Photo 1

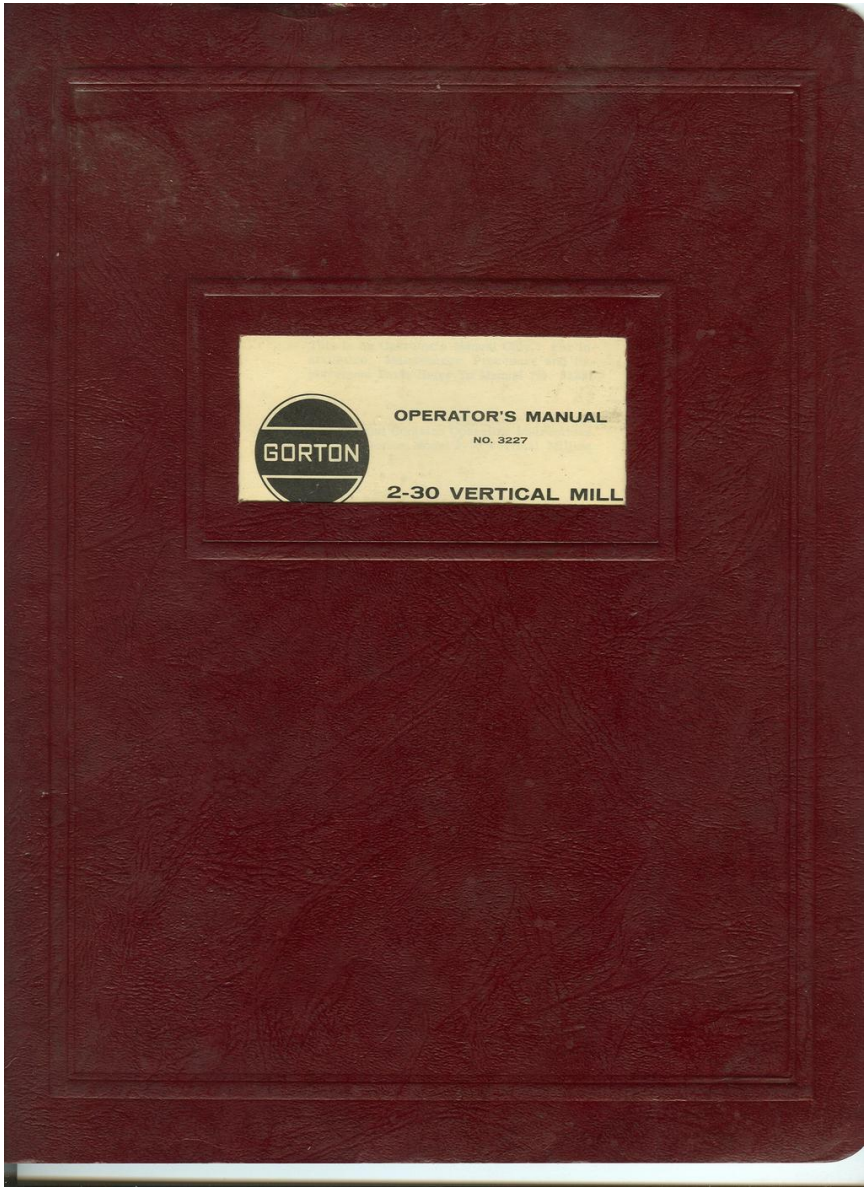
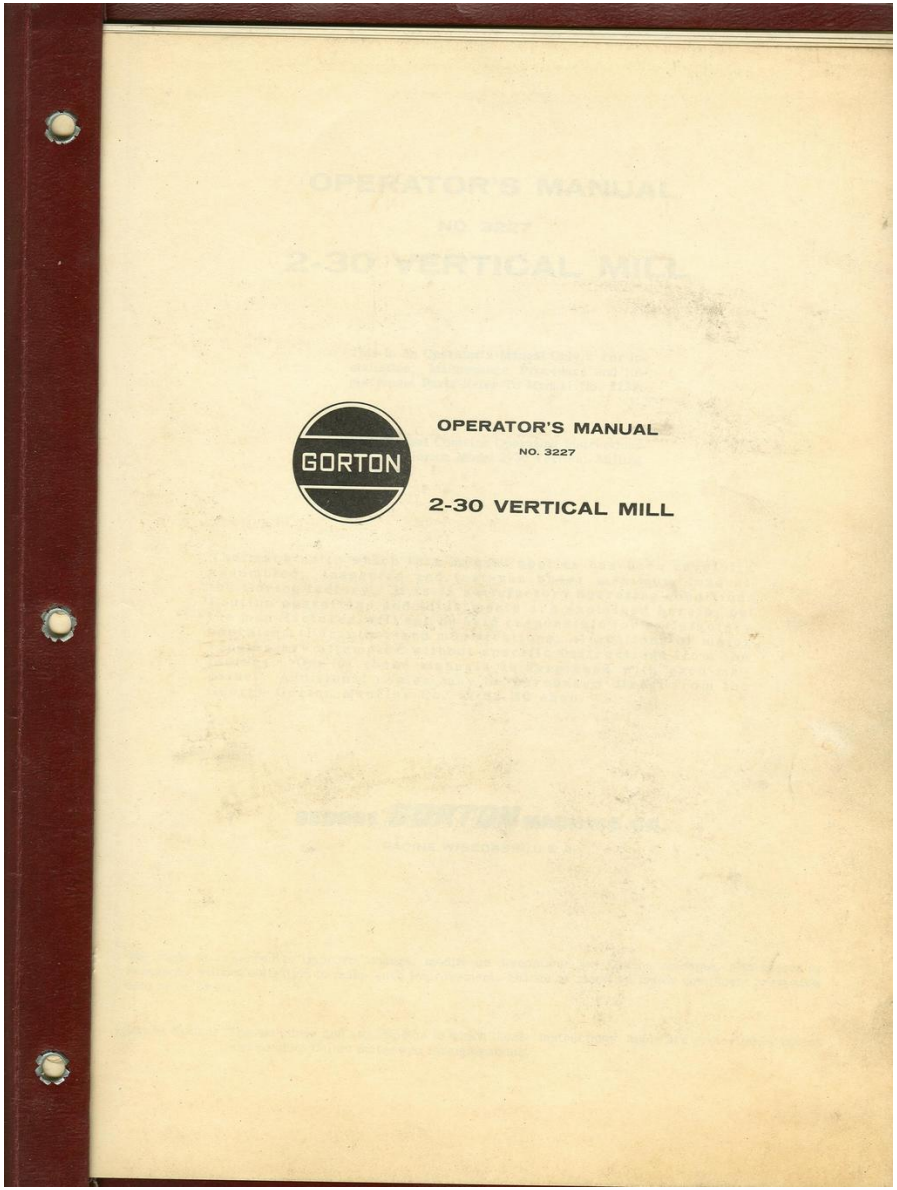


Photo 2



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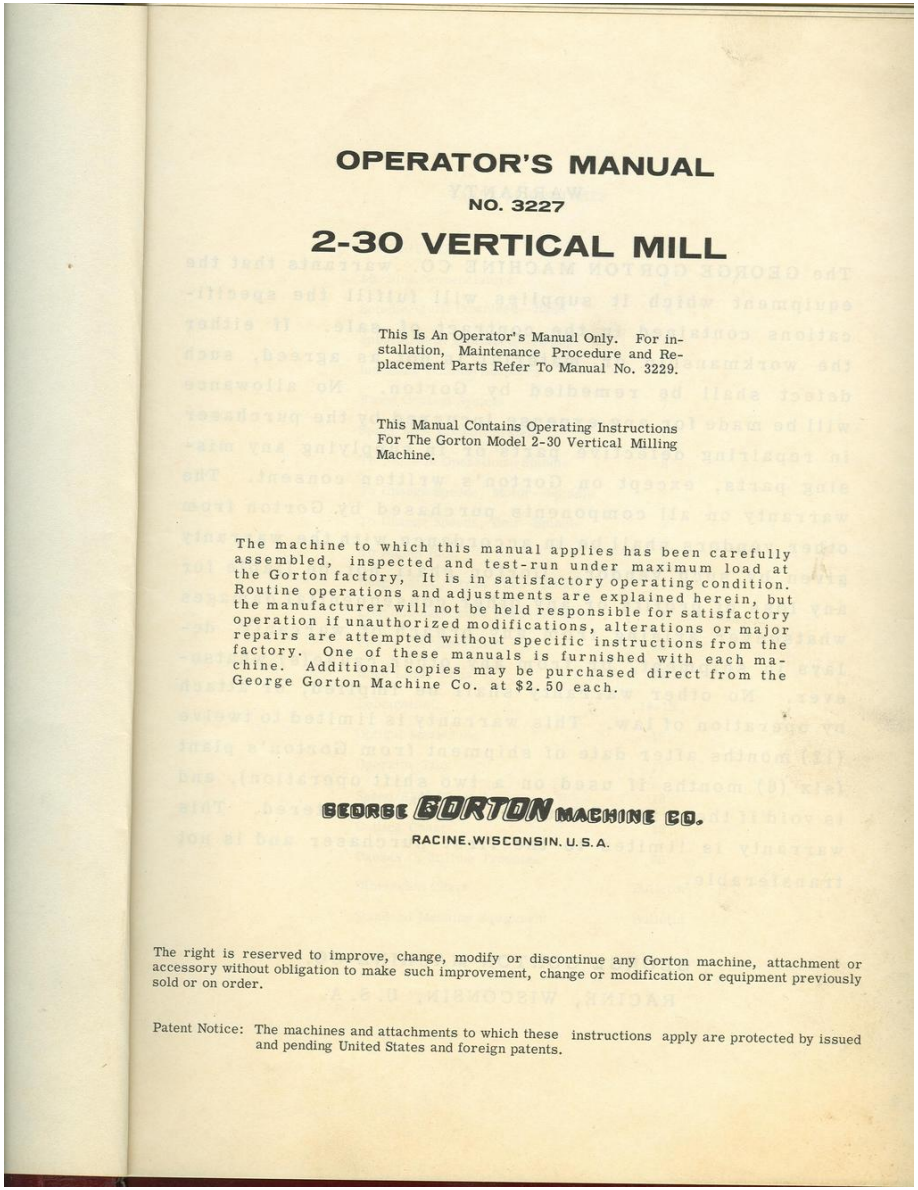


OPERATOR'S MANUAL

NO. 3227

2-30 VERTICAL MILL

This Is An Operator's Manual Only. For installation, Maintenance Procedure and Replacement Parts Refer To Manual No. 3229.

