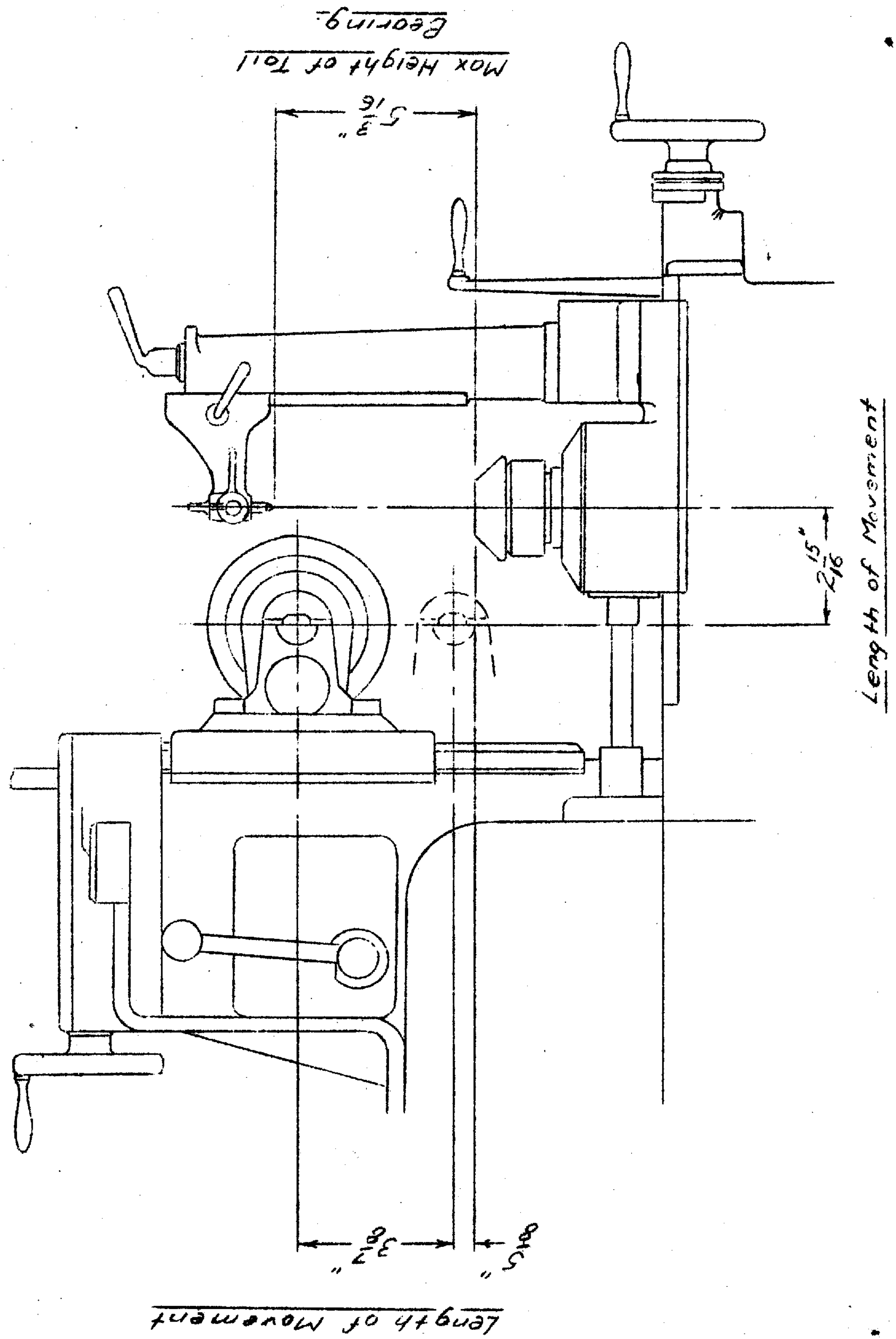

Max Height of Tail
Bearing.
3 5/16"
2 15/16"
Length of Movement
3 7/8"
5/8"
Length of Movement

Fig 17.

