OPERATION, MAINTENANCE AND REPAIR PARTS

of the

BROWN & SHARPE

No. 20

UNIVERSAL MILLING MACHINE

SLIDING-HEAD TYPE

For Machines Beginning Serial No. 506-20-1

BROWN & SHARPE MFG. CO.

PROVIDENCE 1, R. I., U. S. A.

750-7-55
Printed in U.S.A.

FOREWORD

The purpose of this book is to give a thorough practical working knowledge of the Brown & Sharpe No. 20 Universal Milling Machine (Sliding Head Type).

The book explains in detail each set-up adjustment and operating control of the machine and its standard equipment. Representative operations are illustrated and described. A description is given of the various items of additional equipment available, together with instructions on the set-up and operation of this equipment. A chapter on maintenance covers the slinging and installation of the machine, lubrication, mechanical adjustments and electrical maintenance. Finally there is a repair parts section, with the parts of the machine laid out in correct relation to each other to facilitate identification and reassembly.

Such subjects as the selection of feeds and speeds, types of cutters and other phases of general milling practice have not been included, since this book is intended primarily to cover the Brown & Sharpe No. 20 Universal (Sliding Head Type)

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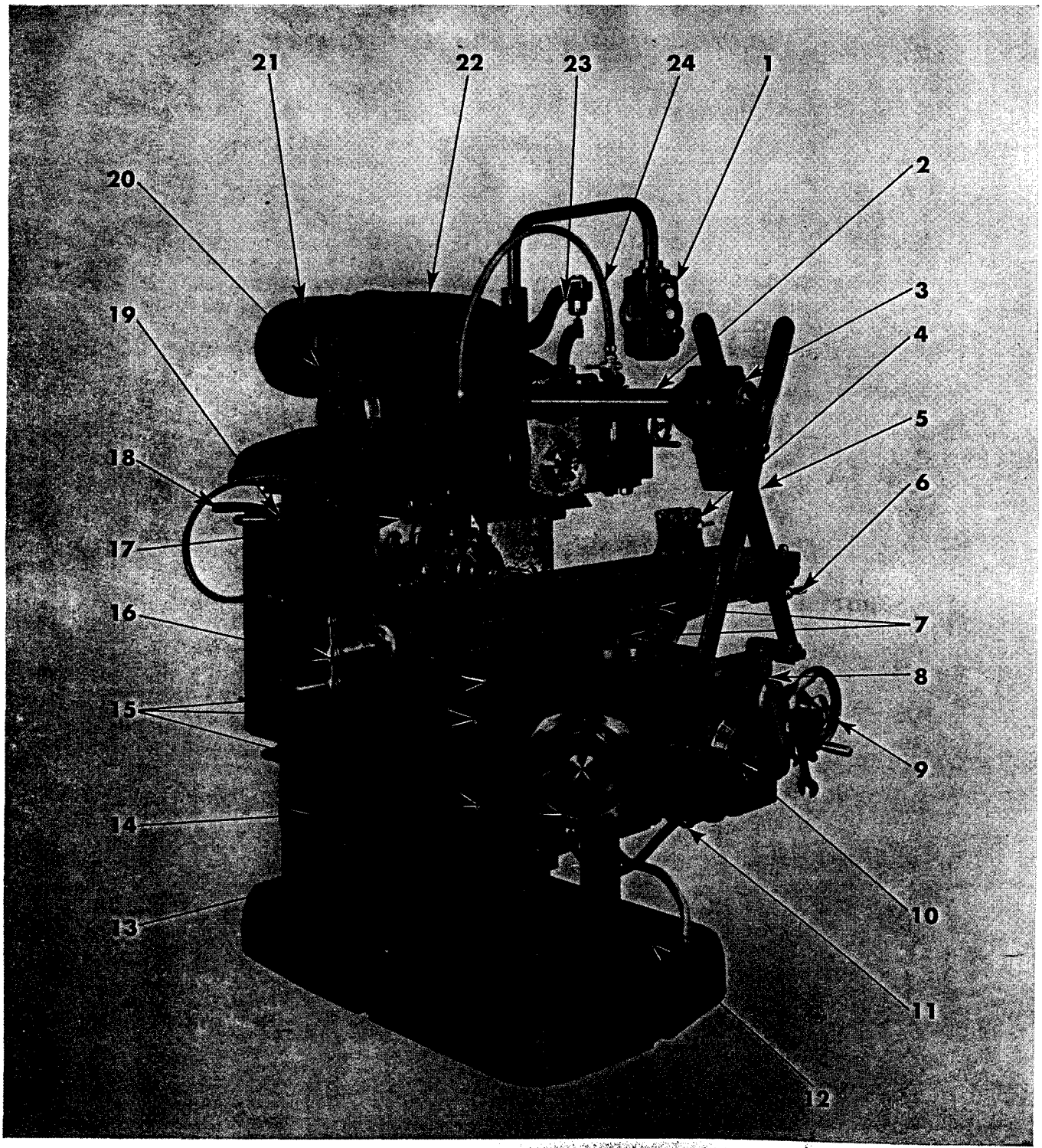
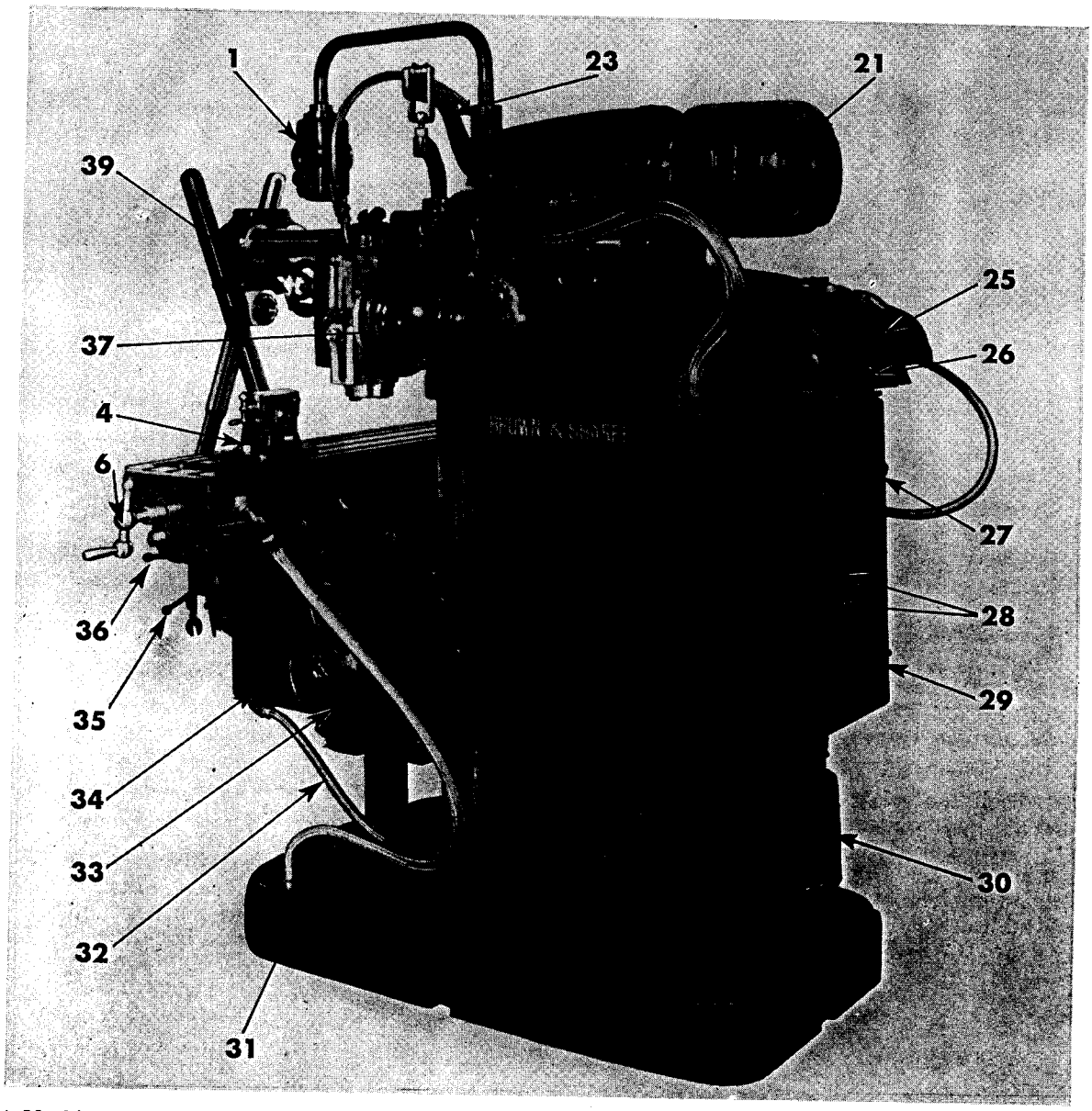
Sliding-Head Type





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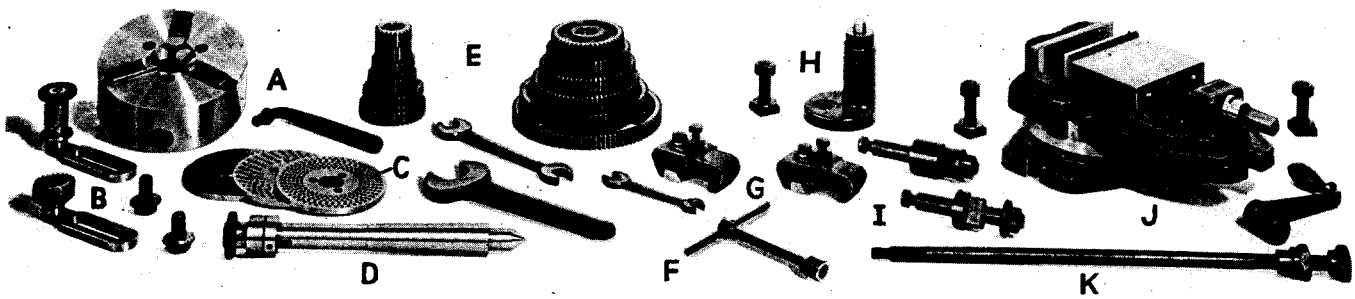


STANDARD EQUIPMENT

A 7″ 3-jawed self-centering chuck
B Intermediate gear plate, and reverse gear and plate for headstock
C Index plates for headstock
D Differential indexing center
E Change gears for headstock
F Set of wrenches
G 2 table stops
H Center rest
I Bolts for clamping braces to arbor yoke
J No. 22S swivel vise
K Draw-in bolt

Not shown above —
Spindle driving motor
Table driving motor
Coolant system
10″ universal spiral index centers
Electrical controls and wiring
Instruction booklets and tables

CHAPTER I

Set-up Adjustments and Operating Controls

This chapter explains in detail the purpose and use of each of the controls and adjustments used in setting-up and operating the No. 20 Universal Sliding Head Type Milling Machine and its equipment.

A general familiarity with this machine will be gained by a study of the introductory material on the pages immediately preceding.

Machine Start-Stop Controls

The start-stop control push buttons together with the jog switch button are located at the front of a control station. This station is attached to an arm which can be swung (Fig. 1) to the front or either side of the machine to a position most convenient to the operator.

Pressing the start button starts the spindle rotating as well as the table driving mechanism.

The coolant pump is controlled by start-stop buttons at the rear of the machine on the electrical cabinet door (Fig. 3). During operation the coolant pump is started or stopped with the spindle control buttons.

Contacts on the machine stop button energize brake windings of the spindle motor for rapid and positive stopping of the spindle.

The control station is provided with a Hubbel Midget plug-in receptacle for an extension light (maximum 100 watts).

Horizontal Spindle

Spindle Drive. The spindle is gear-driven from a constant-speed motor mounted on the rear of the sliding head. The various spindle speeds provided are obtained through sliding gears in the head controlled by the speed selector lever. A section drawing of the driving mechanism is shown on page 32.

Selecting Rate of Speed. Eighteen rates of spindle speed are provided on this machine—40 to 1530 R.P.M. (with 60-cycle motor) in either direction.

To change the speed, rotate the speed selector lever on the left side of the machine (Figs. 1 and 2). The lever can be rotated in either direction and each complete turn gives a change in speed, the

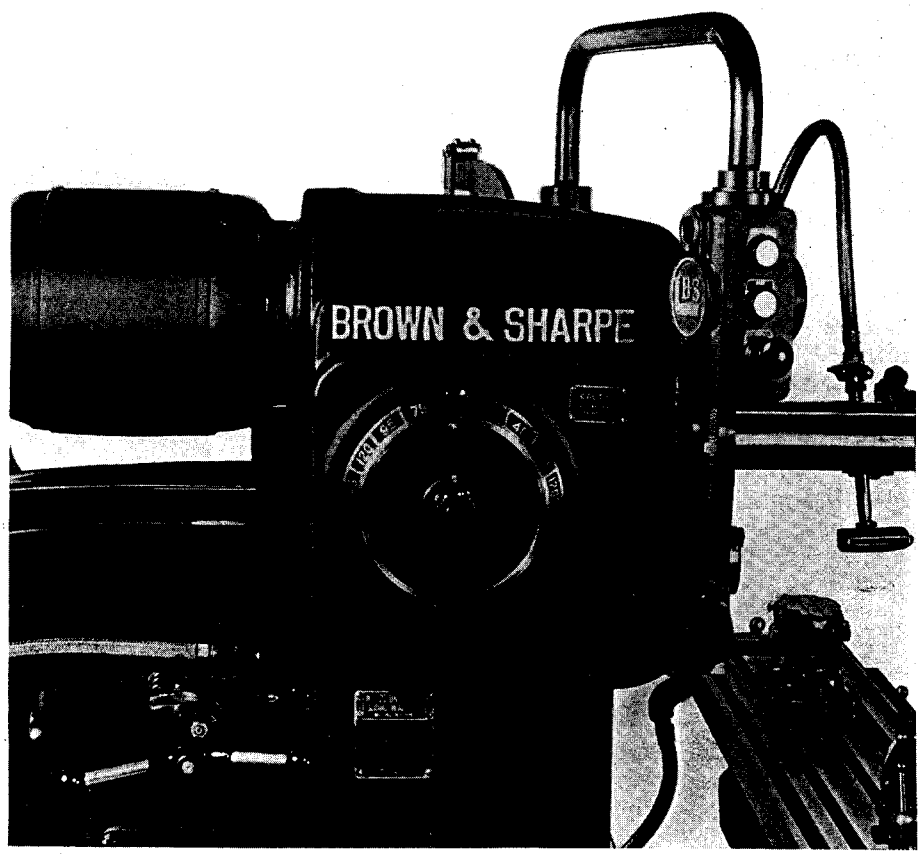


Fig. 1. Electrical control station easily swung to most convenient position to the operator.

rate engaged being shown in revolutions per minute on the large rotating dial. Always stop the machine before changing speed.

The spindle jog button, located on the moveable control station, is swung around to a convenient location (Fig. 2) when the operator changes spindle speeds. If occasional difficulty should be encountered in changing speed, pressing the jog button will remedy the situation.

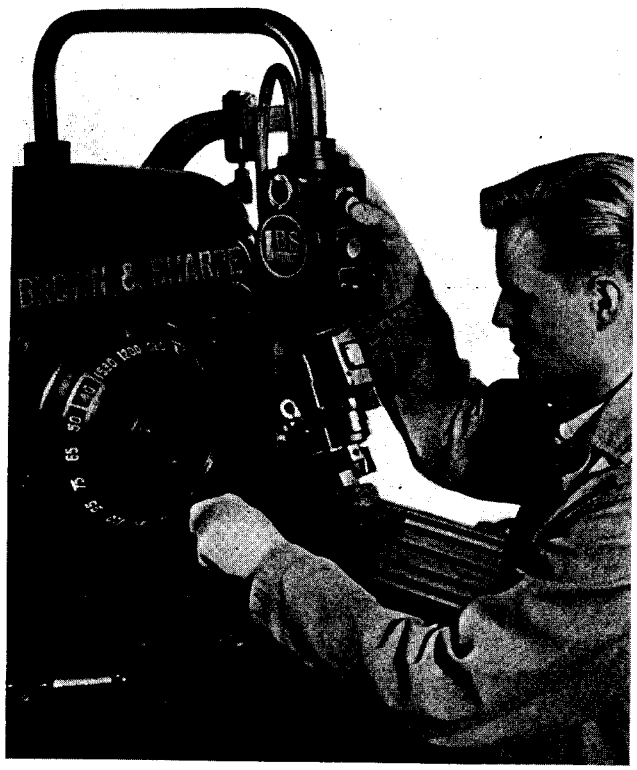


Fig. 2. Using the spindle jog button when changing speeds.