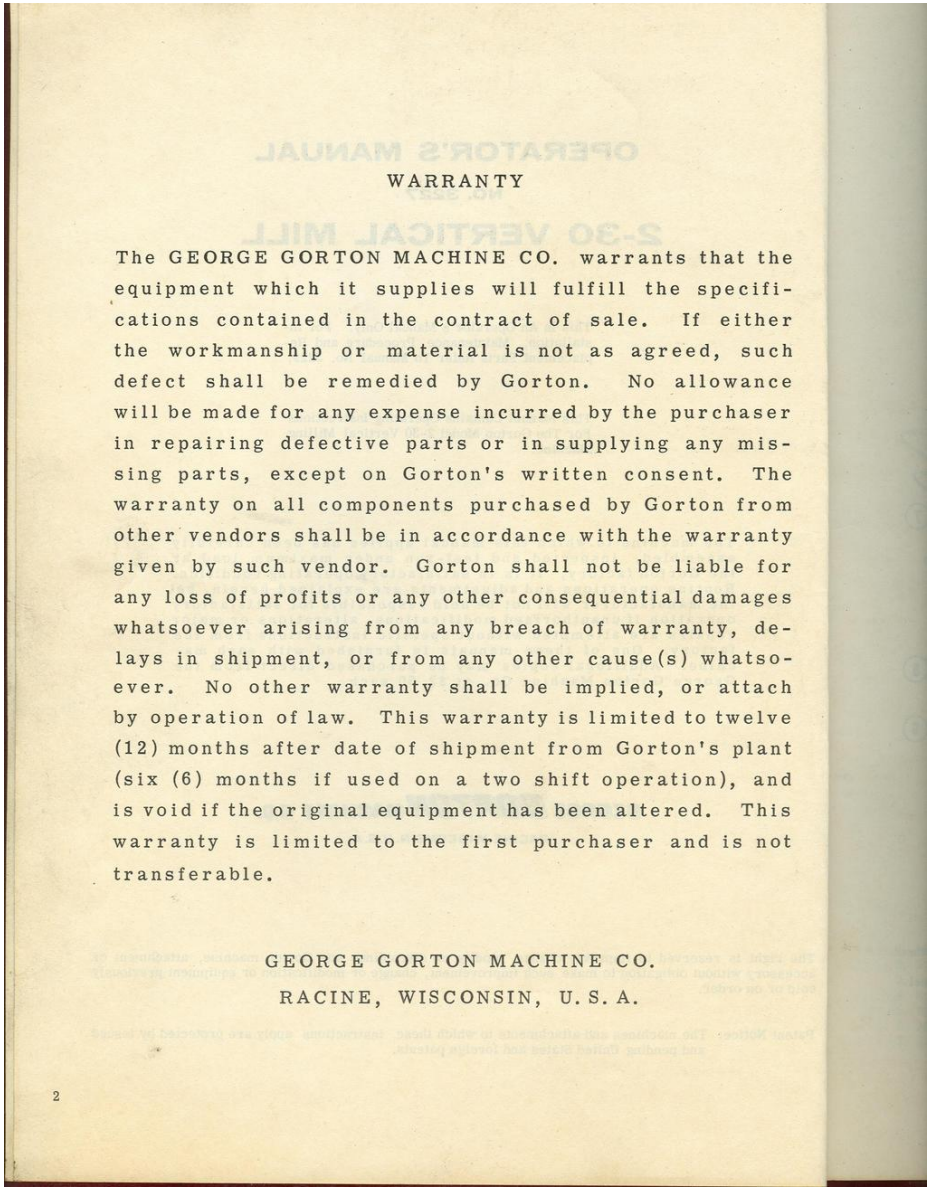
This Manual Contains Operating Instructions For The Gorton Model 2-30 Vertical Milling Machine.

The machine to which this manual applies has been carefully assembled, inspected and test-run under maximum load at the Gorton factory, It is in satisfactory operating condition. Routine operations and adjustments are explained herein, but the manufacturer will not be held responsible for satisfactory operation if unauthorized modifications, alterations or major repairs are attempted without specific instructions from the factory. One of these manuals is furnished with each machine. Additional copies may be purchased direct from the George Gorton Machine Co. at $2.50 each.

GEORGE GORTON MACHINE CO.

RACINE, WISCONSIN, U.S.A.

Photo 4



WARRANTY

The GEORGE GORTON MACHINE CO. warrants that the equipment which it supplies will fulfill the specifications contained in the contract of sale. If either the workmanship or material is not as agreed, such defect shall be remedied by Gorton. No allowance will be made for any expense incurred by the purchaser in repairing defective parts or in supplying any missing parts, except on Gorton's written consent. The warranty on all components purchased by Gorton from other vendors shall be in accordance with the warranty given by such vendor. Gorton shall not be liable for any loss of profits or any other consequential damages whatsoever arising from any breach of warranty, delays in shipment, or from any other cause(s) whatsoever. No other warranty shall be implied, or attach by operation of law. This warranty is limited to twelve (12) months after date of shipment from Gorton's plant (six (6) months if used on a two shift operation), and is void if the original equipment has been altered. This warranty is limited to the first purchaser and is not transferable.

GEORGE GORTON MACHINE CO.
RACINE, WISCONSIN, U. S. A.

Photo 5

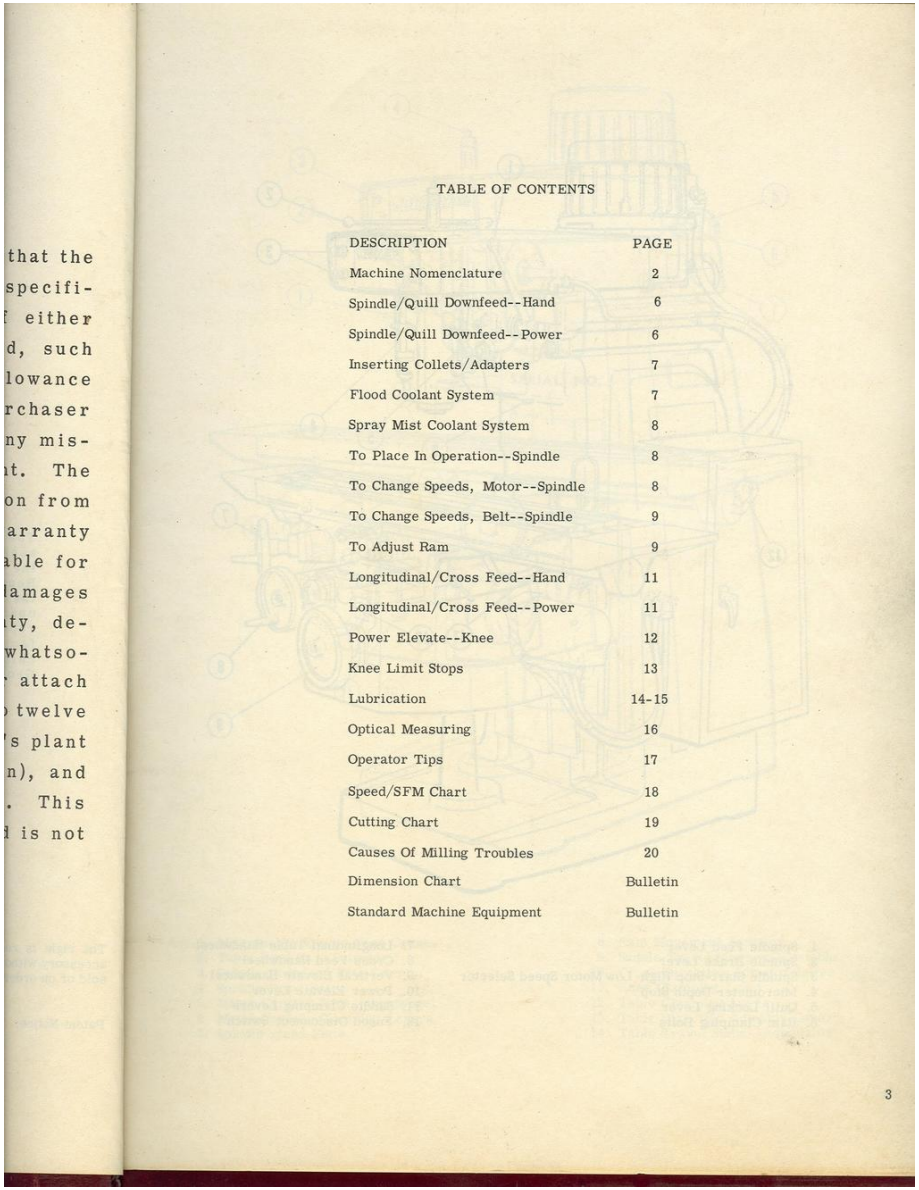


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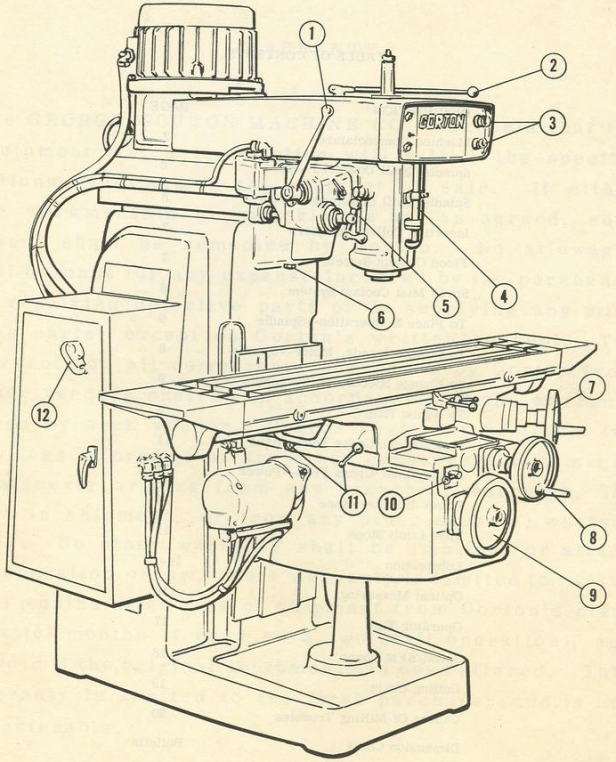
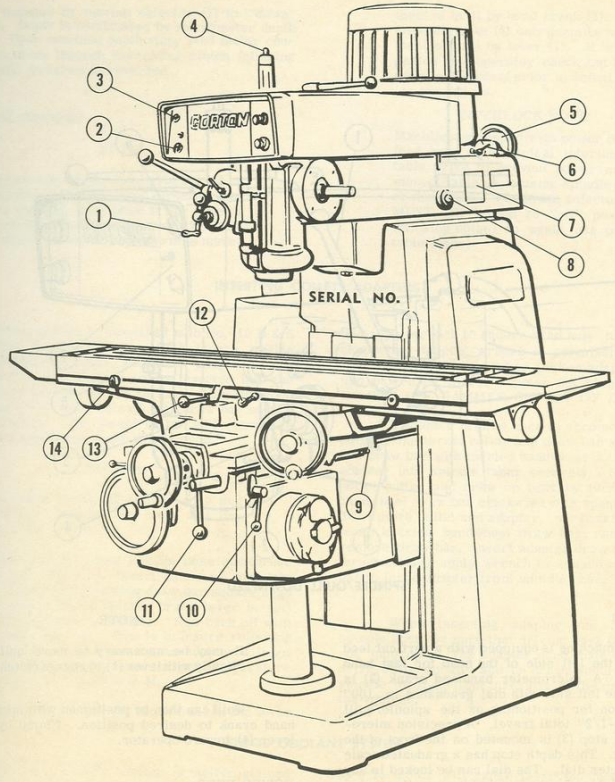
Photo 6