HOB HEAD MOVEMENTS FOR RH & LH SPIRAL GEARS

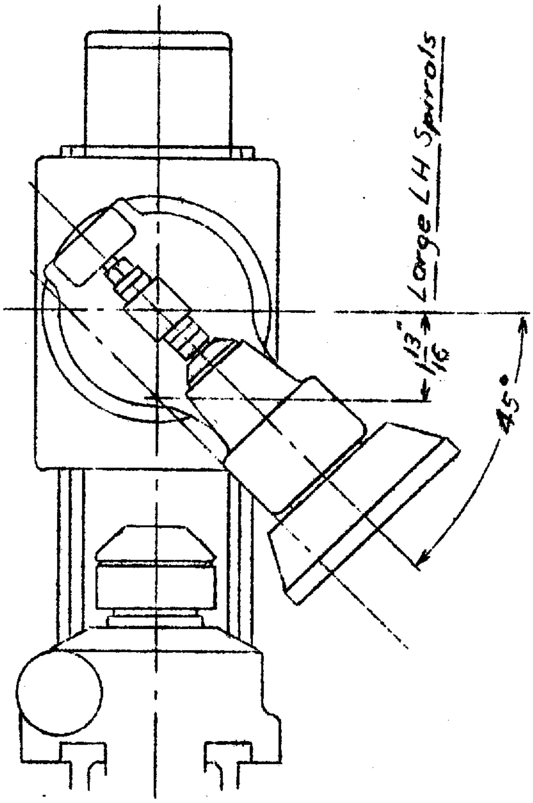


Fig. 18

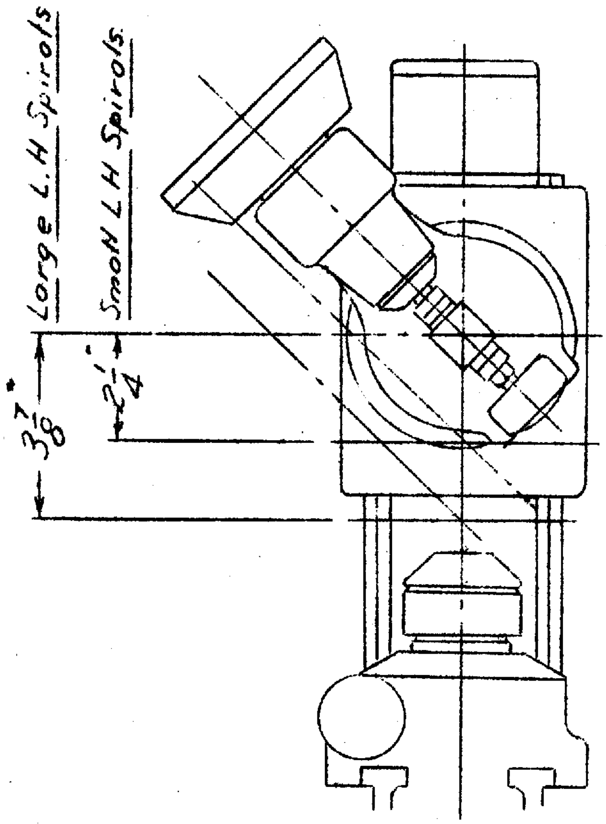


Fig. 19