Reversing the Spindle. The direction of spindle rotation is governed by a reversing switch at the left-rear of the machine (Fig. 3), the setting for right-hand and left-hand cutter rotation being shown on an adjacent plate. With the switch at Off position, only the spindle motor is disconnected. Stop the machine before operating the reversing switch.

Sliding Head

The sliding head can be moved transversely up to 22¾", has large bearing surfaces and is easily clamped or released by means-of the "sliding head clamp lever" Fig. 4.

To relocate the head first release the clamping lever, by pushing it toward the rear of the machine, then engage the hub of the "sliding head operating handle" with the end of the shaft and

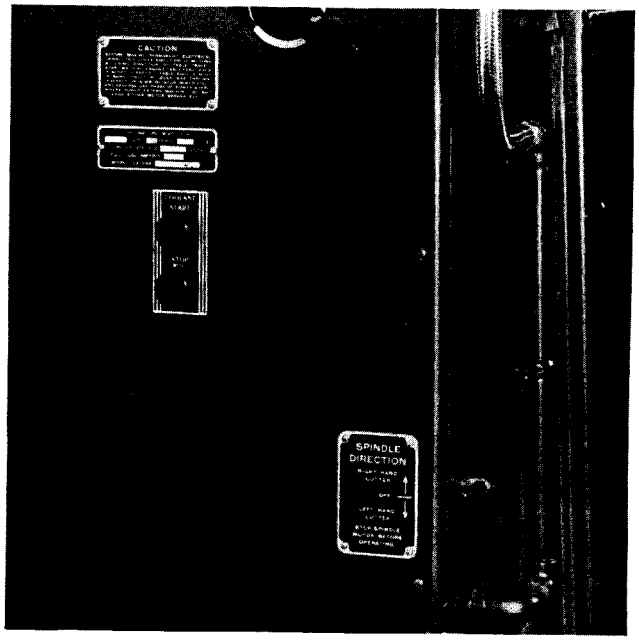


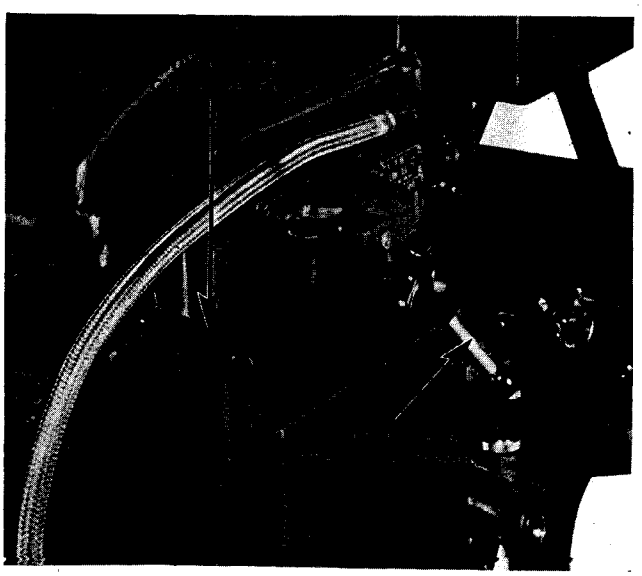
Fig. 3. Spindle reversing switch and coolant start-stop push buttons.

turn clockwise to move the sliding head to the front or counterclockwise to the rear. When the sliding head is at the desired position it is securely locked by pulling the clamping lever toward the front of the machine. Movement of the lever from clamp to release position is about 4".

Universal Milling Head

This head (Fig. 5), when combined with the features of the sliding head, permits boring operations and milling of horizontal, angular or vertical slots as well as facilitating such jobs as thread

Fig. 4. Sliding head is moved by operating handle and clamped by lever.



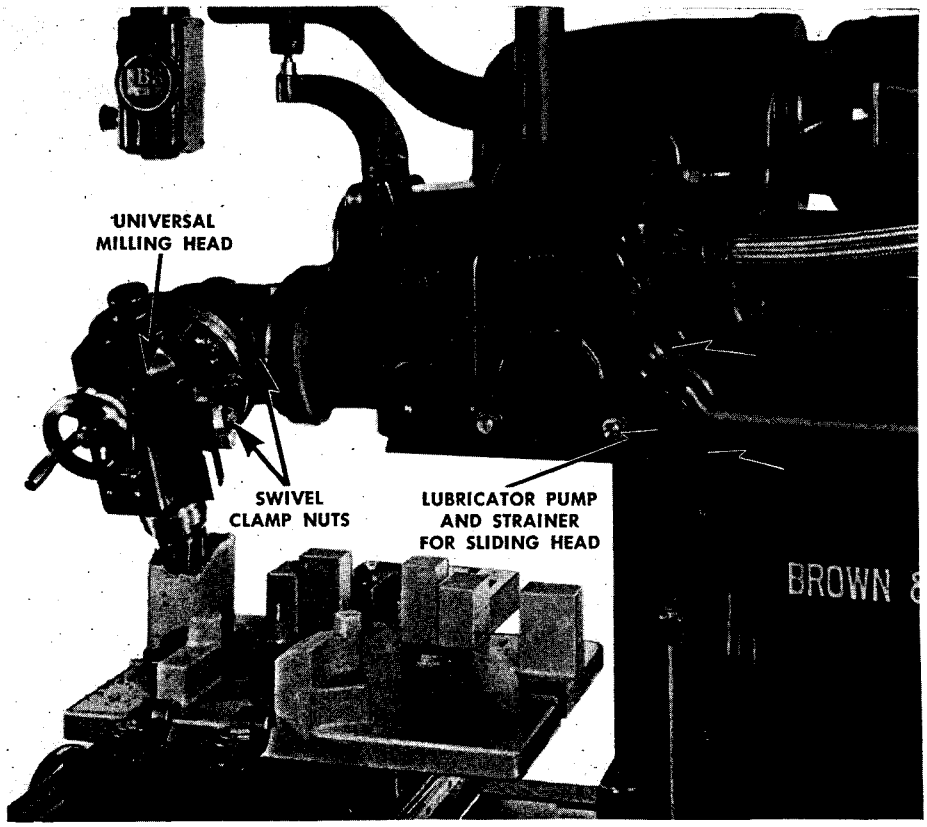


Fig. 5. Universal milling head in operating position. Note the extended position of the sliding head.

milling, rack milling and others requiring compound angular settings.

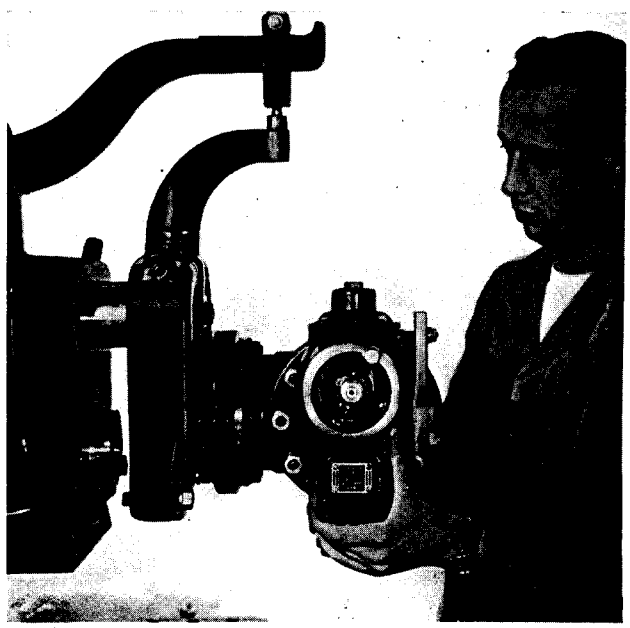
Installing the head. First set both overarms (and clamp them by means of the overarm clamp lever Fig. 8) so that they project about three inches from the face of the sliding head as shown in Fig. 6. At the same time remove the three cap screws from the face of the sliding head. Then, at the storage position (Fig. 8) loosen the two "mounting studs" (nuts pinned on) and swing the universal head into position at the front of the sliding head. At this point it is necessary to see that the spindle keys are in alignment with the universal head driving gear slots. Loosen the "overarm clamp screw" (Fig. 8) enough so that the whole unit can be worked onto the overarms. When the unit is in position against the face of the sliding head secure it by tightening the three mounting studs.

Angular settings of head. Scales on the swiveling faces of the head are graduated in ½ degrees. The scale for horizontal positioning reads to 90° either side of opposed zero marks and the vertical positioning scale reads to 180° either side of zero.

To position the head at either horizontal or vertical angular settings, loosen the six swivel clamp nuts on either or both faces of the universal head (Fig. 5) just enough to allow the unit to be rotated by hand pressure. Set at the desired angle and tighten the clamp nuts. When coolant is desired attach the coolant bracket as shown in Fig. 7.

Universal head spindle. Operating at a 2:1 ratio this spindle has a speed range of 80 to 3060 R.P.M. as governed by the 18 speeds provided on the machine. The spindle can be fed axially up to 3½" by means of the spindle feed handwheel (Fig. 8). An adjustable dial with .001 graduations reading to .100 is located back of the handwheel. The dial can

Fig. 6. Mounting the universal milling head.



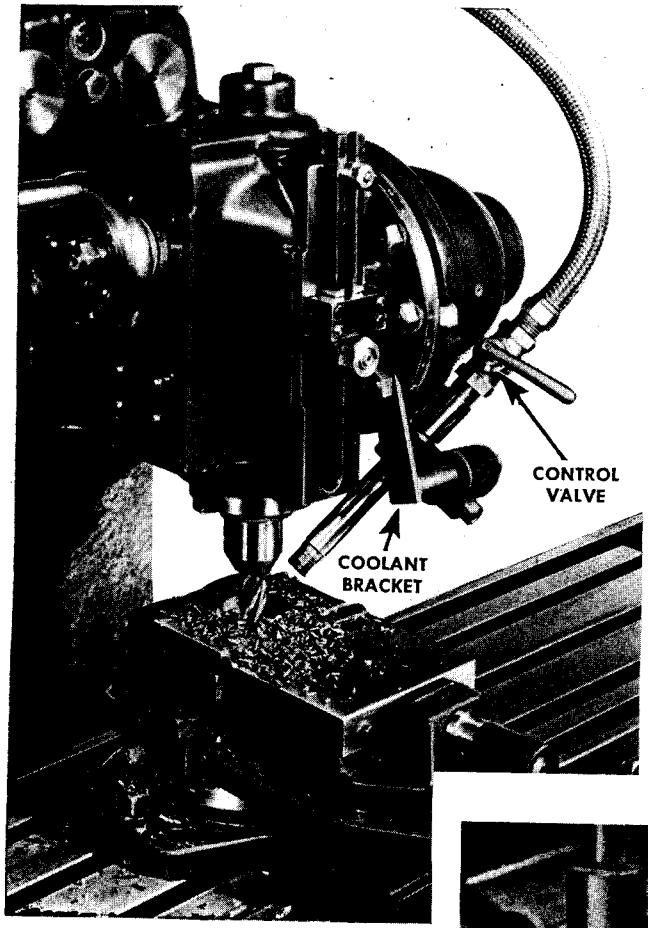


Fig. 7. Above — Universal head with coolant bracket and distributor pipe in position.

be set at any reading desired by loosening the knurled nut at the front of the dial and after turning the dial to the desired reading lock it with the nut.

Spindle clamp and stops. The spindle can be clamped at any point within its 3½" range of travel by means of the spindle clamp nut (Fig. 8).

The adjustable stop and the stopping block in Fig. 8 permit the accurate duplication of repeat operations. Gage blocks of desired thickness can be placed between the stopping blocks and the adjustable stop when setting-up to assure positive stopping with repeat accuracy on duplicate pieces.

Table and Knee

Drive. A constant-speed motor on the right side of the knee provides power for all feed and fast travel movements, independent of the spindle drive. For feed drive, this motor is controlled by the machine start-stop buttons along with the spindle motor, and for fast travel it is started and stopped by the fast travel lever. Feeds are obtained through sliding gears in the feed case unit assembly in the knee, and drive for fast travel is taken from the same unit. A section drawing through the feed case is shown on page 33.

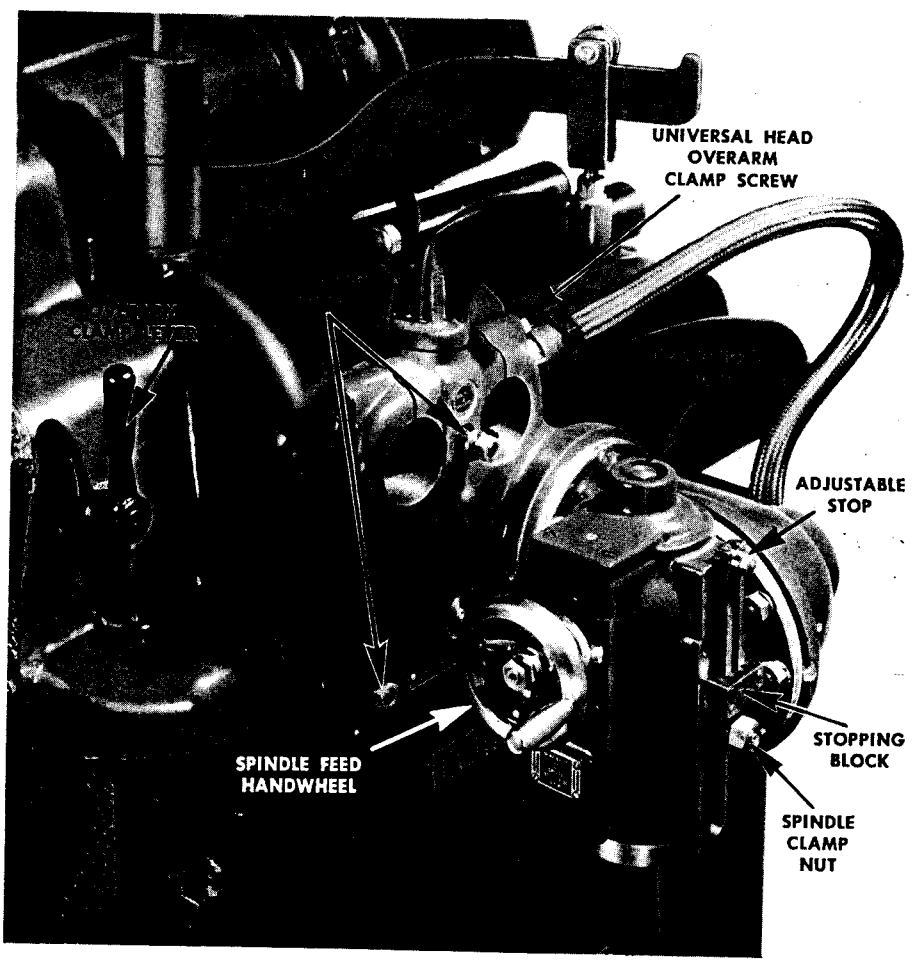


Fig. 8. Right — Overarm clamp lever and universal head in storage position.