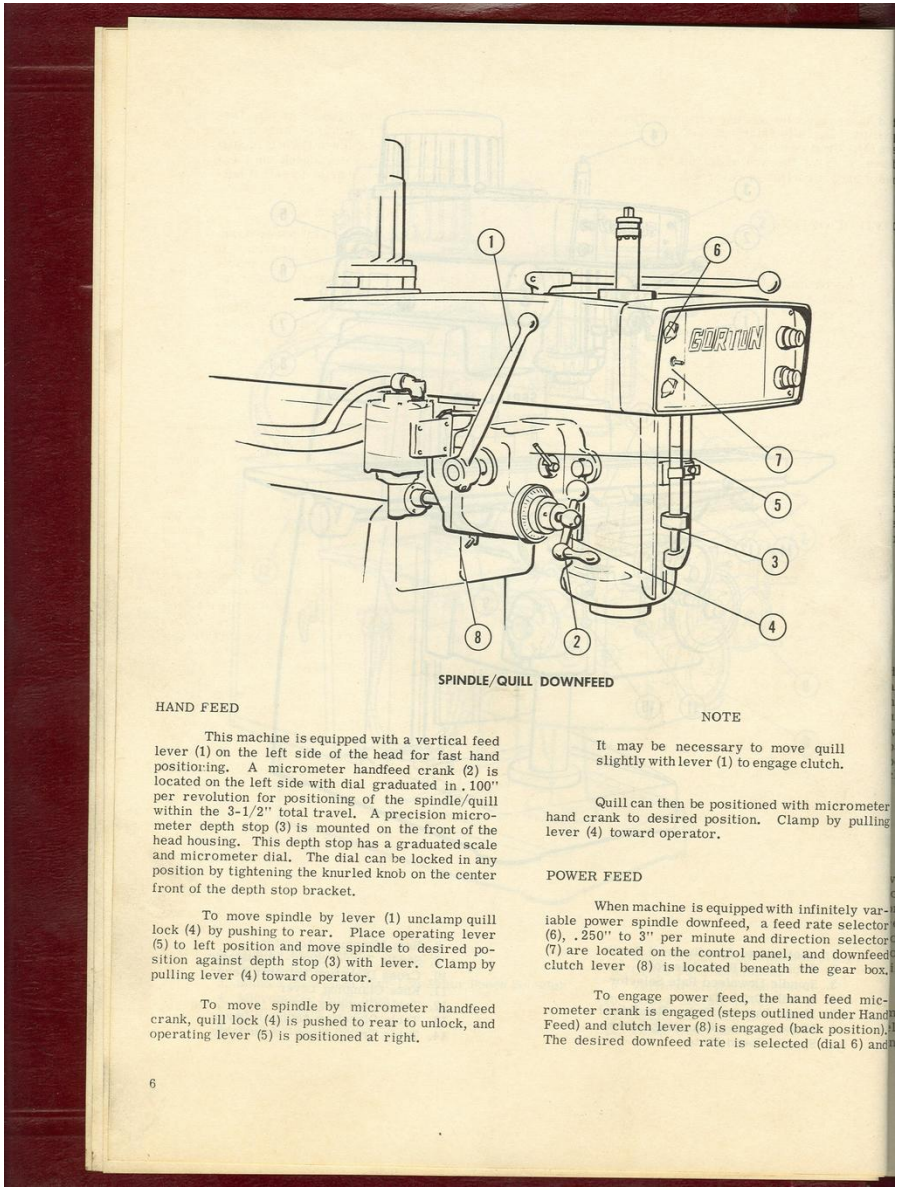
1. Spindle Feed Lever
2. Spindle Brake Lever
3. Spindle Start-Stop High-Low Motor Speed Selector
4. Micrometer Depth Stop
5. Quill Locking Lever
6. Ram Clamping Bolts
7. Longitudinal Table Handwheel
8. Cross Feed Handwheel
9. Vertical Elevate Handwheel
10. Power Elevate Lever
11. Saddle Clamping Levers
12. Fused Disconnect Switch

Photo 7



1. Micrometer Spindle Feed Crank
2. Table Feed Rate Selector
3. Spindle Downfeed Rate Selector
4. Spindle Draw Bar
5. Motor Carrier Slide--Handwheel
6. Motor Carrier Clamping Levers
7. Spindle Speed Plate
8. Ram Movement Actuator
9. Saddle Travel Stops--Adjustable
10. Cross Direction Actuator Lever
11. Knee Clamping Lever
12. Table Clamping Lever
13. Table Direction Actuator Lever
14. Table Travel Stops--Adjustable

Photo 8



SPINDLE/QUILL DOWNFEED

HAND FEED

This machine is equipped with a vertical feed lever (1) on the left side of the head for fast hand positioning. A micrometer handfeed crank (2) is located on the left side with dial graduated in .100" per revolution for positioning of the spindle/quill within the 3-1/2" total travel. A precision micrometer depth stop (3) is mounted on the front of the head housing. This depth stop has a graduated scale and micrometer dial. The dial can be locked in any position by tightening the knurled knob on the center front of the depth stop bracket.

To move spindle by lever (1) unclamp quill lock (4) by pushing to rear. Place operating lever (5) to left position and move spindle to desired position against depth stop (3) with lever. Clamp by pulling lever (4) toward operator.

To move spindle by micrometer handfeed crank, quill lock (4) is pushed to rear to unlock, and operating lever (5) is positioned at right.

NOTE

It may be necessary to move quill slightly with lever (1) to engage clutch.

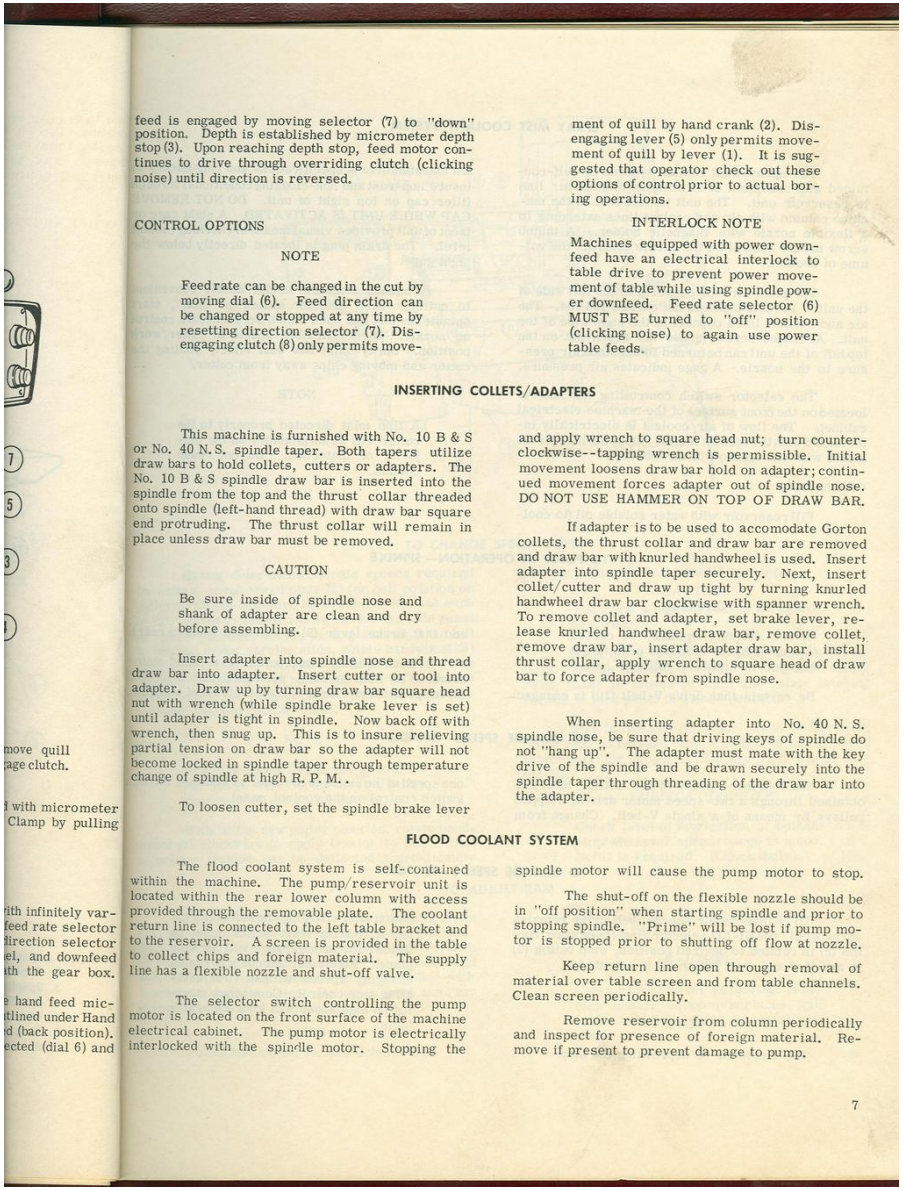
Quill can then be positioned with micrometer hand crank to desired position. Clamp by pulling lever (4) toward operator.

POWER FEED

When machine is equipped with infinitely variable power spindle downfeed, a feed rate selector (6), .250" to 3" per minute and direction selector (7) are located on the control panel, and downfeed clutch lever (8) is located beneath the gear box.

To engage power feed, the hand feed micrometer crank is engaged (steps outlined under Hand Feed) and clutch lever (8) is engaged (back position). The desired downfeed rate is selected (dial 6) and

Photo 9



feed is engaged by moving selector (7) to "down" position. Depth is established by micrometer depth stop (3). Upon reaching depth stop, feed motor continues to drive through overriding clutch (clicking noise) until direction is reversed.

CONTROL OPTIONS

NOTE

Feed rate can be changed in the cut by moving dial (6). Feed direction can be changed or stopped at any time by resetting direction selector (7). Disengaging clutch (8) only permits movement of quill by hand crank (2). Disengaging lever (5) only permits movement of quill by lever (1). It is suggested that operator check out these options of control prior to actual boring operations.

INTERLOCK NOTE

Machines equipped with power downfeed have an electrical interlock to table drive to prevent power movement of table while using spindle power downfeed. Feed rate selector (6) MUST BE turned to "off" position (clicking noise) to again use power table feeds.

INSERTING COLLETS/ADAPTERS

This machine is furnished with No. 10 B & S or No. 40 N.S. spindle taper. Both tapers utilize draw bars to hold collets, cutters or adapters. The No. 10 B & S spindle draw bar is inserted into the spindle from the top and the thrust collar threaded onto spindle (left-hand thread) with draw bar square end protruding. The thrust collar will remain in place unless draw bar must be removed.

CAUTION

Be sure inside of spindle nose and shank of adapter are clean and dry before assembling.

Insert adapter into spindle nose and thread draw bar into adapter. Insert cutter or tool into adapter. Draw up by turning draw bar square head nut with wrench (while spindle brake lever is set) until adapter is tight in spindle. Now back off with wrench, then snug up. This is to insure relieving partial tension on draw bar so the adapter will not become locked in spindle taper through temperature change of spindle at high R. P. M. .

To loosen cutter, set the spindle brake lever and apply wrench to square head nut; turn counter-clockwise--tapping wrench is permissible. Initial movement loosens draw bar hold on adapter; continued movement forces adapter out of spindle nose. DO NOT USE HAMMER ON TOP OF DRAW BAR.

If adapter is to be used to accomodate Gorton collets, the thrust collar and draw bar are removed and draw bar with knurled handwheel is used. Insert adapter into spindle taper securely. Next, insert collet/cutter and draw up tight by turning knurled handwheel draw bar clockwise with spanner wrench. To remove collet and adapter, set brake lever, release knurled handwheel draw bar, remove collet, remove draw bar, insert adapter draw bar, install thrust collar, apply wrench to square head of draw bar to force adapter from spindle nose.

When inserting adapter into No. 40 N. S. spindle nose, be sure that driving keys of spindle do not "hang up". The adapter must mate with the key drive of the spindle and be drawn securely into the spindle taper through threading of the draw bar into the adapter.

FLOOD COOLANT SYSTEM

The flood coolant system is self-contained within the machine. The pump/reservoir unit is located within the rear lower column with access provided through the removable plate. The coolant return line is connected to the left table bracket and to the reservoir. A screen is provided in the table to collect chips and foreign material. The supply line has a flexible nozzle and shut-off valve.