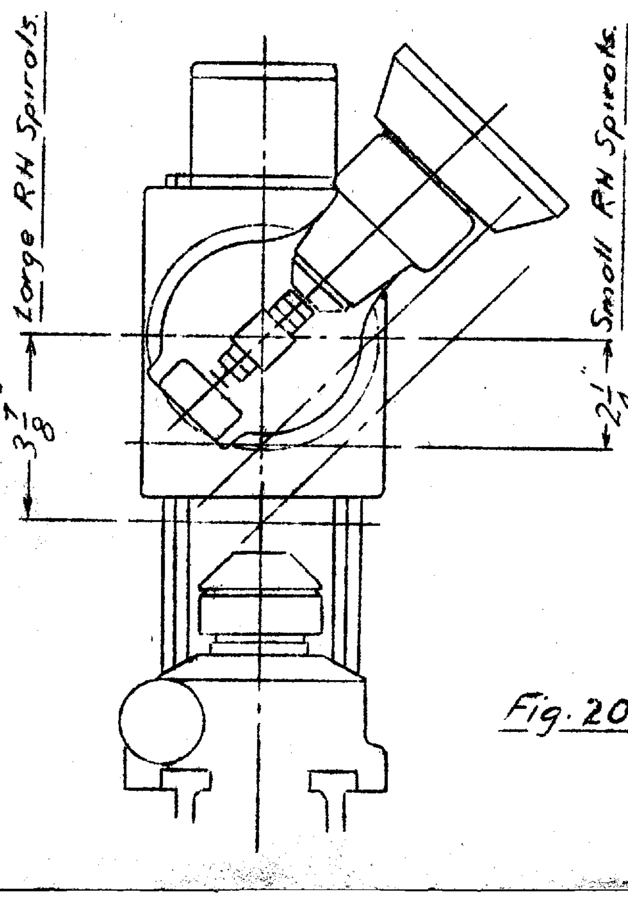


Fig. 20

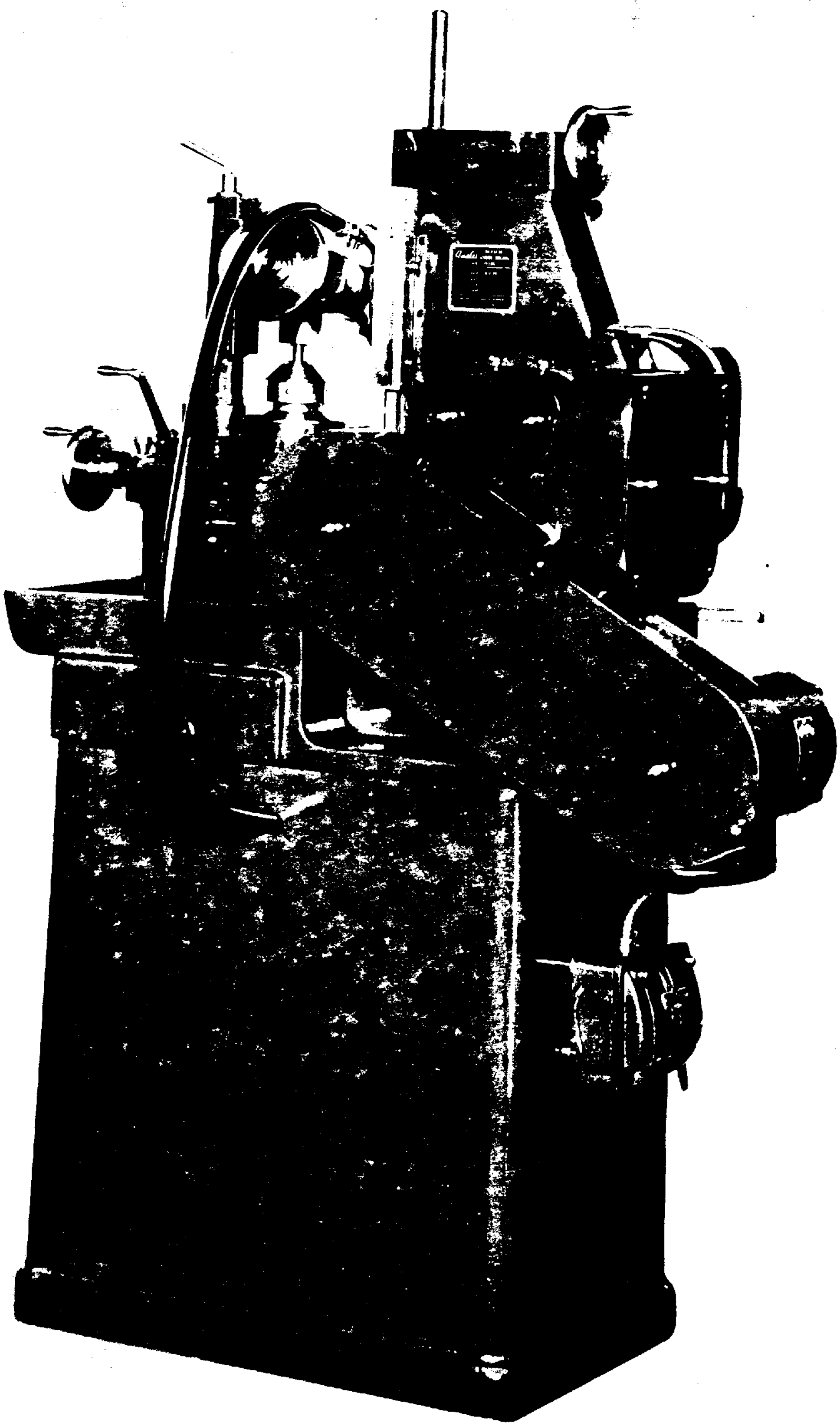
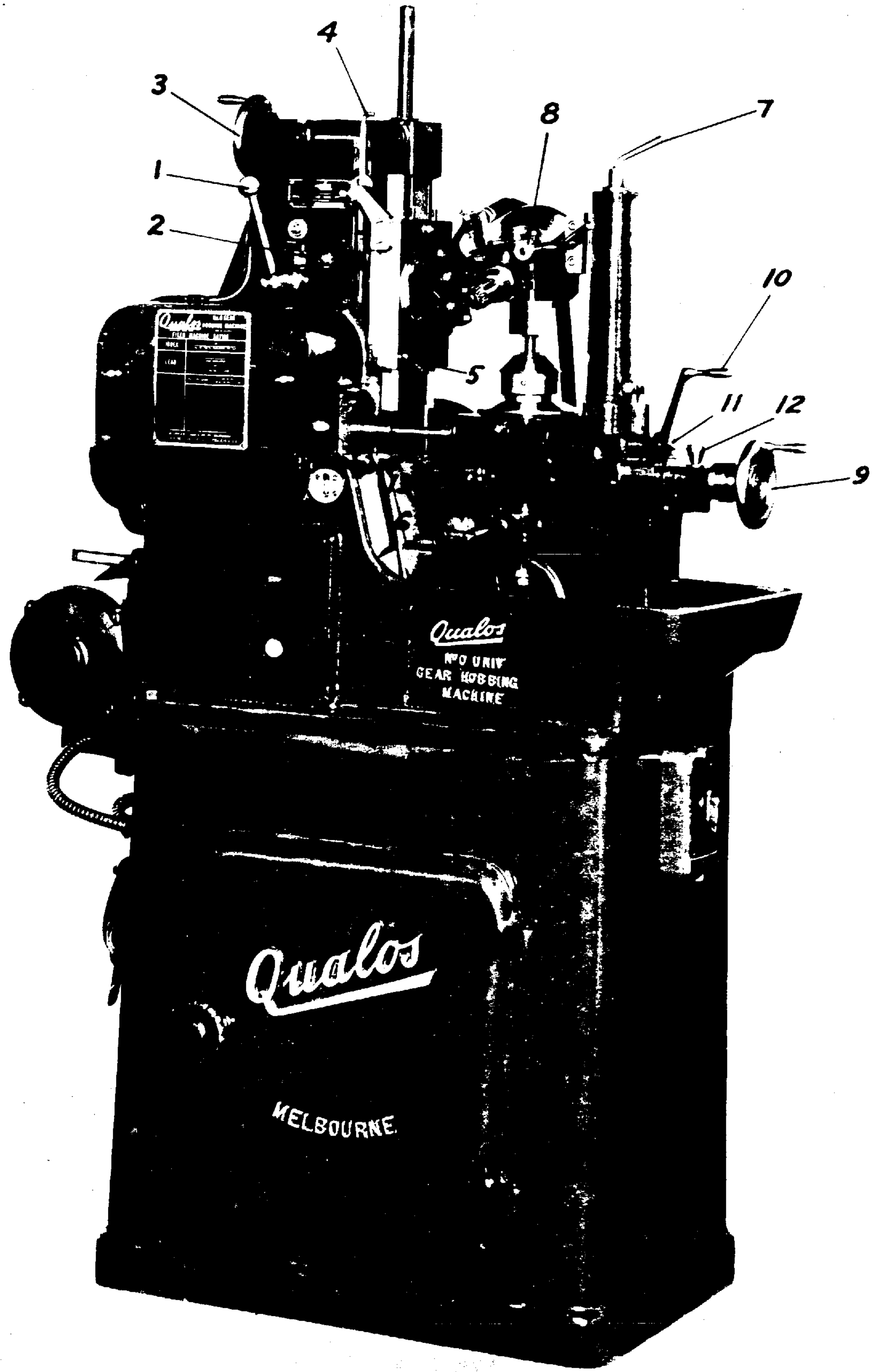


Fig. 22.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3
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9
Qualos
Nº0 UNIV
GEAR HOBBING
MACHINE
Qualos
MELBOURNE

Fig. 21.