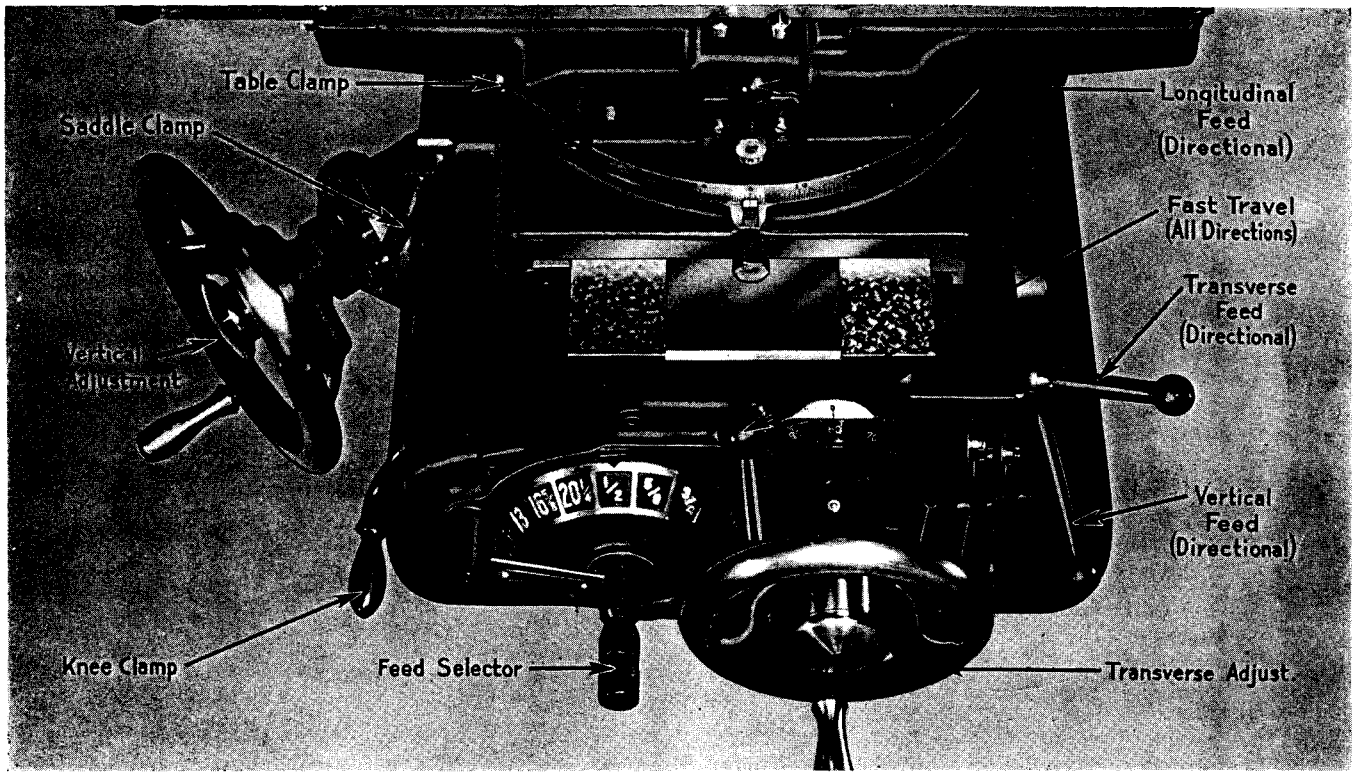


Fig. 9. Controls and adjustments at front of machine.

Hand Adjustments. Longitudinal, transverse and vertical hand adjustments have adjustable dials reading to .001". To set a dial, turn the adjacent knurled clamp nut counterclockwise to release the dial; turn the adjustment crank or handwheel in the direction of intended movement enough to take up the normal backlash; then turn the dial to the desired setting and tighten the clamp nut.

Turning the longitudinal adjustment crank clockwise moves the table to the right.

Turning the transverse adjustment handwheel clockwise moves the table to the rear.

Turning the vertical adjustment handwheel clockwise raises the knee.

Each of the three adjustments is automatically disengaged when the respective power feed is engaged. The longitudinal handcrank is engaged by pushing it inward, while the transverse and vertical handwheels are each engaged by pushing in the clutch knob at the center of the handwheel (see Fig. 9).

Adjustment Clamps. Clamps for longitudinal, transverse and vertical adjustments are shown in Fig. 9. To clamp the table, pull the table clamp lever upward; to clamp the saddle, push the saddle clamp lever downward; and to clamp the knee, pull the knee clamp lever to the left.

A mechanical interlock prevents tightening the table clamp while longitudinal feed is engaged, and prevents engaging longitudinal feed while the table is clamped.

The angular adjustment of the table is clamped by a hexagonal-headed screw at the lower front of the saddle (shown in Fig. 9) and by a clamp bolt in a circular T-slot under each end of the saddle. Tighten all three clamps before starting a cut.

Selecting Rate of Feed. Eighteen rates of power feed are provided—½" to 20¼" per minute (with 60-cycle motor). To change the feed rate, turn the feed selector lever on the front of the knee (Fig. 9). The lever can be rotated in either direction, and each complete turn gives a change in feed, the rate engaged being shown in inches per minute on the large rotating dial. Feeds can be changed with the table motor running, although this should not be done with longitudinal, transverse or vertical feed engaged. If difficulty should be encountered in changing feed with the machine stopped, jogging with the start button or by the fast travel lever will remedy the situation.

Feed Control Levers. Longitudinal, transverse and vertical feeds are each engaged by a single lever. All feed control levers are directional, so that to engage feed in a given direction the operator simply moves the proper lever (longitudinal, transverse or vertical) in the desired direction of feed. For example, to engage left-hand feed of the table, throw the longitudinal feed control lever to

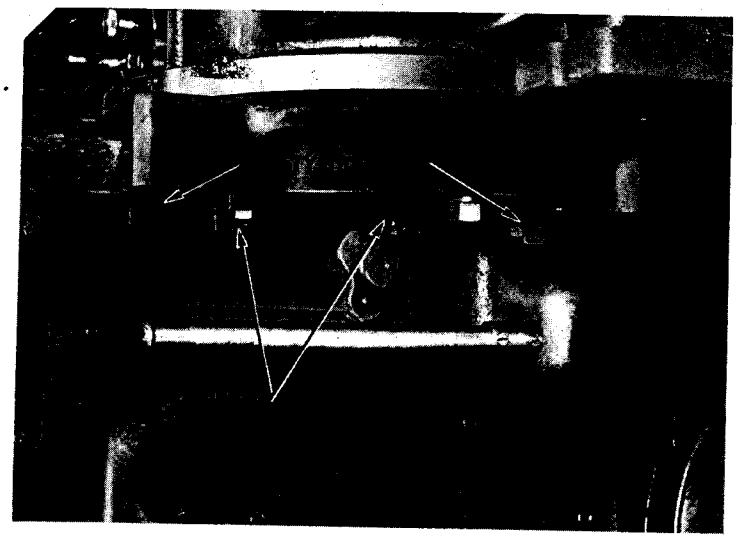


Fig. 10. Transverse feed trip dogs.

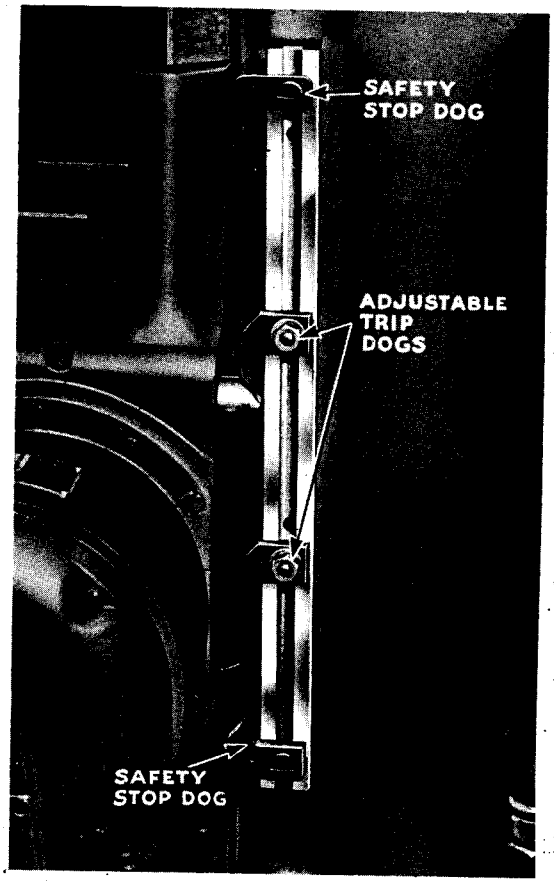


Fig. 11. Right — Vertical feed trip dogs.

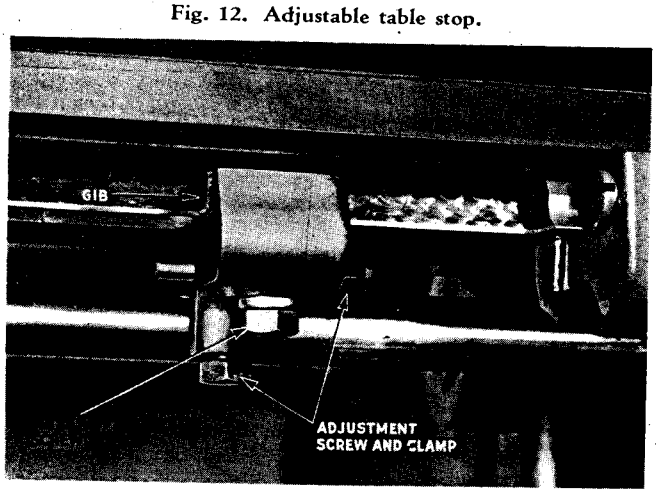
the left; to engage upward feed of the knee, pull the vertical feed control lever upward; and so on. These levers are identified in Fig. 9.

The longitudinal feed control lever is provided with a safety stop which can be used to prevent engagement of feed in either direction as selected. This device consists of a finger on the back of the lever which can be turned by a knurled knob at the front so as to come in contact with either of two pins, preventing the lever from being thrown to engage feed in the direction in which the finger is pointing. The finger is turned upward to permit engaging longitudinal feed in both directions.

Power Fast Travel. Power table movement in any direction—longitudinal, transverse or vertical —can be instantly speeded-up to a rate of 75″ per minute (with 60-cycle motor) by means of the power fast travel lever on the front of the knee, illustrated in Fig. 9. Fast travel is engaged by pulling the lever to the left, and the original feed movement is resumed automatically when the lever is released.

For convenience in setting-up, the same lever also provides fast travel when the machine is stopped — that is, when neither the spindle nor table feed is operating. The direction of movement is determined by the feed control levers; and the movement in this instance is both started and stopped by the fast travel lever.

Fig. 12. Adjustable table stop.



Trip Dogs. Adjustable trip dogs are provided for longitudinal, transverse and vertical power movements in each direction. In addition, safety stop dogs are fastened at both ends of each path of travel. The longitudinal dogs are on the front of the table, while the transverse and vertical dogs are located under the right-hand side of the saddle and on the right-hand side of the column as shown in Figs. 10 and 11 respectively.

When longitudinal or transverse feed has been disengaged by a dog, power movement in the opposite direction can be engaged by the respective feed control lever. When vertical feed has been tripped out by a dog, the knee must be moved by hand a short distance in the opposite direction until the plunger is off the dog before engaging power movement.

Table Stops. The two positive stops for longitudinal table movement are clamped onto the front table way by means of a gib and clamp screw as illustrated in Fig. 12. Fine adjustment of each stop is provided by a screw which bears against the saddle when the table reaches the desired stopping point, and a clamp screw maintains the adjustment.

Before starting the machine, the operator should make sure that power feed will be disengaged by a feed trip dog before the stop comes in contact with the saddle.

Arbor Support

Provision is made for ample rigidity of arbor support and full advantage should be taken of this at all times, for rigid cutter support is essential both to long cutter life and to desired accuracy and finish of the work.

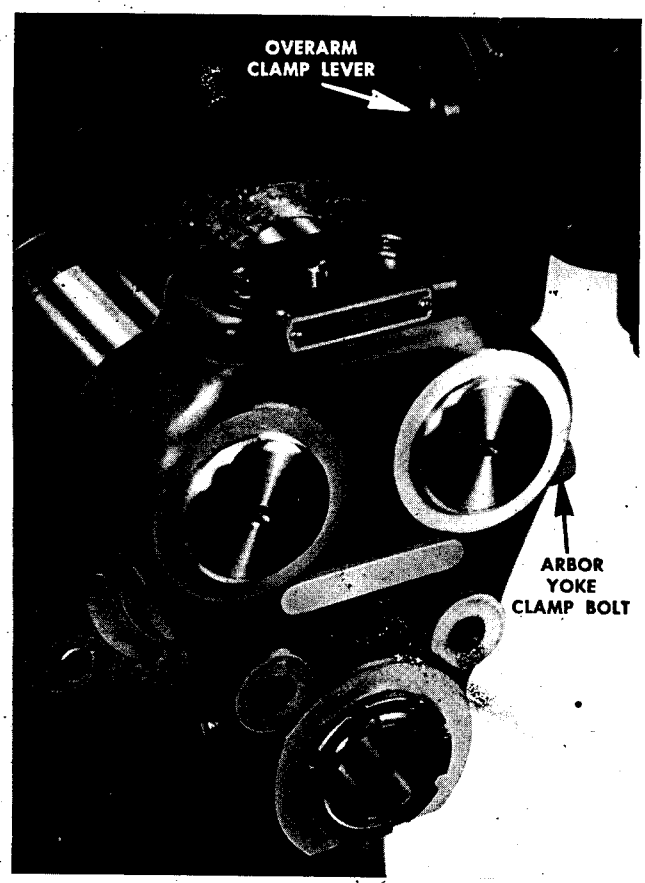


Fig. 13. Overarm clamp lever and arbor yoke (Inner yoke shown).

For maximum rigidity, the cutter should be mounted as close as possible to the spindle nose. The added clearance for work and fixtures provided by the extended sliding head permits the cutter to be located closer to the spindle nose than is possible on other machines, and the set-up man or operator should not fail to take advantage of this feature.

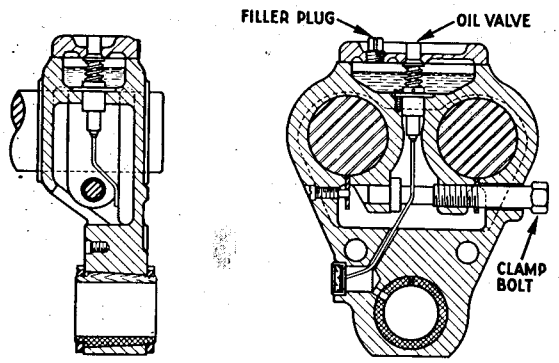


Fig. 14. Sections through arbor yoke show valve and reservoir for oiling adjustable arbor bushing, and illustrate method of securing equalized clamping to overarms.

The rigid arbor support which is provided by the extended sliding head also allows the use of smaller diameter arbors which in turn permit the use of smaller cutters. By using smaller cutters, run-in time is reduced and also cutter cost.

Overarms. The two solid steel cylindrical overarms are clamped evenly at the front of the sliding head by a small forward movement of the overarm clamp lever (illustrated in Fig. 13). When the clamp is released, the overarms can be moved in or out of the sliding head from the front of the machine.

Arbor Yokes. Two arbor yokes are furnished —one inner yoke and one outer. The inner yoke takes arbor sleeves 1⅞" diameter, and the outer yoke supports the outer end of arbors having a $^{23}/_{32}$"-diameter pilot. The arm braces can be used with either arbor yoke.

Each of the arbor yokes is clamped evenly to both overarms by a single clamp bolt at the right-hand side of the yoke (Figs. 13 and 14).

Each yoke has an adjustable bronze bushing for supporting the arbor. To tighten the rear yoke bushing, first loosen the rear nut; then take up on the front nut until the bushing is adjusted properly and tighten the rear nut. The front yoke requires only one adjusting nut at the front.

Each arbor bushing is lubricated from an oil reservoir at the top of the yoke by means of a manually-operated spring-closed push valve (Fig. 14). Pushing the plunger all the way down and immediately releasing it will deliver a drop of oil to the bushing. The sight gage at the side of the yoke enables the operator to see the amount of oil released. The reservoir is filled by removing a plug at the top.