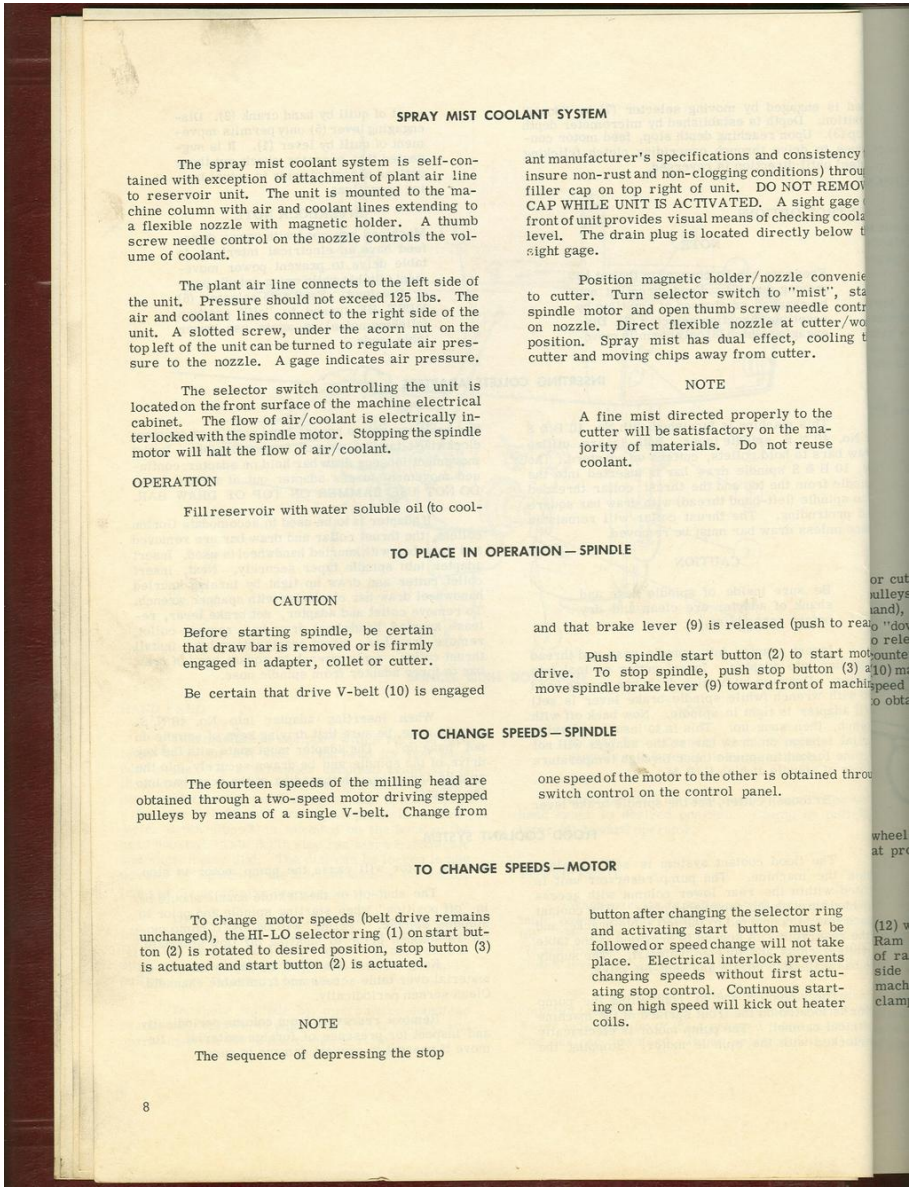
The selector switch controlling the pump motor is located on the front surface of the machine electrical cabinet. The pump motor is electrically interlocked with the spindle motor. Stopping the spindle motor will cause the pump motor to stop.

The shut-off on the flexible nozzle should be in "off position" when starting spindle and prior to stopping spindle. "Prime" will be lost if pump motor is stopped prior to shutting off flow at nozzle.

Keep return line open through removal of material over table screen and from table channels. Clean screen periodically.

Remove reservoir from column periodically and inspect for presence of foreign material. Remove if present to prevent damage to pump.

Photo 10



SPRAY MIST COOLANT SYSTEM

The spray mist coolant system is self-contained with exception of attachment of plant air line to reservoir unit. The unit is mounted to the machine column with air and coolant lines extending to a flexible nozzle with magnetic holder. A thumb screw needle control on the nozzle controls the volume of coolant.

The plant air line connects to the left side of the unit. Pressure should not exceed 125 lbs. The air and coolant lines connect to the right side of the unit. A slotted screw, under the acorn nut on the top left of the unit can be turned to regulate air pressure to the nozzle. A gage indicates air pressure.

The selector switch controlling the unit is located on the front surface of the machine electrical cabinet. The flow of air/coolant is electrically interlocked with the spindle motor. Stopping the spindle motor will halt the flow of air/coolant.

OPERATION

Fill reservoir with water soluble oil (to coolant manufacturer's specifications and consistency insure non-rust and non-clogging conditions) throu filler cap on top right of unit. DO NOT REMOV CAP WHILE UNIT IS ACTIVATED. A sight gage front of unit provides visual means of checking coola level. The drain plug is located directly below t sight gage.

Position magnetic holder/nozzle convenie to cutter. Turn selector switch to "mist", sta spindle motor and open thumb screw needle contr on nozzle. Direct flexible nozzle at cutter/wo position. Spray mist has dual effect, cooling t cutter and moving chips away from cutter.

NOTE

A fine mist directed properly to the cutter will be satisfactory on the majority of materials. Do not reuse coolant.

TO PLACE IN OPERATION — SPINDLE

CAUTION

Before starting spindle, be certain that draw bar is removed or is firmly engaged in adapter, collet or cutter.

Be certain that drive V-belt (10) is engaged and that brake lever (9) is released (push to rea

Push spindle start button (2) to start mot drive. To stop spindle, push stop button (3) a move spindle brake lever (9) toward front of machi

TO CHANGE SPEEDS — SPINDLE

The fourteen speeds of the milling head are obtained through a two-speed motor driving stepped pulleys by means of a single V-belt. Change from one speed of the motor to the other is obtained throu switch control on the control panel.

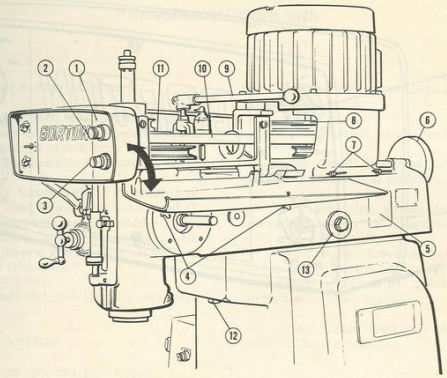
TO CHANGE SPEEDS — MOTOR

To change motor speeds (belt drive remains unchanged), the HI-LO selector ring (1) on start button (2) is rotated to desired position, stop button (3) is actuated and start button (2) is actuated.

NOTE

The sequence of depressing the stop button after changing the selector ring and activating start button must be followed or speed change will not take place. Electrical interlock prevents changing speeds without first actuating stop control. Continuous starting on high speed will kick out heater coils.

Photo 11



TO CHANGE SPEEDS—BELT

Having determined spindle speeds required for cutter, check speed plate (5) for belt position on pulleys. Grasp half-turn latch screws (4) (one each hand), rotate to unlock and swing shroud side panel to "down" position. Rotate locking screws (7) to left to release motor carrier slide, rotate handwheel (6) counterclockwise to release belt to point where belt (10) may be moved over pulleys (8) and (11). Follow speed plate (5) directions for belt position on pulleys to obtain desired spindle speed.

NOTE

Belt is designed and arranged to drive on "cross-over" from driving pulley groove to driven pulley groove.

With belt in new pulley position, rotate handwheel (6) clockwise to apply tension to belt. Belt at proper tension can be deflected approximately 1/4" by pulling on belt nearest opening.

CAUTION

Too great a tension causes excessive belt wear.

Lock motor slide by rotating screws (7) to right. Grasp latching screws (4) (one each hand), swing panel to closed position and rotate latching screws to lock panel in closed position.

Step to front of machine. Push brake lever (9) to rear to release, check setting of motor speed selector (1) for proper setting and push "start" button (2).

LUBRICATION NOTE

Check level of lubrication in spindle oiler whenever speed change is made. Refill is required. (Check daily).

TO ADJUST RAM

Loosen front and rear ram clamping bolts (12) with open-end wrench furnished with machine. Ram positioning is accomplished through rotation of ram positioning gear shaft (13) located on right side of ram. Apply socket wrench furnished with machine to shaft extension. Retighten front and rear clamping bolts after ram adjustment.

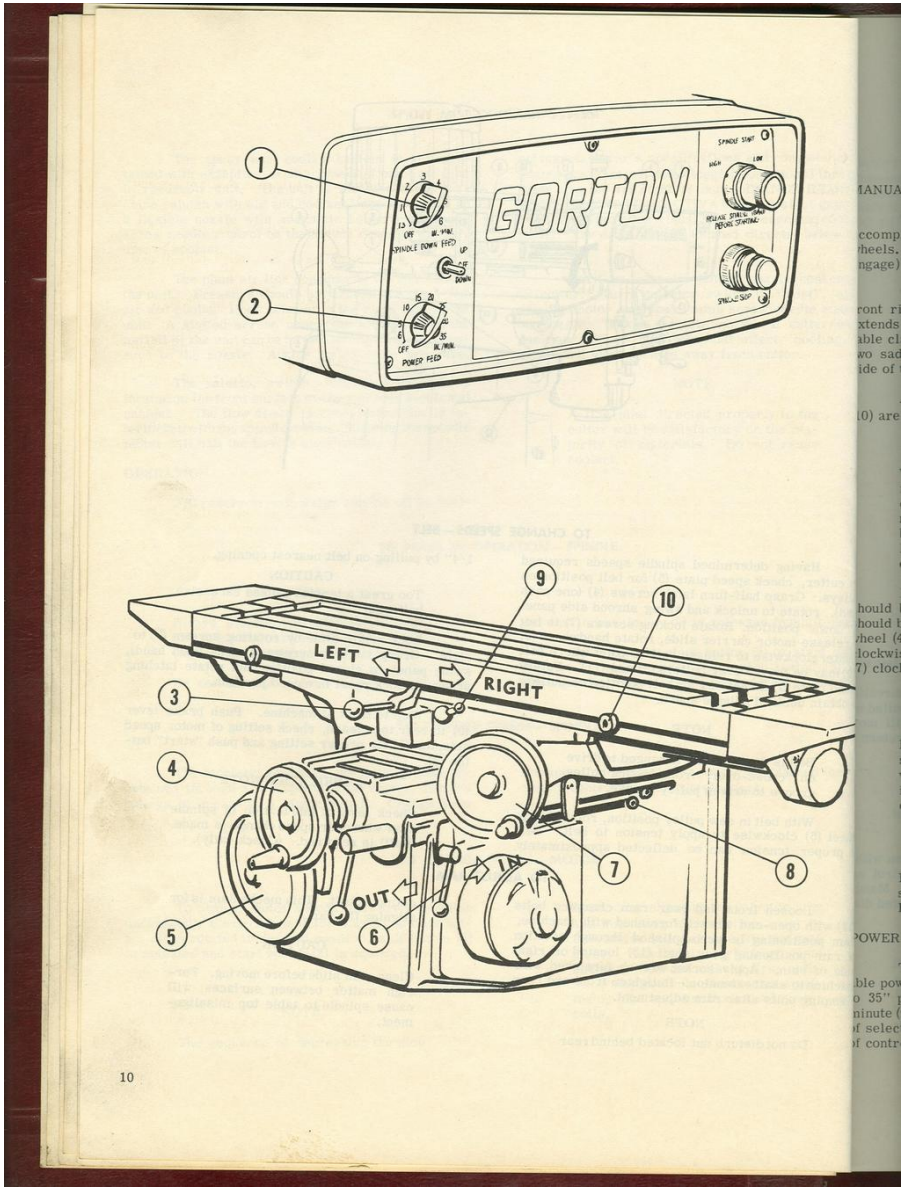
NOTE

Do not disturb nut located behind rear clamping bolt. This mechanism is for aligning the ram.

CAUTION

Clean ram slide before moving. Foreign matter between surfaces will cause spindle to table top misalignment.

Photo 12


GORTON
SPINDLE START
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LOW
SPINDLE STOP
SPINDLE DOWN FEED
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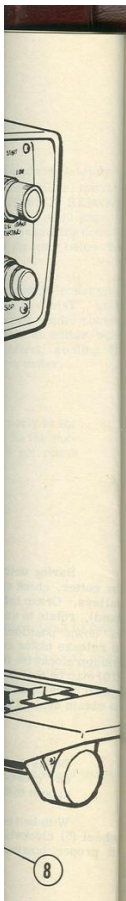
Photo 13



MANUAL FEED--TABLE AND SADDLE

Table and saddle feed and positioning are accomplished by means of centrally located handwheels. Each handwheel of clutch-type (press in to engage) is equipped with adjustable micrometer dials.

The cross feed handwheel (4) is located at front right of knee. The table feed handwheel (7) extends at an angle from right front of saddle. The table clamping lever (9) is at center position. The two saddle clamping levers are located on the left side of the saddle (not illustrated).

Adjustable cross (8) and longitudinal stops (10) are provided.

CAUTION

When feeding or positioning under manual control, stops should be located against limit pins to avoid damage. Stops cannot be positioned beyond limits of travel of cross or longitudinal motions (factory installed limit pins).

Prior to moving either axis, the clamp (s) should be released and location of adjustable stops should be checked. To feed saddle in, rotate handwheel (4) clockwise; to feed out, rotate counterclockwise. To feed table to right, rotate handwheel (7) clockwise; to feed left, rotate counterclockwise.

CAUTION

Do not engage and lock handwheels to shafts. This causes overload to motor when operating under power feed and is a hazardous practice which could cause personal injury

NOTE

For manual/power adjustment of knee, see section -- POWER ELEVATE -- KNEE.

POWER FEED--TABLE AND SADDLE

The machine is equipped with infinitely variable power feed to table and saddle. Feed range .6" to 35" per minute. Rapid traverse rate 35" per minute (full feed rate). Feed rate control is by means of selector dial (2) located in lower left-hand corner of control panel on milling head.

Suggested sequence to engage power cross and longitudinal feeds:

A. Release saddle and table clamps.

B. Feed direction levers for table (3) and saddle (6) in neutral position.

C. Machine power switch (main electrical control panel) in "on" position.

D. Power downfeed switch (1) (when installed --located in upper left corner of milling head control panel) in "click-off" position (electrically interlocked with table drive).

E. Rotate feed rate selector dial (2) clockwise to desired setting.

NOTE

When dial is moved from stop setting, the feed drive is set in motion to cross and longitudinal gear assemblies simultaneously--ready for feed selection.

F. Select direction of motion of table or saddle desired. Table direction selector (3) and saddle direction selector (6) are directional. EITHER OR BOTH FEED DIRECTIONS can be engaged.

G. Adjust feed dial (2) setting for efficient cutting condition as determined by cutter diameter and material. FEED RATE CAN BE CHANGED IN THE CUT.

NOTE

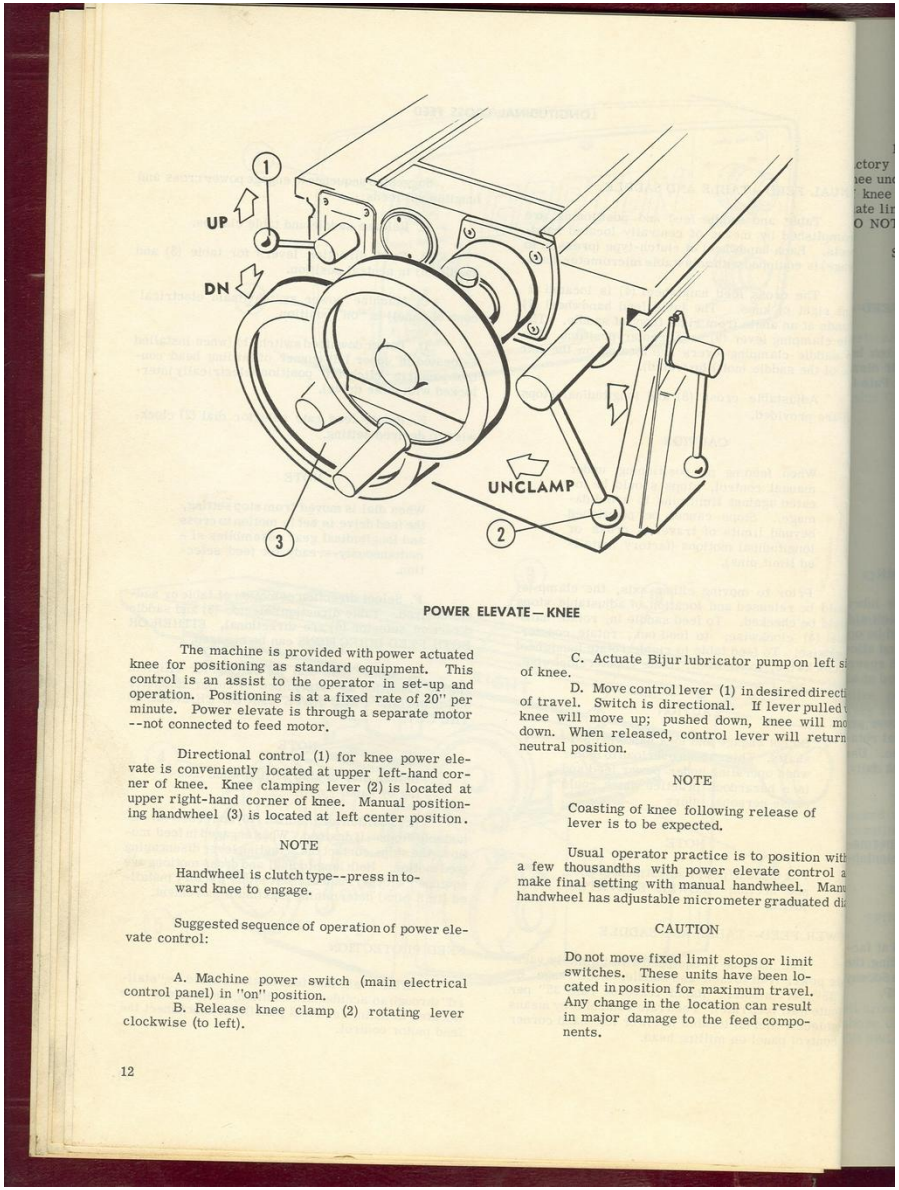
Return dial to stop setting when feeding by hand.

H. Position longitudinal (10) and cross (8) adjustable stops--if desired. When engaged in feed motion, the stops contact the actuating lever disengaging feed motion. Both longitudinal and cross motions are equipped with permanent limit stops (factory installed limit pins) determining maximum movement.

FEED PROTECTION

In the event that feed motion should be "stalled" through an accidental condition, an overload fuse (located in main electrical panel) will disconnect the feed motor control.

Photo 14



POWER ELEVATE — KNEE

The machine is provided with power actuated knee for positioning as standard equipment. This control is an assist to the operator in set-up and operation. Positioning is at a fixed rate of 20" per minute. Power elevate is through a separate motor --not connected to feed motor.

Directional control (1) for knee power elevate is conveniently located at upper left-hand corner of knee. Knee clamping lever (2) is located at upper right-hand corner of knee. Manual positioning handwheel (3) is located at left center position.

NOTE

Handwheel is clutch type--press in toward knee to engage.

Suggested sequence of operation of power elevate control:

A. Machine power switch (main electrical control panel) in "on" position.

B. Release knee clamp (2) rotating lever clockwise (to left).

C. Actuate Bijur lubricator pump on left si of knee.

D. Move control lever (1) in desired directi of travel. Switch is directional. If lever pulled knee will move up; pushed down, knee will mo down. When released, control lever will return neutral position.

NOTE

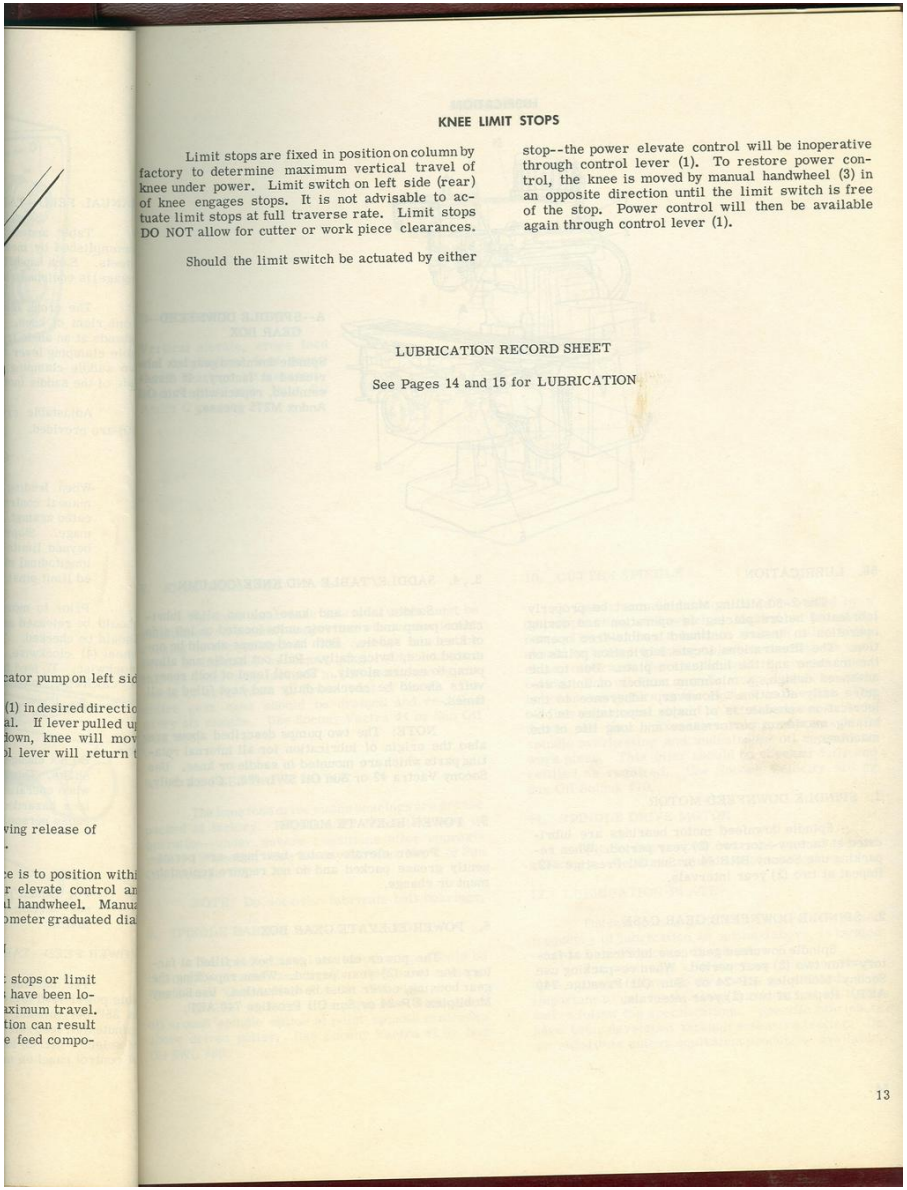
Coasting of knee following release of lever is to be expected.