In putting an arbor yoke on the overarms, it is easiest to start with one of the arms projecting several inches ahead of the other. Clamp the over-

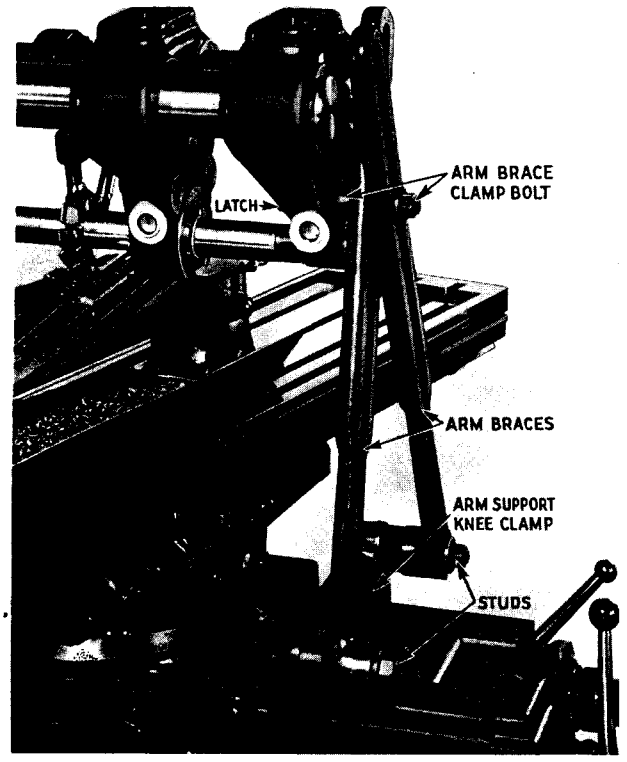


Fig. 15 (left). A typical set-up showing arm braces in use with outer arbor yoke. The set-up illustrated gives maximum rigidity of cutter support, because (1) cutter is near spindle nose; (2) inner arbor yoke is used, and is located close to cutter; and (3) outer orbor yoke and arm braces rigidly tie overarms to knee, keeping vibration and deflection to a minimum.

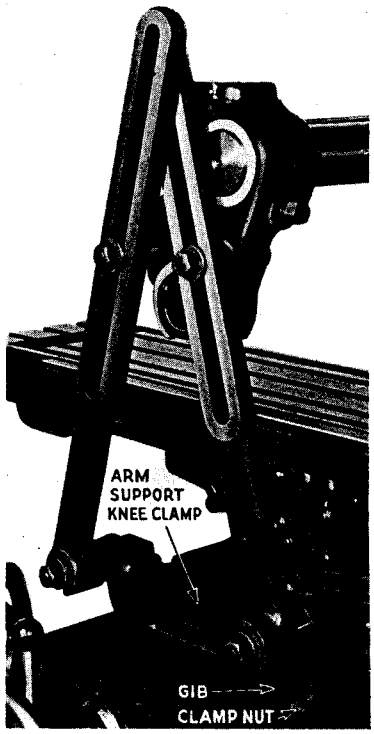


Fig. 16 (right). Arrangement of arm braces when used with inner arbor yoke in outer position. This set-up is used when conditions such as shape of work arrangement of cutters prevent using both arbor yokes .

arms and wring the yoke onto the projecting arm; then slide it along and onto the second overarm.

When changing cutters it is often convenient to bring one of the overarms forward so that the arbor yoke will remain on that arm after being pulled free of the other overarm and arbor; then the yoke can be swung upward on its arm and pushed back to rest on the top of the other overarm while changing the cutter equipment.

Arm Braces. The arm braces serves to tie the overarms and arbor yoke to the knee, giving added stiffness of arbor support. For maximum cutter rigidity the arm braces should be used whenever conditions permit on all but the lightest cuts.

The arm brace equipment is illustrated and its parts are identified in Figs. 15 and 16. It is set up as follows:

After the arbor yokes have been clamped in position on the overarms, put the arm brace clamp bolt in the outermost yoke and lock it by means of the swinging latch at the back of the yoke. (Two bolts are used when the inner arbor yoke is used in the outer position.) Place the arm support knee clamp on the knee of the machine just below this arbor yoke with the two studs facing forward; then place an arm brace on each of the studs and over the bolt or bolts in the arbor yoke, with the braces facing in opposite directions front to back so they will overlap.

Tighten the nuts on the arm support knee clamp studs by hand just enough to bring the braces against the shoulders on the studs; then move the assembly along the knee until the inner arm brace bears squarely against the shoulder of the bolt in the arbor yoke. Now fasten the arm support knee clamp to the knee by means of the clamp nut and gib at the lower right side (Fig. 16), and complete the set-up by tightening the nuts against the arm braces.

Fig. 17. Draw-in bolt — oil filler cap and oil level sight window.

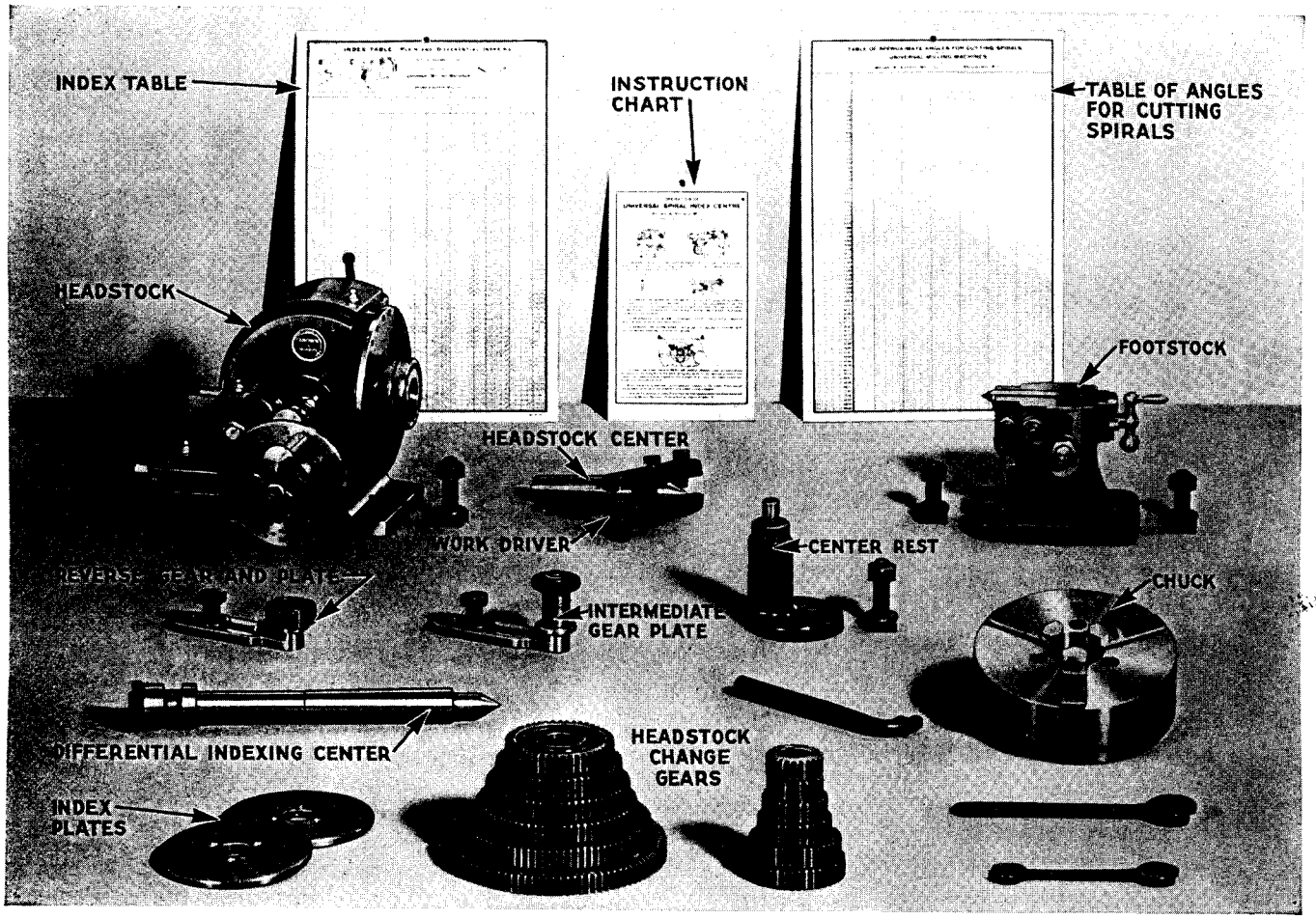


Fig. 18. Universal Spiral Index Centers and equipment.

Draw-In Bolt

The draw-in bolt furnished is of standardized design. With the bolt in the spindle hole, the front end is threaded into the arbor or adapter by means of the hexagonal knob on the rear end; then the arbor is drawn into the spindle nose by turning the nut up against the back end of the spindle. See Fig. 17.

Universal Spiral Index Centers

The Universal Spiral Index Centers and equipment illustrated in Fig. 18 are furnished as standard equipment. These centers swing work to 10″ diameter and take 33″ length.

The headstock change gears are conveniently stored on the inside of the door at the left side of the stand and the headstock itself is stored in the compartment on a swinging table (Fig. 19). When swung outward on the table, the headstock is easily transferred to or from the machine table.

NOTE—Before making any set-up preparations the instruction plate at the rear of the headstock swivel base should be observed.

Plain Indexing is done by means of the index sector and crank and one of three index plates furnished. The theory and procedure of indexing are covered in detail in Chapter VI of our "Practical Treatise on Milling and Milling Machines".

The adjustments used in setting-up for plain indexing are shown in Fig. 20 (page 16). Set-up data for all available divisions to 382 are listed in the index table furnished.

The handle of the index crank includes a spring-loaded pin which fits into the holes of the index plate. The pin can be locked out of engagement by withdrawing the knob and turning it 90°.

To change the index plate, remove the worm shaft nut; slip off the index crank assembly, sector spring and sector arms; and remove the three screws holding the index plate in position.

For plain indexing, the stop pin behind the upper part of the index plate must be inserted in one of the holes of the plate. Turn the knurled body counterclockwise to allow the pin to come forward to engage the index plate.

To set the sector arms to the graduation listed

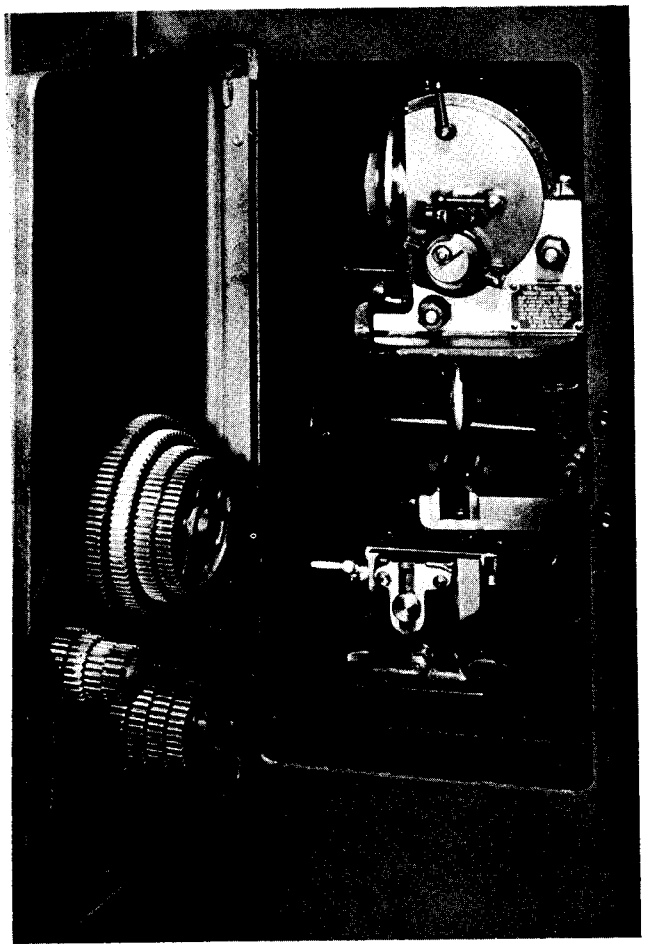


Fig. 19. Left — Spiral head on swiveling table and footstock as well as the swivel vise are stored in the stand compartment.

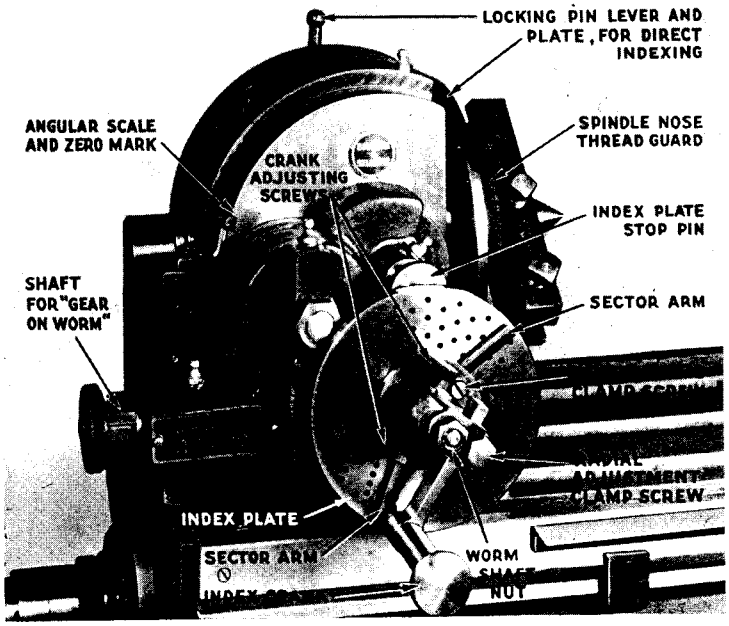


Fig. 20. Details of the spiral head as seen at the front.

in the index table, loosen the sector arms clamp screw, adjust the arms and tighten the screw.

To adjust the index crank radially for the specified circle of holes, loosen the radial adjustment clamp screw, insert the index pin in one of the holes in the required circle and tighten the screw.

To bring the index pin to the nearest hole in the plate without disturbing the setting of the work, turn the index crank relative to the worm by means of the two knurled crank adjusting screws on the hub assembly. Turn both screws, loosening one and tightening the other, until the pin enters a hole; then tighten both screws.

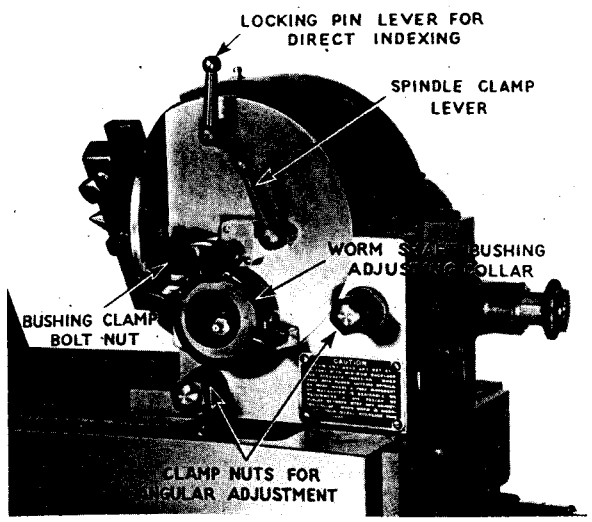
Differential Indexing is used to obtain those divisions which are not obtainable by plain indexing. Set-up data for differential indexing are listed in the index table, and a diagram at the top of the table indicates how to arrange the gearing.

Use of eight additional change gears, furnished as extras, permits indexing all divisions to 1008; and set-up data for all divisions from 383 to 1008 inclusive are listed in a table in our "Practical Treatise on Milling and Milling Machines". Note that many of the divisions within this range are obtained either by plain indexing or by differential indexing using the gears regularly furnished.

For differential indexing, the index plate stop pin must be disengaged to permit the index plate to rotate. To lock the pin out of engagement, push the knurled body inward and turn it clockwise.

Direct Indexing of 2, 3, 4, 6, 8, 12 and 24 divisions is accomplished by means of the 24-hole plate on the spindle nose and the lever-operated locking pin at the top of the headstock. To allow the spindle

Fig. 21. Detail of spiral head — rear.



to be turned by hand, the headstock worm is disengaged as follows:

First disengage the index plate stop pin. Then referring to Fig. 21, loosen the bushing clamp bolt nut and swing the bolt out of the slot. This allows the worm shaft bushing adjusting collar to be turned in a counter clockwise direction about one-quarter revolution. When the worm shaft bushing adjusting collar brings up against the stop block, the worm is completely disengaged.