Usual operator practice is to position with a few thousandths with power elevate control a make final setting with manual handwheel. Manu handwheel has adjustable micrometer graduated di

CAUTION

Do not move fixed limit stops or limit switches. These units have been located in position for maximum travel. Any change in the location can result in major damage to the feed components.

Photo 15



KNEE LIMIT STOPS

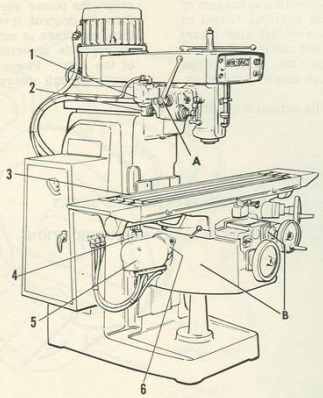
Limit stops are fixed in position on column by factory to determine maximum vertical travel of knee under power. Limit switch on left side (rear) of knee engages stops. It is not advisable to actuate limit stops at full traverse rate. Limit stops DO NOT allow for cutter or work piece clearances.

Should the limit switch be actuated by either stop--the power elevate control will be inoperative through control lever (1). To restore power control, the knee is moved by manual handwheel (3) in an opposite direction until the limit switch is free of the stop. Power control will then be available again through control lever (1).

LUBRICATION RECORD SHEET

See Pages 14 and 15 for LUBRICATION

Photo 16



A--SPINDLE DOWNFEED GEAR BOX

Spindle downfeed gear box lubricated at factory. If disassembled, repack with Pate Oil Andox M275 grease.

58. LUBRICATION

The 2-30 Milling Machine must be properly lubricated before placing in operation and during operation to insure continued trouble-free operation. The illustrations locate lubrication points on the machine and the lubrication plate. Due to the advanced design, a minimum number of units require daily attention. However, adherence to the lubrication schedule is of major importance in obtaining maximum performance and long life of the machine.

1. SPINDLE DOWNFEED MOTOR

Spindle downfeed motor bearings are lubricated at factory--for two (2) year period. When repacking use Socony BRB #4 or Sun Oil Prestige #42. Repeat at two (2) year intervals.

2. SPINDLE DOWNFEED GEAR CASE

Spindle downfeed gear case lubricated at factory--for two (2) year period. When re-packing use Socony Mobilplex EP-24 or Sun Oil Prestige 740 AEP. Repeat at two (2) year intervals.

3., 4. SADDLE/TABLE AND KNEE/COLUMN

Saddle/table and knee/column slide lubrication pump and reservoir units located on left side of knee and saddle. Both hand pumps should be operated once, twice daily. Pull out handle and allow pump to return slowly. The oil level of both reservoirs should be checked daily and kept filled at all times.

NOTE: The two pumps described above are also the origin of lubrication for all internal rotating parts which are mounted in saddle or knee. Use Socony Vactra #2 or Sun Oil SWL #80. Check daily.

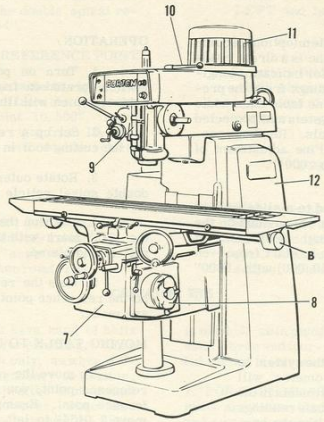
5. POWER ELEVATE MOTOR

Power elevate motor bearings are permanently grease packed and do not require replenishment or change.

6. POWER ELEVATE GEAR BOX

The power elevate gear box is filled at factory for two (2) year period. When repacking the gear housing, cover must be dismantled. Use Socony Mobilplex EP-24 or Sun Oil Prestige 740 AEP.

Photo 17



B--BEARINGS

Vertical elevate, cross feed and longitudinal feed screw thrust bearings. If disassembled, repack with Pate Oil Andox C grease.

7. KNEE GEAR CASE

The knee gear case lubricant level must be maintained. A monthly inspection when motor is not running is recommended. The correct lubrication level is indicated by brass plug. Add lubricant through filler plug (access to the gear case by removal of cover plate at lower front of knee). The entire gear case should be drained and re-filled every six months. Use Socony Vactra #4 or Sun Oil SWL #90.

8. KNEE FEED DRIVE MOTOR

The knee feed drive motor bearings are grease packed at factory. Repack after three (3) years of operation--under severe conditions after approximately 18 months. Use Socony Mobilux No. 2 or Sun Oil Prestige #42.

NOTE: Do not over-lubricate ball bearings.

9. SPINDLE BARREL AND DEPTH STOP

The spindle barrel and depth stop should be thoroughly cleaned and lightly oiled once a week. Use Socony Vactra #4 or Sun Oil SWL #90.

NOTE: At same time place five (5) drops of oil around spindle spline at point spindle protrudes above driven pulley. Use Socony Vactra #2 or Sun Oil SWL #80.

10. CUTTER SPINDLE

Cutter spindle lubrication is provided by a drip-type oiling unit which is located on top of the ram. The oiler has a built-in shut-off valve which should be turned (pointing up) when starting the machine, otherwise the spindle will receive no lubrication. The oil flow may be stopped when machine is not in use by turning the shut-off to one side. The oil flow adjustment should be set to feed one to three drops per hour. Excessive oiling will result in spindle overheating and undesirable oil deposits on work piece. This oiler should be checked daily and refilled as required. Use Socony Velocity #10 or Sun Oil Solnus #70.

11. SPINDLE DRIVE MOTOR

Spindle drive motor bearings are lubricated at factory. Requires no additional lubrication.

12. LUBRICATION PLATE

The lubrication plate which indicates type and frequency of lubrication as outlined above, is located on rear curved section of column.

For maximum efficiency and minimum downtime, always follow the directions as outlined. It is important to use fresh, clean lubricants at all times and to follow the specifications. Specific lubricants have been developed through extensive testing. Do not substitute unless equivalent product is available.

Photo 18

OPTICAL MEASURING

The Vernac measuring system (optional equipment) incorporated into the machine is a direct reading optical measuring instrument for indicating longitudinal and lateral position. Readings from the precision scales affixed to the machine table and saddle are transmitted through a lens system and projected onto illuminated direct-reading dials. Readings projected are in .025" intervals. Fine adjustment of the dial provides measurement to .0001".

The reader unit is mounted to a slide with 1" adjustment range. A clamp lever is provided on the reader slide for position clamping. Positioning of the reader slide permits operator to start from even number reading on reader (ref. 10.000) with .0000" on tenth scale.

NOTE

Considering the units of the system as components of a micrometer will greatly simplify the adjustments in the operator's mind. The scale readings in .025" increments are like the barrel of a micrometer and the double spiral reticle the thimble.

OPERATION

1. Turn on power switch for optic system (switch located on front face of machine electrical cabinet) which will illuminate readers.

2. Set up a reference point on the readers for the cutting tool in relationship to the workpiece.

3. Rotate outer ring of reader to position the double spiral reticle at .000" on the reticle scale.

4. Position the reader on its slide to bracket the .025" mark with the parallel lines of the double reticle and clamp.

5. Note the reading on the scale as this will be the reference point from which all measurements are made.

MOVING TABLE TO LEFT OF REFERENCE POINT

To move the machine table to the left of the reference point, you ADD the dimension to the reference point. Example: reference point 10.500", move 2.0154" to left. Rotate reticle clockwise until .015 mark lines up with line in reading area at bottom of dial. Then continue to rotate dial four di-

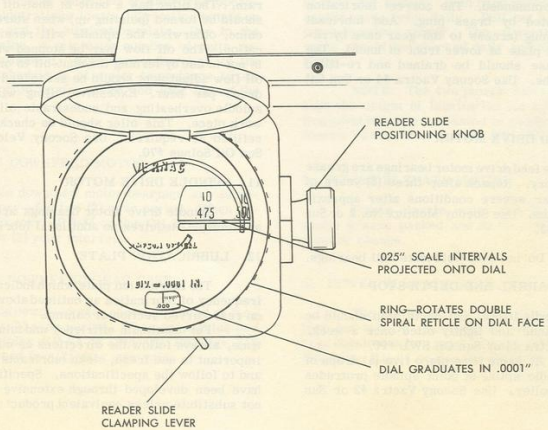
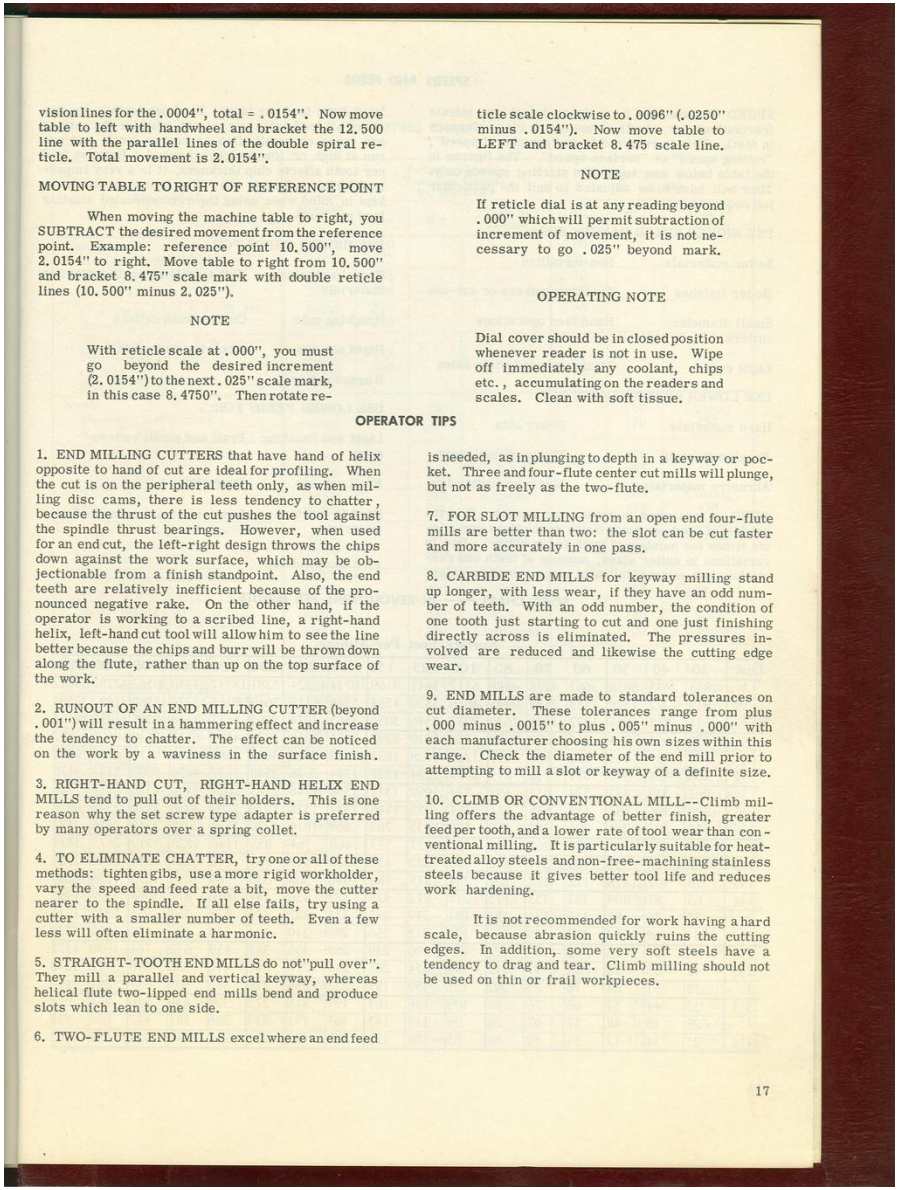


Photo 19



vision lines for the .0004", total = .0154". Now move table to left with handwheel and bracket the 12.500 line with the parallel lines of the double spiral reticle. Total movement is 2.0154".