To engage the worm, align crank plunger with knurled pin. Align mark "A" on large plate with line on spindle stop pin. Reengage worm and wheel. When using power feed a .010 feeler should be placed between stop and adjusting collar.

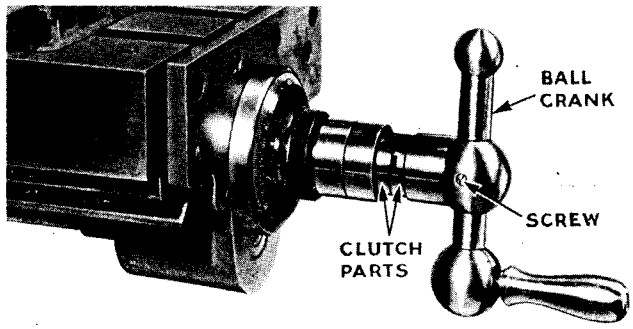
Cutting Spirals. The change gears furnished permit cutting spirals of all common leads from 2.500" to 149.31" when geared to the headstock worm; and leads 1/40 of all leads within this range are obtainable by gearing directly to the headstock spindle, using the differential indexing center in the spindle. (This latter method of gearing bypasses the regular indexing mechanism and requires that the spindle be horizontal.) The Table of Approximate Angles for Cutting Spirals lists the gearing for a wide range of leads together with the required angular settings.

Detailed instructions for setting-up the gearing are given in Chapter VI of the "Practical Treatise on Milling and Milling Machines". In brief, the "Gear on Worm" listed in the table is put on the headstock shaft (Fig. 20); the "1st Gear on Stud" and "2nd Gear on Stud" are put on the stud of the intermediate gear plate in the order named (the "1st Gear" is put on first, nearest to the headstock) and the "Gear on Screw" is installed as described below. Four gears are used for cutting right-hand spirals, and the gear on the reverse gear plate is added to the train for cutting left-hand spirals.

To install the "Gear on Screw", first take off the ball crank by removing the screw in the center ball (Fig. 22). Now unscrew hand clutch nut and take off the ball crank clutch at the end of the table screw (Fig. 23), pull off the remaining two clutch parts and remove the two collars from their sleeve. Slip the gear and one of the collars onto the sleeve, putting the gear on first, and reassemble the other parts in their original order.

In reassembling, note that the inside clutch member (the part replaced next to the collar—Fig. 23) must be put on the screw so that its two teeth will engage the mating slots in the end of the sleeve on which the gear and collar are mounted; otherwise the table cannot be driven by power.

Before starting to drive the headstock, make sure that the locking pin at the top rear of the index plate is locked out of engagement. Also see that the direct-indexing plunger is withdrawn; that the spindle clamp is released; that the worm is engaged; and that the index crank pin is inserted in one of the holes of the index plate.



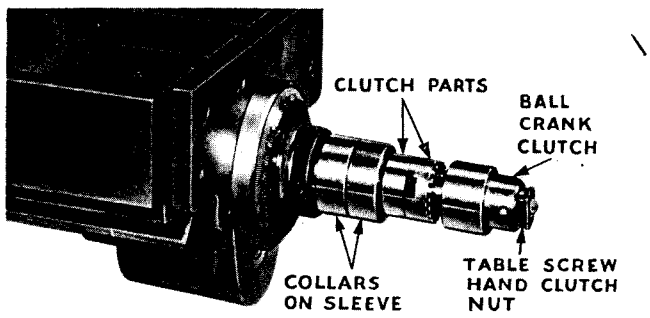


Fig. 22 (above) and Fig. 23 (below). Parts to be removed for installing "Gear on Screw". In lower illustration the ball crank has been removed and the nut on table screw loosened.

Using Headstock for Rotary Milling. Within certain obvious limitations the headstock of the Universal Spiral Index Centers can be used like a Rotary Attachment for milling segments of circles or circular slots. To drive the spindle by power for work of this sort, arrange the headstock gearing the same as for cutting a spiral but disengage power drive to the table screw, as follows:

Install the "Gear on Screw", but in reassembling the parts on the table screw turn the inside clutch member around so that its two teeth will face outwards and fit in the slot in the next clutch part to be replaced, instead of engaging the sleeve on which the gear is mounted.

The rate of rotation is governed by the headstock gearing and feed rate selected, and direction of rotation is controlled by the longitudinal feed control lever.

With the machine arranged in this way the table can be moved longitudinally by means of the hand-crank; but the adjustable dial cannot be used, since the sleeve on which the dial is mounted is no longer connected to the table screw. Lock the table in the desired longitudinal position by means of the

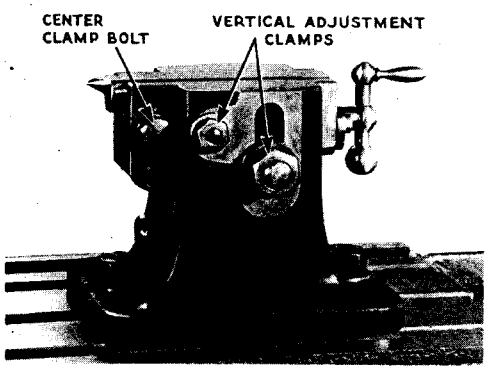
table stops (page 13) with one stop clamped in contact with each end of the saddle.

Angular Setting of Headstock. The headstock can be driven with the spindle set at any angle from 10° below horizontal to 5° beyond the vertical. Graduations on the side of the head read to ½°. The angular setting is clamped by the two nuts shown in Fig. 21.

Footstock Adjustments. The footstock adjustments and clamps are shown and identified in Fig. 24.

Turning the ball crank clockwise moves the center toward the headstock. This adjustment is clamped by the center clamp bolt.

Releasing the two vertical adjustment clamps allows the center to be set at an angle in the vertical plane, and to be adjusted vertically above or below center height by turning the pinion shaft at the rear.



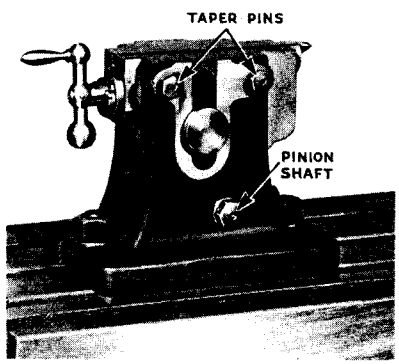


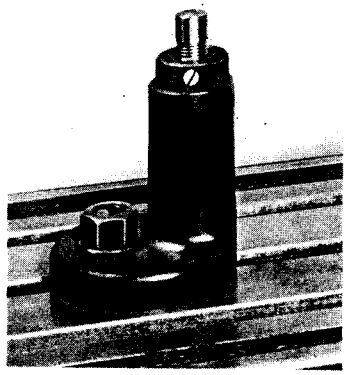
Fig. 24.
Footstock
Above-Front
Below-Rear

Before making either angular or vertical adjustment, remove the two taper pins at the rear; a twist with a wrench will free them. These pins should be used in relocating the center horizontal and at center height.

Make certain that both the vertical adjustment clamps and the center clamp bolt are tight before starting to take a cut.

Center Rest. The adjustable center rest (Fig. 25) is included with the Universal Spiral Index Centers and is used to give additional support to long or slender work held between centers. To adjust this unit, turn the knurled nut at the top to bring the non-rotating inner part to the desired height. To clamp the adjustment, tighten the set screw in the adjusting nut.

Fig. 25.
Adjustable center rest.



Coolant System

The Coolant System includes a motor-driven centrifugal pump (Fig. 26), piping, check valve, control valve, distributor, flexible return pipe and all necessary connections, together with a push-button-type manual starter having overload protection. This equipment is installed with the pump wired so as to start and stop with the machine. When coolant is not wanted, push the Stop button to shut off the pump.

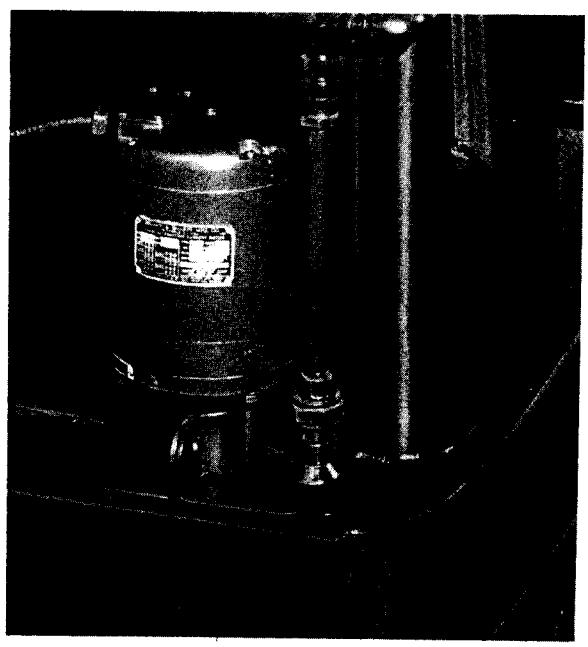


Fig. 26. Coolant pump.

A flexible supply pipe is furnished together with a distributor and adjustable bracket assembly of the type shown in Fig. 27. This unit can be quickly transferred to an overarm at the rear of the machine for storage.

A chip strainer is provided for the sump or well in the right-hand end of the table from which coolant is returned to the tank in the base. Lift-off plates and strainers in the top of the base provide for easy clean-out of the coolant tank.

The check valve is located just below the electrical cabinet where the delivery pipe rises alongside of the column and keeps the pipe full of coolant to give immediate splashless flow when the pump starts. If a condition should ever arise where the coolant starts each time with a surge or splash, the check valve needs cleaning.

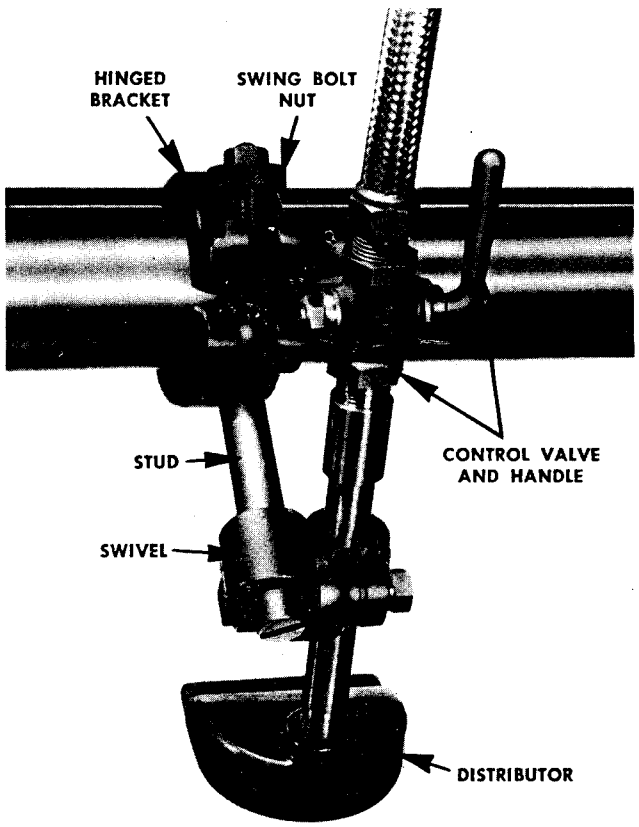


Fig. 27. Coolant distributor and bracket assembly.

CHAPTER II

Typical Operations

The operations shown in this chapter are representative of the wide variety of work performed on this machine. No attempt has been made to cover all types of jobs, or to describe each operation in detail. Rather, the following material is presented with a view to demonstrating as many different operating principles as possible, and to bring to the operator some of the machine's capabilities which will aid him in doing a better job. Be sure to take advantage of the greater rigidity of cutter support due to the extended spindle face design. It frequently permits use of smaller diameter arbors and consequently smaller cutters, thereby reducing cutter costs — smaller cutters permit faster feeds for equal surface finish and also save with shorter run-in.

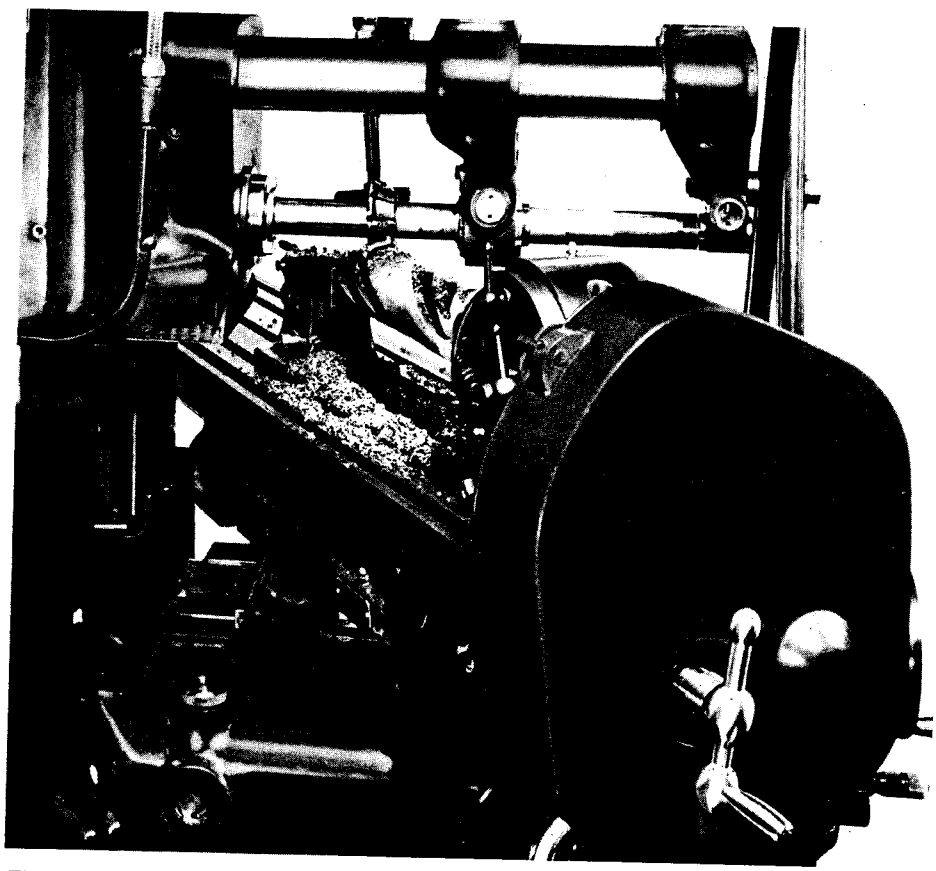


Fig. 28. Cutting teeth in an arbor-type helical milling cutter. The arrangement of headstock gearing (here enclosed by Change Gear Guard) for proper lead and angle at which to set swivel table are taken from the charts furnished. On completion of a cut, the work is returned at fast travel to starting position and is plain-indexed for the next cut.

The work is driven by a dog clamped in the headstock work driver. Use of both arbor yokes and the arm braces assures adequate rigidity of cutter support.