MOVING TABLE TO RIGHT OF REFERENCE POINT

When moving the machine table to right, you SUBTRACT the desired movement from the reference point. Example: reference point 10.500", move 2.0154" to right. Move table to right from 10.500" and bracket 8.475" scale mark with double reticle lines (10.500" minus 2.025").

NOTE

With reticle scale at .000", you must go beyond the desired increment (2.0154") to the next .025" scale mark, in this case 8.4750". Then rotate reticle scale clockwise to .0096" (.0250" minus .0154"). Now move table to LEFT and bracket 8.475 scale line.

NOTE

If reticle dial is at any reading beyond .000" which will permit subtraction of increment of movement, it is not necessary to go .025" beyond mark.

OPERATING NOTE

Dial cover should be in closed position whenever reader is not in use. Wipe off immediately any coolant, chips etc., accumulating on the readers and scales. Clean with soft tissue.

OPERATOR TIPS

1. END MILLING CUTTERS that have hand of helix opposite to hand of cut are ideal for profiling. When the cut is on the peripheral teeth only, as when milling disc cams, there is less tendency to chatter, because the thrust of the cut pushes the tool against the spindle thrust bearings. However, when used for an end cut, the left-right design throws the chips down against the work surface, which may be objectionable from a finish standpoint. Also, the end teeth are relatively inefficient because of the pronounced negative rake. On the other hand, if the operator is working to a scribed line, a right-hand helix, left-hand cut tool will allow him to see the line better because the chips and burr will be thrown down along the flute, rather than up on the top surface of the work.

2. RUNOUT OF AN END MILLING CUTTER (beyond .001") will result in a hammering effect and increase the tendency to chatter. The effect can be noticed on the work by a waviness in the surface finish.

3. RIGHT-HAND CUT, RIGHT-HAND HELIX END MILLS tend to pull out of their holders. This is one reason why the set screw type adapter is preferred by many operators over a spring collet.

4. TO ELIMINATE CHATTER, try one or all of these methods: tighten gibs, use a more rigid workholder, vary the speed and feed rate a bit, move the cutter nearer to the spindle. If all else fails, try using a cutter with a smaller number of teeth. Even a few less will often eliminate a harmonic.

5. STRAIGHT-TOOTH END MILLS do not "pull over". They mill a parallel and vertical keyway, whereas helical flute two-lipped end mills bend and produce slots which lean to one side.

6. TWO-FLUTE END MILLS excel where an end feed is needed, as in plunging to depth in a keyway or pocket. Three and four-flute center cut mills will plunge, but not as freely as the two-flute.

7. FOR SLOT MILLING from an open end four-flute mills are better than two: the slot can be cut faster and more accurately in one pass.

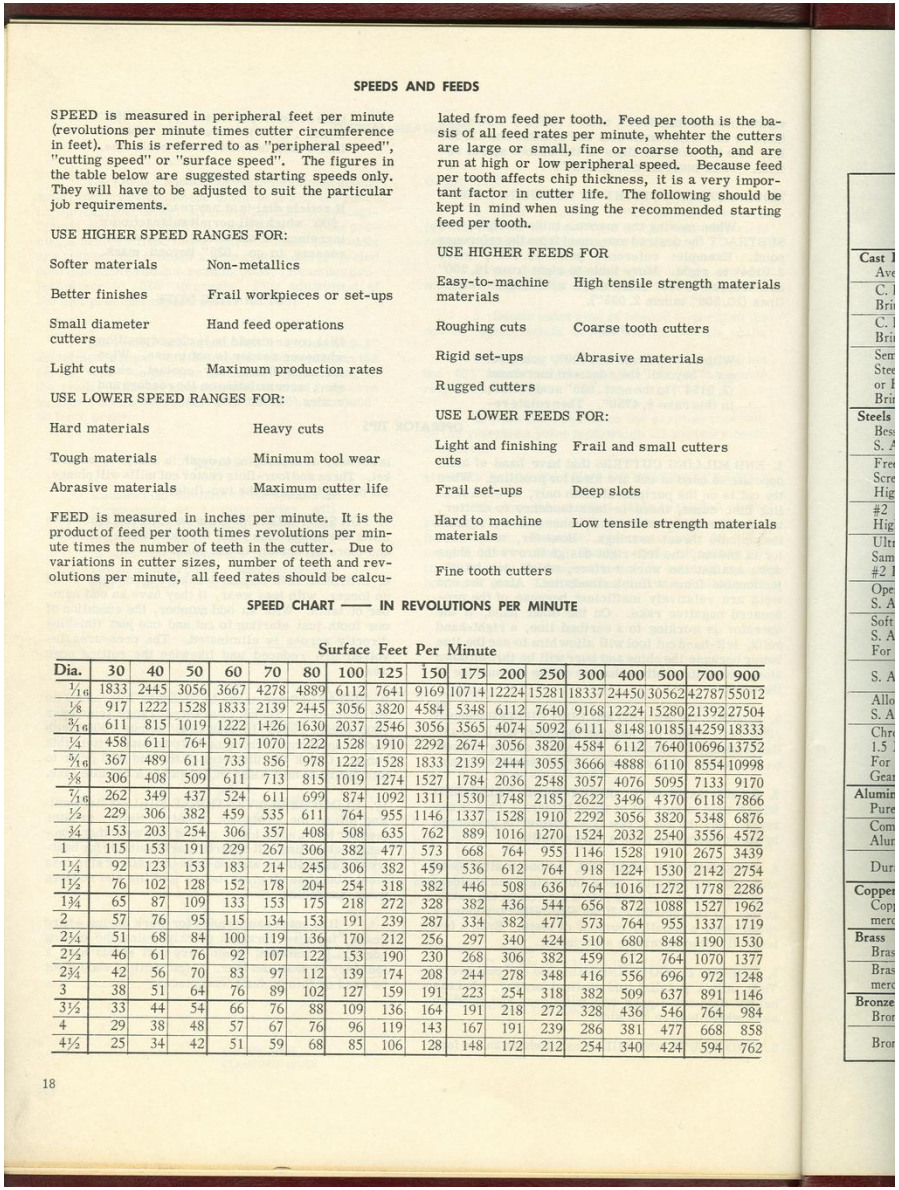
8. CARBIDE END MILLS for keyway milling stand up longer, with less wear, if they have an odd number of teeth. With an odd number, the condition of one tooth just starting to cut and one just finishing directly across is eliminated. The pressures involved are reduced and likewise the cutting edge wear.

9. END MILLS are made to standard tolerances on cut diameter. These tolerances range from plus .000 minus .0015" to plus .005" minus .000" with each manufacturer choosing his own sizes within this range. Check the diameter of the end mill prior to attempting to mill a slot or keyway of a definite size.

10. CLIMB OR CONVENTIONAL MILL--Climb milling offers the advantage of better finish, greater feed per tooth, and a lower rate of tool wear than conventional milling. It is particularly suitable for heat-treated alloy steels and non-free-machining stainless steels because it gives better tool life and reduces work hardening.

It is not recommended for work having a hard scale, because abrasion quickly ruins the cutting edges. In addition, some very soft steels have a tendency to drag and tear. Climb milling should not be used on thin or frail workpieces.

Photo 20



SPEEDS AND FEEDS

SPEED is measured in peripheral feet per minute (revolutions per minute times cutter circumference in feet). This is referred to as "peripheral speed", "cutting speed" or "surface speed". The figures in the table below are suggested starting speeds only. They will have to be adjusted to suit the particular job requirements.

USE HIGHER SPEED RANGES FOR:

Softer materials	Non-metallics
Better finishes	Frail workpieces or set-ups
Small diameter cutters	Hand feed operations
Light cuts	Maximum production rates

USE LOWER SPEED RANGES FOR:

Hard materials	Heavy cuts
Tough materials	Minimum tool wear
Abrasive materials	Maximum cutter life

FEED is measured in inches per minute. It is the product of feed per tooth times revolutions per minute times the number of teeth in the cutter. Due to variations in cutter sizes, number of teeth and revolutions per minute, all feed rates should be calculated from feed per tooth. Feed per tooth is the basis of all feed rates per minute, whehter the cutters are large or small, fine or coarse tooth, and are run at high or low peripheral speed. Because feed per tooth affects chip thickness, it is a very important factor in cutter life. The following should be kept in mind when using the recommended starting feed per tooth.

USE HIGHER FEEDS FOR

Easy-to-machine materials	High tensile strength materials
Roughing cuts	Coarse tooth cutters
Rigid set-ups	Abrasive materials
Rugged cutters	

USE LOWER FEEDS FOR:

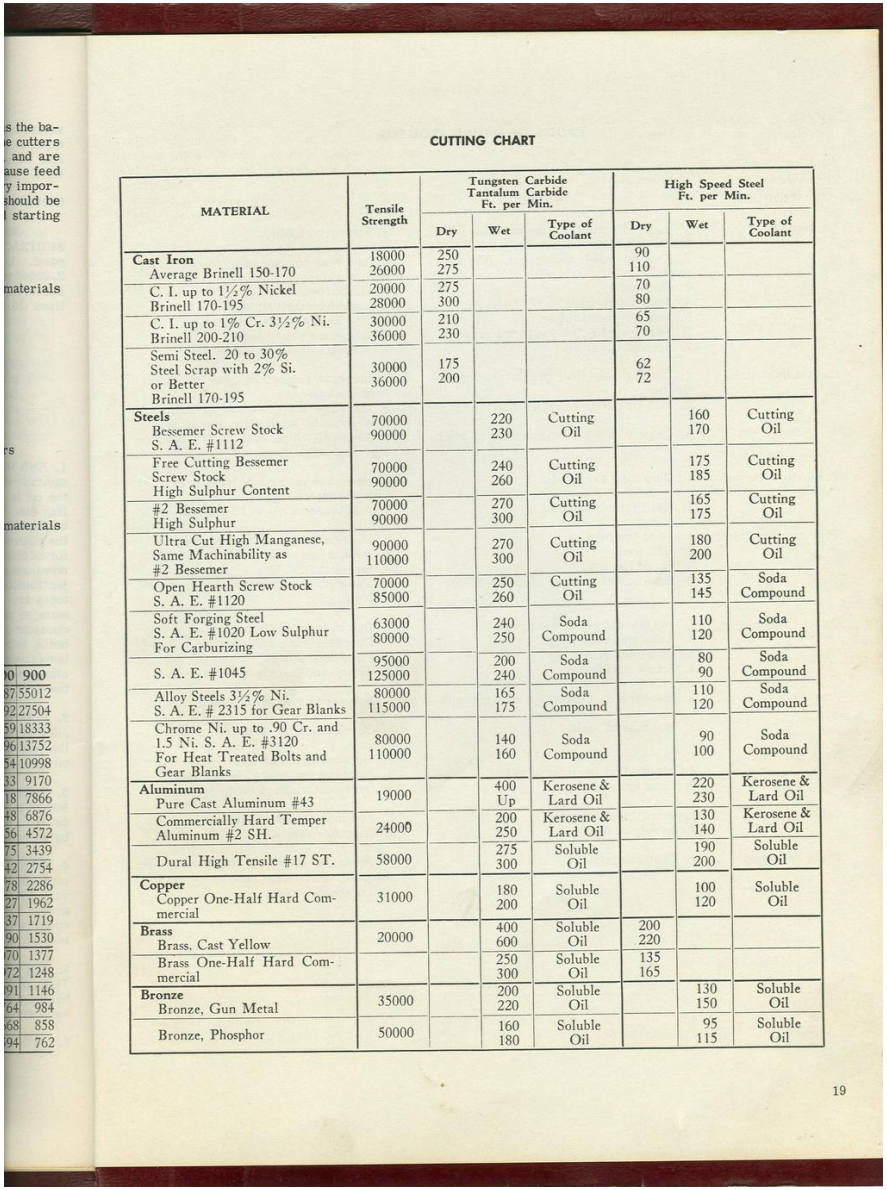
Light and finishing cuts	Frail and small cutters
Frail set-ups	Deep slots
Hard to machine materials	Low tensile strength materials
Fine tooth cutters	