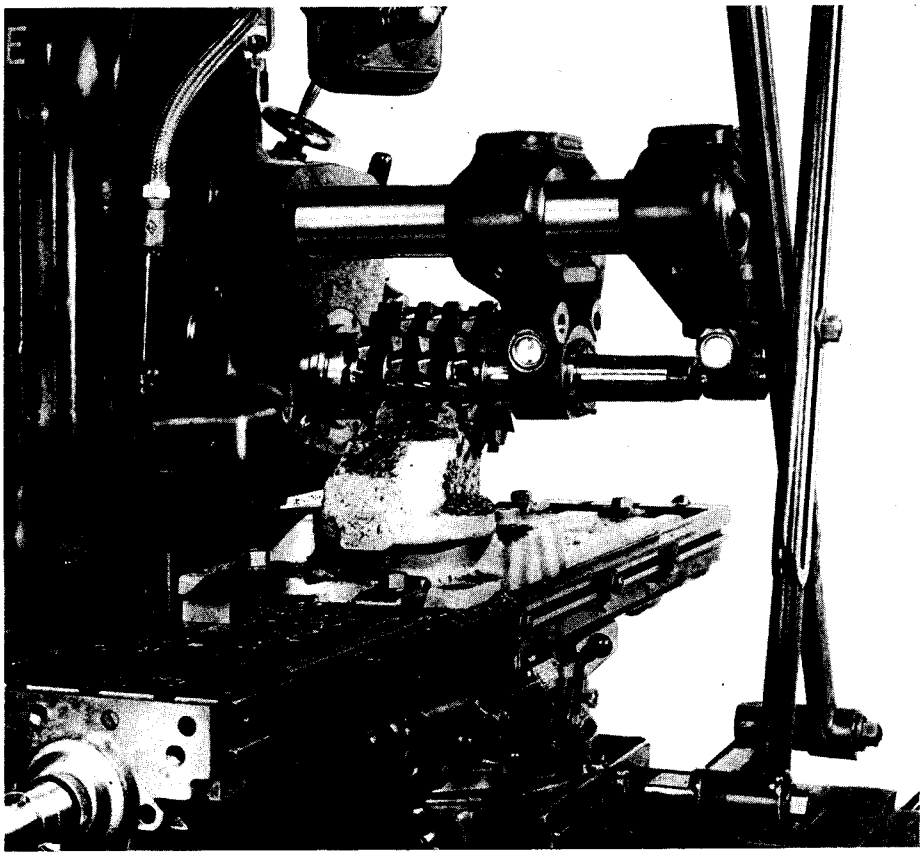


Fig. 29. The view at the left illustrates a typical straddle milling job.

Four side milling cutters are used for this operation, two cutting right and two left.

The sliding head is extended to permit mounting the cutters close to the spindle nose.

Both of the arbor yokes and the arm braces should be used when making this type of a cut.

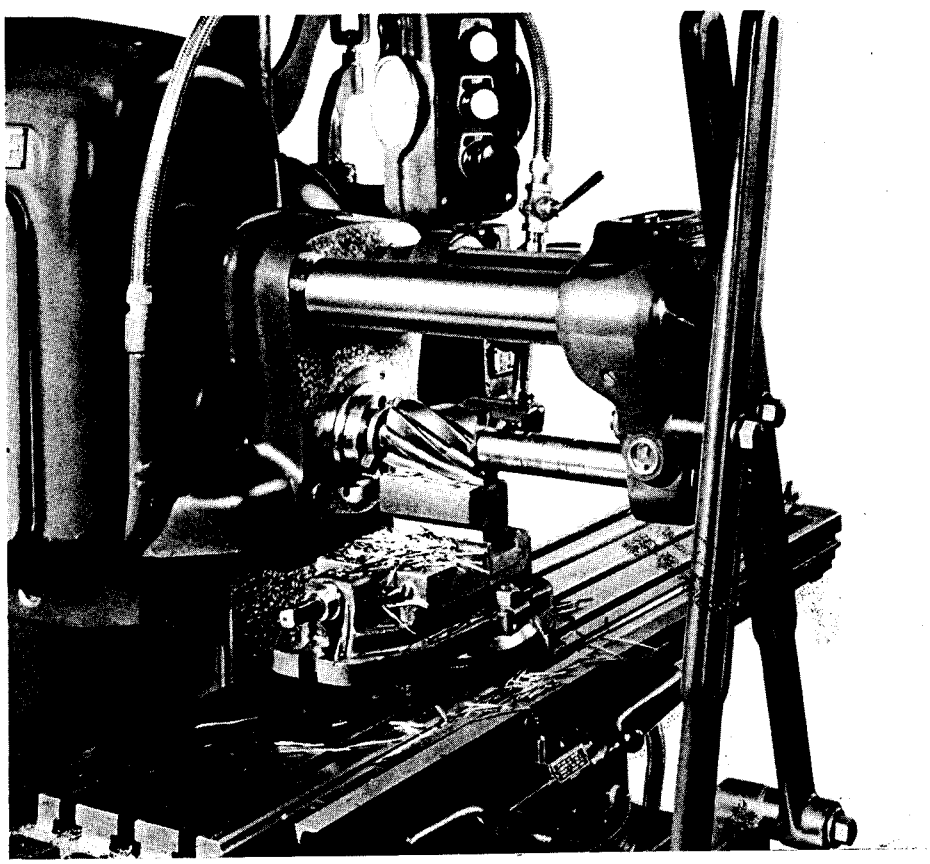


Fig. 30. Using a coarse tooth plain milling cutter mounted close to the spindle nose gives a good surface finish.

The work-piece is clamped in the vise (furnished with the machine). Note that the inner arbor yoke and arm braces are used.

Coolant is not shown although its use is indicated.

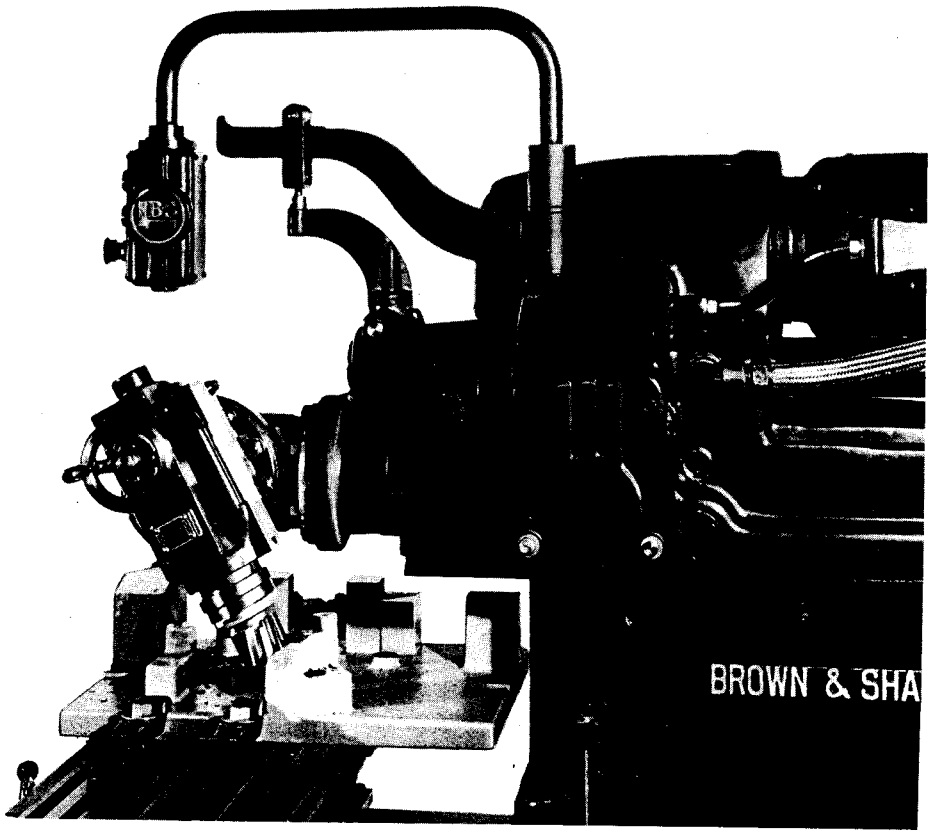


Fig. 31. This set-up illustrates the sliding head extended permitting cuts on work with large overhang.

The universal milling head is clamped at the angular setting desired by means of the six swivel clamp bolts.

The table stops are then set and table feed, either by hand or power is used to mill the surface.

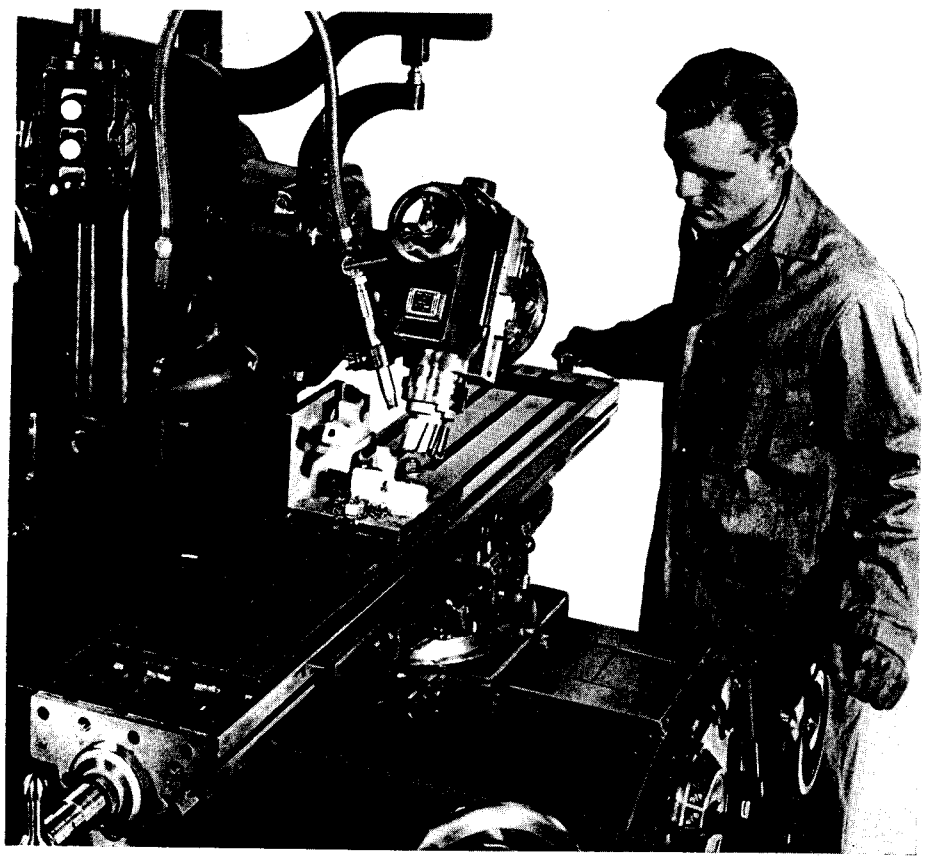


Fig. 32. Setting-up for a step-milling job. Note the convenient location of the operating controls. The operator is bringing the workpiece (bolted to machine table) into transverse and longitudinal alignment with the cutter preparatory to making the first cut.

In this set-up the coolant bracket is held in position by one of the swivel clamp bolts on the universal milling head.

Coolant is not shown although its use is indicated.

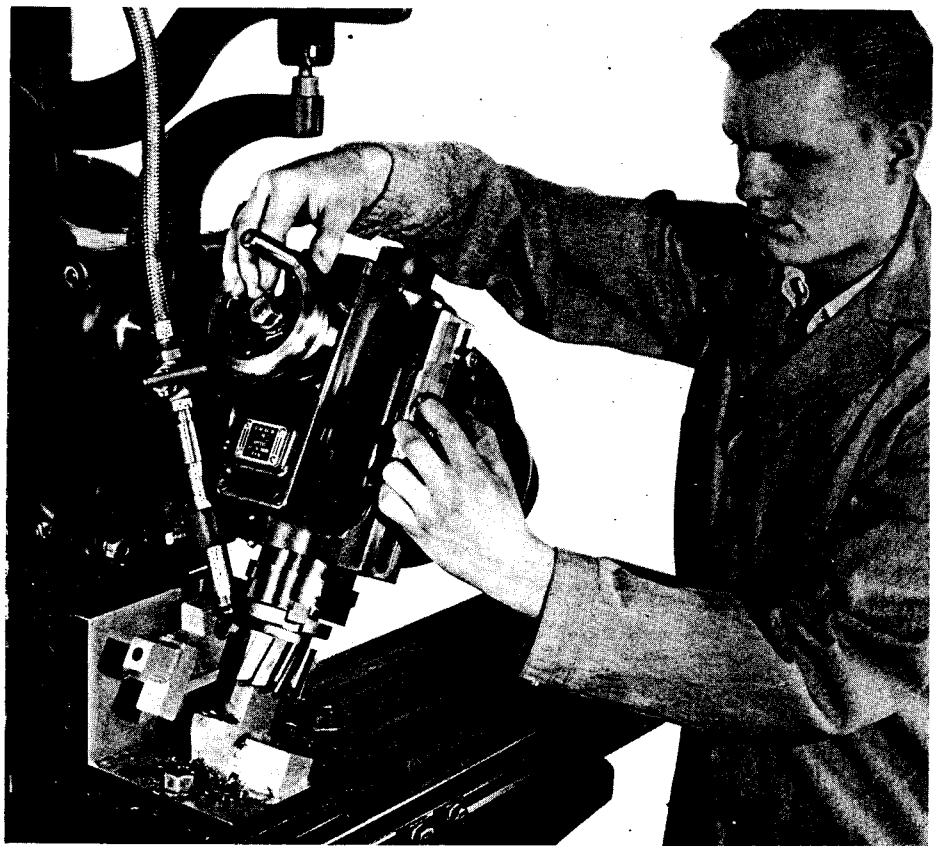


Fig. 33. Step milling assures accuracy when milling surfaces or boring holes to relative heights or depths.

The first step is milled to the desired height, then the adjustable stop is set to gage blocks of the required thickness. The operator is removing the gage blocks preparatory to making the next cut.

CHAPTER III

Additional Equipment (Furnished at Extra Cost)

This chapter describes and illustrates the numerous items of additional equipment available as extras, and gives data and instructions needed for set-up and operation.

No. 0 Slotting Attachment

The Slotting Attachment (Fig. 34) offers a convenient means of handling a wide variety of toolroom and small-lot work such as cutting keyways, forming special tools and dies and making templates.

The slide is operated by a crank of adjustable radius which is driven from the machine spindle by a pair of gears in 1:1 ratio. To set the length of stroke, bring the slide to the top of its path of movement, loosen the crank adjusting nut (a socket wrench is furnished), move the slide to bring the zero mark to the desired length of stroke as shown on the adjacent scale, and tighten the nut. Any length of stroke from zero to 3″ may be selected; and the tool slide can be set at any angle to 90° either side of zero.

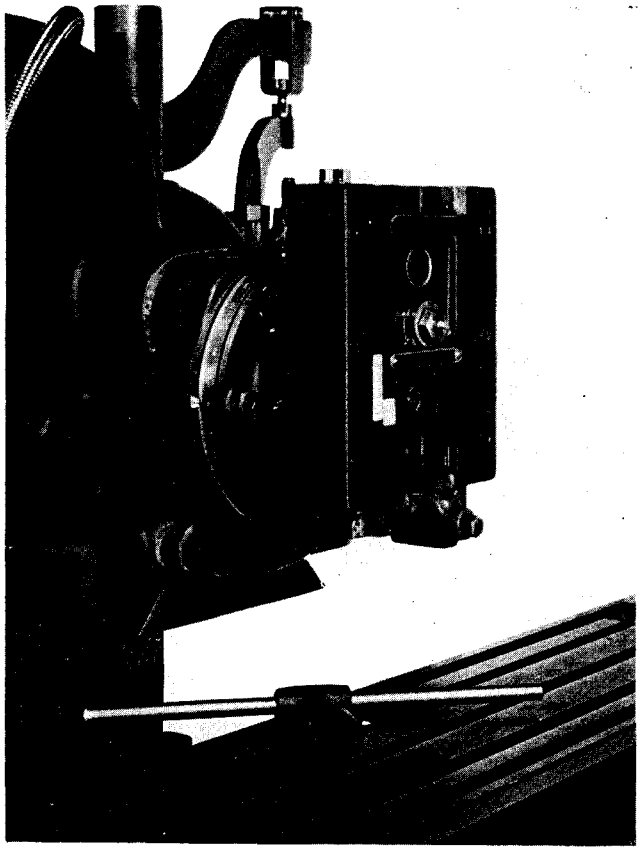


Fig. 34. No. 0 slotting attachment.

The slotting tool is held in position by a clamp bolt at the front, and a stop that swings over the top of the tool shank makes it impossible for the tool to be pushed through.

Rotary Attachments

When used on this machine which is equipped with a Universal Milling Head or when using a Vertical Milling Attachment, the Rotary Attachments make possible a variety of rotary milling operations such as milling segments of circles and circular slots. They also afford a convenient means of indexing for such operations as milling clutch teeth or locating angularly-spaced holes or slots, and in addition are useful in die sinking and a wide variety of slotted work when using the Slotting Attachment.

This machine takes the 10″ and 18″ Rotary Attachments (Hand Feed) as well as the 18″ Rotary Attachment (Power Feed) illustrated in Fig. 35. In many respects the two Hand Feed Attachments and the table unit of the Power Feed Attachments are quite similar in design. With all three Attachments the table is rotated by a worm and wheel operated by a handwheel at the front (or by power in the case of the Power Feed Attachment), and to facilitate set-up the worm can be disengaged by a lever to permit turning the table directly by hand. When engaged, the worm and wheel serve as a lock to prevent unwanted table rotation, while rigid clamping of the table is provided by a lever near the front.

The circumference of the Attachment tables is graduated to half-degrees, and an adjustable index finger permits readings to be taken from the nearest graduation at all settings. The index finger is adjusted by loosening its clamp screw and pushing the finger sideways. An adjustable dial behind the handwheel provides for fine adjustments of the table.

To install the Power Feed Attachment on the machine, first remove the ball crank as well as disk and sleeve from the projection of the table feed shaft at the right-hand end of the milling machine table and put on the driving gear, which is shipped loose with the Attachment. Then put the Attachment gear bracket in position, bolting it to the three T-slots of the machine table as illustrated in Fig.

Fig. 35. Right — 18" Rotary attachment (Power feed)

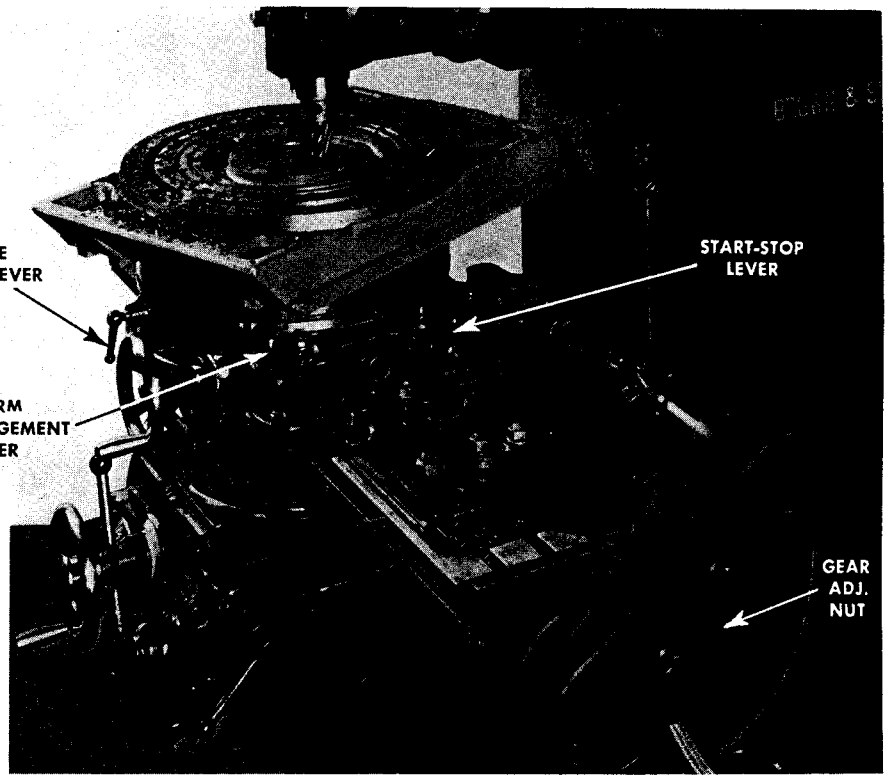
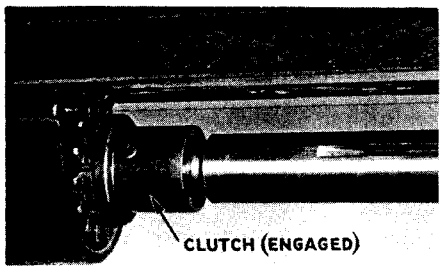


Fig. 36. Below — Clutch on table feed shaft must be disengaged before power drive to Rotary Attachment is engaged.



35. Loosen the gear adjusting nut on the bracket and bring the adjustable gear into proper mesh with the gear installed on the table feed shaft. Now slip the long shaft of the universal joint assembly into its hole at the upper left part of the gear bracket. Position the rotary table unit on the machine, bolt it to the table and connect the universal joint assembly to it by means of the pin provided.

Before operating the Attachment it is necessary to disconnect the drive to the table feed screw of the machine; otherwise the table will be fed longitudinally when the Attachment is driven by power. To do this, disengage the clutch on the feed shaft under the left-hand end of the table, shown engaged in Fig. 36. Loosen the set screw, slide the clutch to the right to disengage it, and tighten the set screw. With the drive thus disconnected, the handcrank and adjustable dial can still be used for longitudinal adjustment of the machine table.

Lock the machine table in the desired longitudinal position by means of the table stops (page 13) with one stop clamped in contact with each end of the saddle.

Drive to the Attachment is established by throwing the longitudinal feed control lever of the machine to engage power feed, the position of the lever determining the direction of rotation of the Attachment table. This lever can also be used to start and stop the Attachment, although power rotation is usually controlled by the lever at the right-hand side of the Attachment table. A plunger at the left of the latter lever provides for automatic throwout of power rotation in either direction by adjustable dogs mounted in the T-slot in the side of the Attachment table.

The rate of power rotation is governed by the rate of feed for which the machine is set. Power fast travel can be used for rapid rotation during set-up or for jumping gaps between cuts.

On long runs with this Attachment where the longitudinal feed control lever of the machine is not used, this lever should be reciprocated through twenty to twenty-five complete strokes once a day to lubricate the table driving mechanism.

Indexing Attachments, used in place of the Rotary Attachment handwheel, are available as extras for use with the 18" Rotary Attachments (both Hand Feed and Power Feed). Each Indexing Attachment includes four index plates and an index table listing set-up data for all available divisions to 372. The index crank and sector are like those used on our Index Centers.

Index Centers

The extensive line of Brown & Sharpe Index Centers covers a wide range of work from complex toolroom operations to high-production three-spindle indexing. With the exception of the No. 2½ Triple Index Centers, all of this equipment has the following similar features of design and operation:

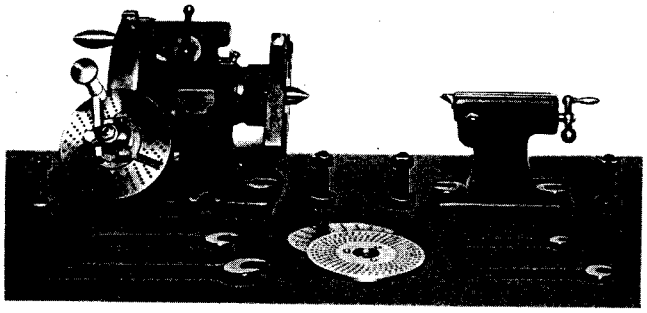


Fig. 37. 10" Plain Index Centers.

In setting-up, two knurled thumbscrews on the index crank hub assembly provide for bringing the pin to the nearest hole in the index plate without disturbing the setting of the work. Both screws should be tightened before indexing.

The index sector is graduated to permit setting-up without counting the number of holes required. Simply set the sector arms to the graduation listed in the index table furnished. The setting is clamped by a screw in the face of the sector.

The worm can be locked out of engagement to allow the headstock spindle to be turned by hand; and a spindle clamp is provided. Positive stops indicate when the worm is completely disengaged and properly engaged.

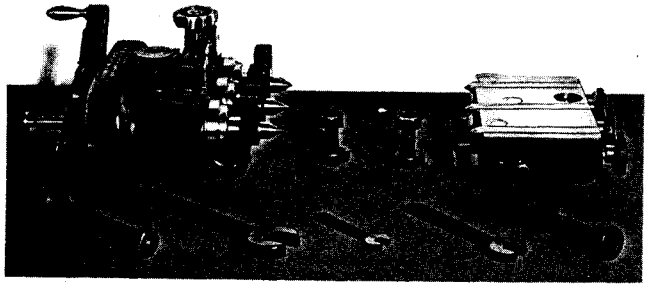
The front end of the headstock spindle is threaded to accommodate a chuck or face plate. When not in use, the threads should be protected by the knurled guard nut provided.

Illustrated specifications describing the various Index Centers in detail will be furnished on request.

Plain Index Centers. These centers (Fig. 37) are exceptionally rigid in construction. As the wormwheel is accurately cut and of large diameter, the possibility of error in indexing is considerably lessened. They are frequently used on jig work where accurate indexing is imperative.

No. 2½ Triple Index Centers. These centers (Fig. 38) are equipped only for direct indexing by means of an index plate, ratchet handle and spring-loaded locking pin on the left-hand end of the headstock. The three spindles are indexed in unison and are clamped by turning the knob at the top of the headstock. The footstock centers are operated and clamped individually.

Fig. 38. No. 2½ Triple Index Centers.



Universal Index Centers. These centers are similar to the Universal *Spiral* Index Centers, except that the *Universal* Index Centers have no provision for gear drive. Sizes available swing work to 6" and 19" diameter.

No. 0 Micrometer Table Setting Attachment

This Attachment (Fig. 39) facilitates positioning the milling machine table both longitudinally and transversely to close limits.

The Attachment includes a set of 12 measuring rods and a micrometer head. Two horizontal brackets are also provided—one for longitudinal adjustments (fastened to the front of the table) and one for transverse adjustments (on the side of the knee). Each bracket has a V-groove for supporting the measuring rods and micrometer head, and carries a dial indicator at one end; and a fixed stop is furnished for use with each bracket. The bracket on the front of the table is adjustable along the table T-slot.

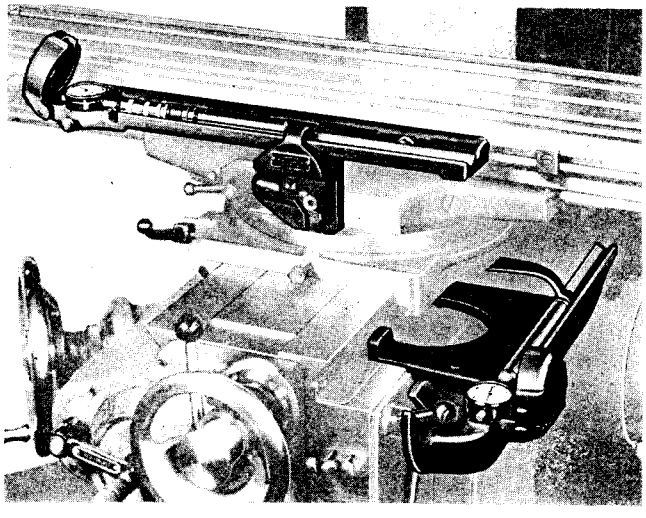


Fig. 39. No. 0 Micrometer Table Setting Attachment.

The Attachment is used as follows: After making one cut and before moving the table for the next, place a measuring rod and the micrometer head in the V-groove of the proper bracket, with the rod, head, positive stop and dial indicator stem all in contact, and set the dial indicator to zero. Then change the rod and reset the micrometer head to give the desired spacing for the next cut, and move the table (using hand feed) until all the units

are again brought into contact with the dial indicator reading zero.

Scales and Verniers

Scales and verniers giving direct readings to thousandths of an inch are available for the longitudinal, transverse and vertical table movements. The longitudinal and vertical scales are 24″ long and the transverse scale is 14″ long.

No. 0 Change Gear Guard for Drive to Universal Spiral Index Centers

Completely enclosing the gearing which drives the headstock of the Universal Spiral Index Centers, (Fig. 40) this Change Gear Guard is for use where the rate of feed and the lead of the spiral being cut are such as to cause the gears to rotate with dangerous rapidity. The guard permits the standard set of change gears to be used; and the hinged construction allows full freedom in changing the gears.

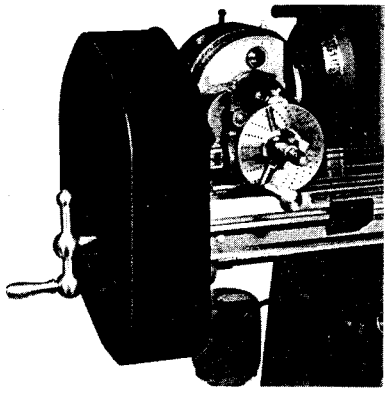


Fig. 40. No. 0 Hinged Change Gear Guard encloses the headstock driving gears.

The guard is light in weight for ease of handling, and is quickly placed in position or removed from the machine, being held in place simply by two screws which attach it to the table. Maximum longitudinal table travel is decreased by 1½″, and clockwise swing of table is limited to 43°.

No. 0 Short Lead and Feed Reducing Attachment

Used with the Universal Spiral Index Centers, this Attachment provides much shorter leads than are otherwise available; and when used alone it provides the very slow rates of longitudinal table travel required for operations such as milling with a fly cutter. The Attachment consists of nine spur gears and a mounting bracket, together with a table containing set-up data, gearing diagrams and formulas.

Five of the gears are used to supplement those regularly furnished with the Universal Spiral Index Centers in gearing-up the headstock in the usual manner for cutting spirals. The four other gears constitute a train between the table screw dial sleeve (which is driven by the table feed shaft) and the longitudinal table screw, and reduce the rate of rotation of the table screw to 1/20 of normal. Consequently, the longitudinal table feed obtained with this Attachment is always 1/20 of the rate for which the machine is set.

In setting-up the Attachment for cutting a spiral, put on the "Gear on Screw" (see page 17) and gear-up the headstock as indicated in the table furnished. Slip the 24-tooth Attachment gear onto the sleeve next to the "Gear on Screw"; then put the 100-tooth gear on the table screw with the clutch teeth on its hub facing outward, and replace insuccession the nut on the end of the table screw, the ball crank clutch and sleeve assembly and the ball crank. Now complete the four-gear train from sleeve to screw by installing the 96-tooth and 20-tooth gears on the Attachment bracket at the front as shown in Fig. 41.

The table furnished lists set-up data for all common leads from .0125″ to 3.000″, and numerous leads above and below these limits are also available. Leads of .150″ and higher are obtained by gearing to the headstock worm as illustrated in Fig. 41, this arrangement giving leads 1/20 of normal; while leads below .150″ are obtained by gearing directly to the headstock spindle, using the differential indexing center in the spindle. This latter method of gearing bypasses the regular indexing mechanism and gives leads 1/800 of those normally obtained with a given gear train.

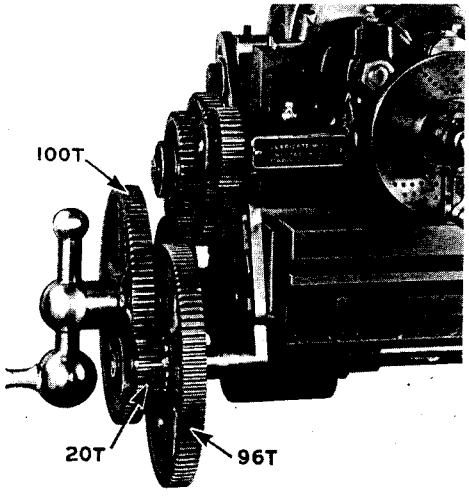


Fig. 41. No. 0 Short Lead and Feed Reducing Attachment.

CHAPTER IV

Maintenance

Installing or Relocating the Machine

In lifting or moving the machine, pass the hoisting rope around the sliding head beneath the bar (inserted through hole through the stand) and around the front of the column (Fig. 42). Take care to protect the machine at points of contact with any suitable material such as canvas or burlap.

Adjustment for balance can be made by moving the saddle in or out.

The machine weighs approx. 5350 lbs. net. The hoisting rope should be strong enough to allow a margin for safety.