SPEED CHART —— IN REVOLUTIONS PER MINUTE

Surface Feet Per Minute

Dia.	30	40	50	60	70	80	100	125	150	175	200	250	300	400	500	700	900
1/16	1833	2445	3056	3667	4278	4889	6112	7641	9169	10714	12224	15281	18337	24450	30562	42787	55012
1/8	917	1222	1528	1833	2139	2445	3056	3820	4584	5348	6112	7640	9168	12224	15280	21392	27504
3/16	611	815	1019	1222	1426	1630	2037	2546	3056	3565	4074	5092	6111	8148	10185	14259	18333
1/4	458	611	764	917	1070	1222	1528	1910	2292	2674	3056	3820	4584	6112	7640	10696	13752
5/16	367	489	611	733	856	978	1222	1528	1833	2139	2444	3055	3666	4888	6110	8554	10998
3/8	306	408	509	611	713	815	1019	1274	1527	1784	2036	2548	3057	4076	5095	7133	9170
7/16	262	349	437	524	611	699	874	1092	1311	1530	1748	2185	2622	3496	4370	6118	7866
1/2	229	306	382	459	535	611	764	955	1146	1337	1528	1910	2292	3056	3820	5348	6876
3/4	153	203	254	306	357	408	508	635	762	889	1016	1270	1524	2032	2540	3556	4572
1	115	153	191	229	267	306	382	477	573	668	764	955	1146	1528	1910	2675	3439
1 1/4	92	123	153	183	214	245	306	382	459	536	612	764	918	1224	1530	2142	2754
1 1/2	76	102	128	152	178	204	254	318	382	446	508	636	764	1016	1272	1778	2286
1 3/4	65	87	109	133	153	175	218	272	328	382	436	544	656	872	1088	1527	1962
2	57	76	95	115	134	153	191	239	287	334	382	477	573	764	955	1337	1719
2 1/4	51	68	84	100	119	136	170	212	256	297	340	424	510	680	848	1190	1530
2 1/2	46	61	76	92	107	122	153	190	230	268	306	382	459	612	764	1070	1377
2 3/4	42	56	70	83	97	112	139	174	208	244	278	348	416	556	696	972	1248
3	38	51	64	76	89	102	127	159	191	223	254	318	382	509	637	891	1146
3 1/2	33	44	54	66	76	88	109	136	164	191	218	272	328	436	546	764	984
4	29	38	48	57	67	76	96	119	143	167	191	239	286	381	477	668	858
4 1/2	25	34	42	51	59	68	85	106	128	148	172	212	254	340	424	594	762

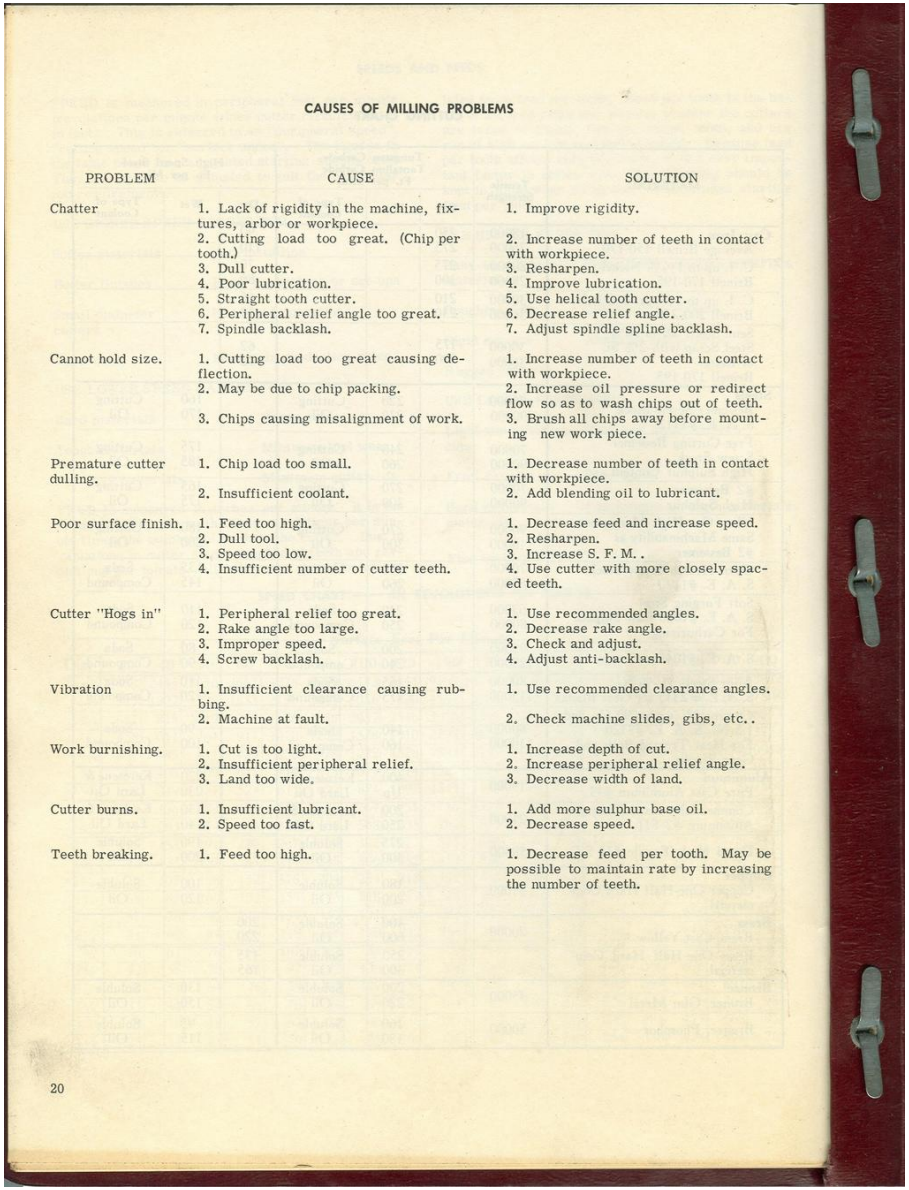
Photo 21



CUTTING CHART

MATERIAL	Tensile Strength	Tungsten Carbide Tantalum Carbide Ft. per Min.			High Speed Steel Ft. per Min.		
		Dry	Wet	Type of Coolant	Dry	Wet	Type of Coolant
Cast Iron Average Brinell 150-170	18000 26000	250 275			90 110		
C. I. up to 1½% Nickel Brinell 170-195	20000 28000	275 300			70 80		
C. I. up to 1% Cr. 3½% Ni. Brinell 200-210	30000 36000	210 230			65 70		
Semi Steel. 20 to 30% Steel Scrap with 2% Si. or Better Brinell 170-195	30000 36000	175 200			62 72		
Steels Bessemer Screw Stock S. A. E. #1112	70000 90000		220 230	Cutting Oil		160 170	Cutting Oil
Free Cutting Bessemer Screw Stock High Sulphur Content	70000 90000		240 260	Cutting Oil		175 185	Cutting Oil
#2 Bessemer High Sulphur	70000 90000		270 300	Cutting Oil		165 175	Cutting Oil
Ultra Cut High Manganese, Same Machinability as #2 Bessemer	90000 110000		270 300	Cutting Oil		180 200	Cutting Oil
Open Hearth Screw Stock S. A. E. #1120	70000 85000		250 260	Cutting Oil		135 145	Soda Compound
Soft Forging Steel S. A. E. #1020 Low Sulphur For Carburizing	63000 80000		240 250	Soda Compound		110 120	Soda Compound
S. A. E. #1045	95000 125000		200 240	Soda Compound		80 90	Soda Compound
Alloy Steels 3½% Ni. S. A. E. # 2315 for Gear Blanks	80000 115000		165 175	Soda Compound		110 120	Soda Compound
Chrome Ni. up to .90 Cr. and 1.5 Ni. S. A. E. #3120 For Heat Treated Bolts and Gear Blanks	80000 110000		140 160	Soda Compound		90 100	Soda Compound
Aluminum Pure Cast Aluminum #43	19000		400 Up	Kerosene & Lard Oil		220 230	Kerosene & Lard Oil
Commercially Hard Temper Aluminum #2 SH.	24000		200 250	Kerosene & Lard Oil		130 140	Kerosene & Lard Oil
Dural High Tensile #17 ST.	58000		275 300	Soluble Oil		190 200	Soluble Oil
Copper Copper One-Half Hard Commercial	31000		180 200	Soluble Oil		100 120	Soluble Oil
Brass Brass, Cast Yellow	20000		400 600	Soluble Oil	200 220		
Brass One-Half Hard Commercial			250 300	Soluble Oil	135 165		
Bronze Bronze, Gun Metal	35000		200 220	Soluble Oil		130 150	Soluble Oil
Bronze, Phosphor	50000		160 180	Soluble Oil		95 115	Soluble Oil

Photo 22



CAUSES OF MILLING PROBLEMS

PROBLEM	CAUSE	SOLUTION
Chatter	1. Lack of rigidity in the machine, fixtures, arbor or workpiece. 2. Cutting load too great. (Chip per tooth.) 3. Dull cutter. 4. Poor lubrication. 5. Straight tooth cutter. 6. Peripheral relief angle too great. 7. Spindle backlash.	1. Improve rigidity. 2. Increase number of teeth in contact with workpiece. 3. Resharpen. 4. Improve lubrication. 5. Use helical tooth cutter. 6. Decrease relief angle. 7. Adjust spindle spline backlash.
Cannot hold size.	1. Cutting load too great causing deflection. 2. May be due to chip packing. 3. Chips causing misalignment of work.	1. Increase number of teeth in contact with workpiece. 2. Increase oil pressure or redirect flow so as to wash chips out of teeth. 3. Brush all chips away before mounting new work piece.
Premature cutter dulling.	1. Chip load too small. 2. Insufficient coolant.	1. Decrease number of teeth in contact with workpiece. 2. Add blending oil to lubricant.
Poor surface finish.	1. Feed too high. 2. Dull tool. 3. Speed too low. 4. Insufficient number of cutter teeth.	1. Decrease feed and increase speed. 2. Resharpen. 3. Increase S. F. M. . 4. Use cutter with more closely spaced teeth.
Cutter "Hogs in"	1. Peripheral relief too great. 2. Rake angle too large. 3. Improper speed. 4. Screw backlash.	1. Use recommended angles. 2. Decrease rake angle. 3. Check and adjust. 4. Adjust anti-backlash.
Vibration	1. Insufficient clearance causing rubbing. 2. Machine at fault.	1. Use recommended clearance angles. 2. Check machine slides, gibs, etc. .
Work burnishing.	1. Cut is too light. 2. Insufficient peripheral relief. 3. Land too wide.	1. Increase depth of cut. 2. Increase peripheral relief angle. 3. Decrease width of land.
Cutter burns.	1. Insufficient lubricant. 2. Speed too fast.	1. Add more sulphur base oil. 2. Decrease speed.
Teeth breaking.	1. Feed too high.	1. Decrease feed per tooth. May be possible to maintain rate by increasing the number of teeth.