The machine should be located on a level and rigid floor which is free from heavy vibration. With the machine in position, test the surface of the table both longitudinally and transversely with a precision spirit level and drive a wooden shingle under any corner or corners of the base that may be low. Make sure that all four corners are supported; then tighten the lag screws, test the level of the table surface again in both directions and readjust if necessary.

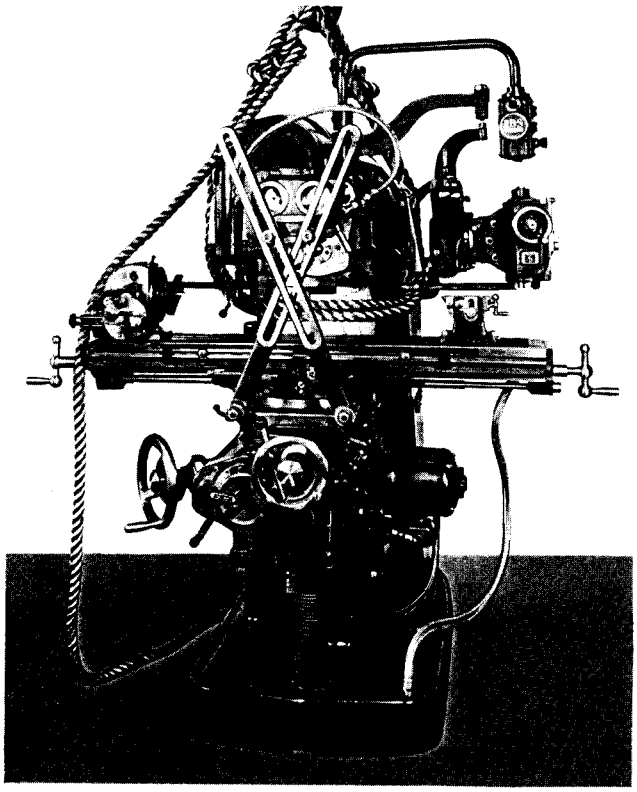


Fig. 42. Proper method of rigging machine.

The subject of connecting to the power supply is covered on page 34. CAUTION: To avoid damage, be sure to check the direction of motor rotation as explained on page 35 before starting to use the machine.

Lubrication

All driving mechanisms throughout the sliding head knee and table, and all the ways are oiled automatically from three reservoirs as described below. These reservoirs are drained before the machine is shipped from our factory; therefore, be sure to fill all three reservoirs before starting a newly-delivered machine. Also take the two screws out of the T-slot on the front right end of the table and oil with 20 to 30 drops of S.A.E. 20 oil, then replace the screws. Oil is supplied automatically after this initial oiling.

The fact that automatic oiling is provided should by no means lead the operator or maintenance man to forget the matter of lubrication. Check the level of the oil reservoirs weekly and refill as necessary (see Figs. 43 and 44). Also, look at the oil sight indicators occasionally during operation to make sure that the oiling systems are functioning.

Note further that a self-closing oiler in the hub of the transverse adjustment handwheel and another in the hub of the vertical adjustment handwheel require oiling every day.

Use a good grade of mineral oil having a viscosity of 300 S.S.U. at 100°F, or S.A.E. 20, throughout.

The gears and bearings within the sliding head are oiled by a plunger pump immersed in a reservoir in the sliding head. The pump runs continuously whenever the spindle motor is running. The filler cap and oil level sight window for the reservoir is on the rear of the sliding head as shown in (Fig. 17).

The pump and strainer unit is located in the right side of the sliding head as illustrated in Fig. 5. To remove this unit take out the three screws, tap the edges of the projecting casting to loosen it and pull it out. Before doing this, empty the oil reservoir by removing the adjacent drain plug.

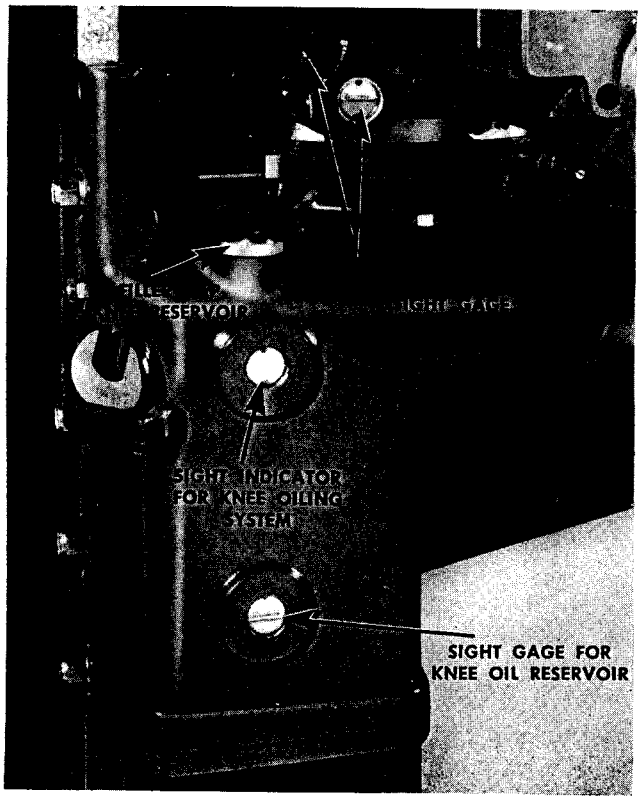


Fig. 43. Oil gages, etc. for automatic lubrication systems.

The oil sight indicator window (see Fig. 5) is located on the front wall of the sliding head beginning Serial No. 506-20-4.

All knee mechanisms and the bearing surfaces on the column and at the top of the knee are oiled by a plunger pump (similar to that used on the sliding head) immersed in a reservoir in the bottom of the knee (Fig. 45). This pump runs continuously whenever the table motor is running and delivers oil to the automatic feed valve (Fig. 46).

The automatic feed valve has a spring-loaded hollow piston. When the machine is started the cycle described later is commenced, and a quantity of oil is passed to the junction while closing the bottom port, the oil pressure quickly moves the piston toward the front of the machine until a hole in the piston comes opposite a port at the top of the valve body. Oil then flows through pipe A (Fig. 46) to provide continuous oiling of the feed case gearing. Part of this oil flows through the sight indicator on the side of the knee.

When the machine is stopped, the spring in the automatic feed valve gradually forces the piston to the rear, first closing the upper port and then, after 15 to 30 minutes, opening the port at the

Fig. 44. Lubrication Diagram.

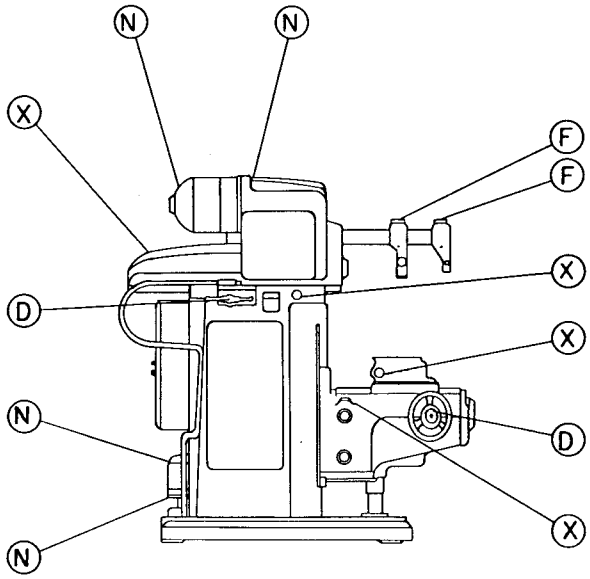
D—Oil daily with good grade machine oil of 300 S.S.U. at 100°F.

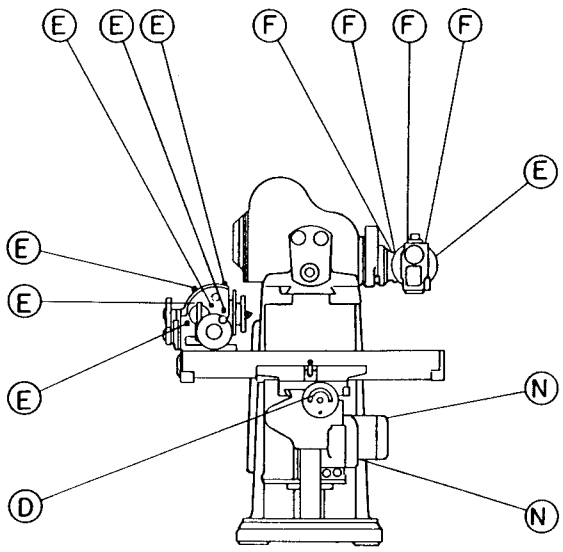
E—Fill when necessary with neutral non-fibrous grease.

F—Fill when necessary. Use good grade machine oil of 300 S.S.U. at 100°F.

N—Permanently-sealed bearings.

X—Keep filled to gage (Automatic lubrication) with good grade machine oil of 300 S.S.U. at 100°F.





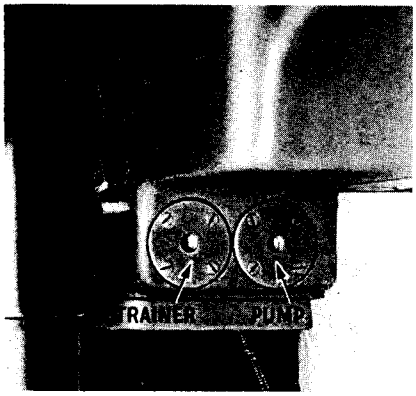


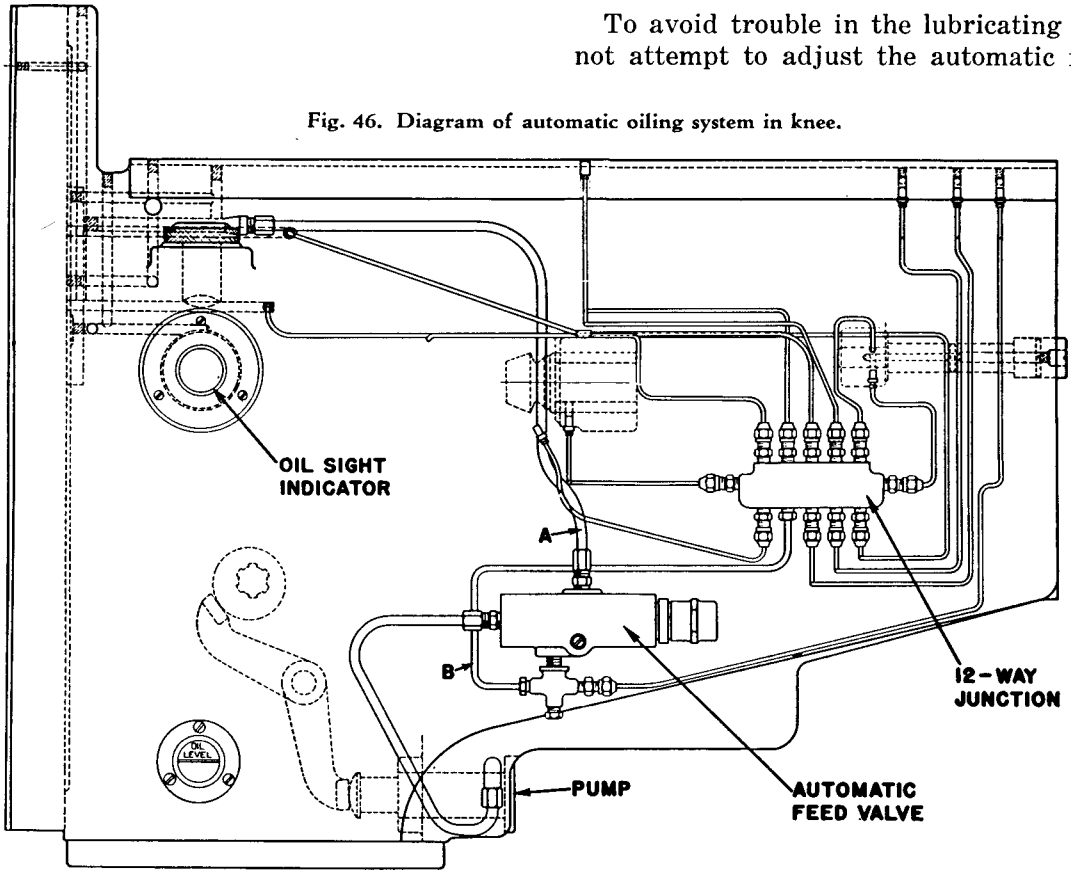
Fig. 45. Pump and strainer for knee oiling system. Drain plug is in bottom of knee behind elevating screw.

bottom. Oil then flows through pipe B to the 12-way junction (Fig. 46). As the piston continues to the end of its stroke a measured quantity of oil is delivered to the junction, and from there it goes through oil tubes to the bearing surfaces on the column and top of the knee, and the various gear and clutch mechanisms in the upper part of the knee. Metering plugs of various sizes provide for delivery of the proper quantity of oil through each tube. Note that this action takes place only after the machine has been stopped for approximately 15 to 30 minutes.

By means of this combination of continuous and intermittent oiling, all parts are given sufficient lubrication and no parts are oiled to excess.

To avoid trouble in the lubricating system, do not attempt to adjust the automatic feed valve.

Fig. 46. Diagram of automatic oiling system in knee.



This unit is set at our factory and should require no attention.

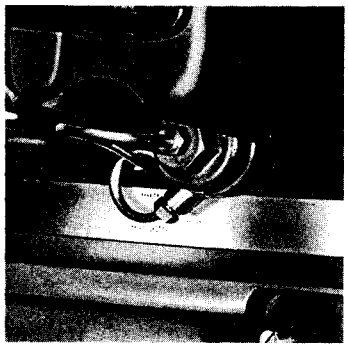


Fig. 47. Pump for lubricating table driving mechanisms and table ways.

The oil pump and the strainer can be removed individually. The pump is behind a circular cap (Fig. 45) in the bottom of the knee. A 1/8" pipe thread tapped in the end of the pump body permits easy removal. The strainer and pump cap are held by four screws (Fig. 45) and both have tapped holes (3/8"-16-N.C.) to facilitate pull-out.

The drain plug for the oil reservoir is in the bottom of the knee in back of the elevating screw.

All table driving mechanisms and table ways are oiled from a reservoir in the back of the saddle by a pump (Fig. 47) under the left front end of the saddle. The pump is actuated by movement of the longitudinal feed control lever and delivers oil to a junction or distributor located in the underside of the right-rear end of the saddle above a cast iron guard. If for any reason tubes are removed allowing air to enter the system, air or oil pressure should be applied to the reservoir to expel this air from the system.

Arbor yokes are oiled manually by means of the push valve at the top of each yoke as described on page 13.

Motors regularly furnished have grease-sealed ball bearings of the "sealed for life" type. Instructions for regreasing (after several years of service) are given on a tag fastened to each motor.

Mechanical Adjustments

The adjustments described here are those which would be puzzling or difficult to make unless explained to some extent. Other more commonplace adjustments which may require occasional attention—for example, taking up the table, saddle and knee gibs—are well understood by the competent maintenance mechanic and are not covered in this book.

Section drawings (Figs. 49 and 52) will be of assistance in diagnosing and curing any troubles in the spindle and table driving mechanisms, and

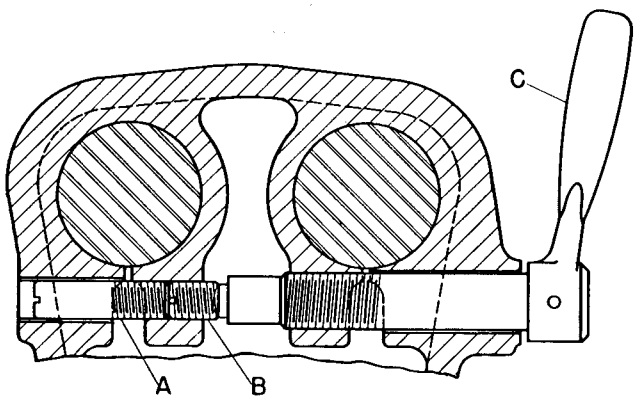


Fig. 48. Section through Arm Clamp.

the illustrations in the Repair Parts section will be found of considerable help in disassembling and reassembling all parts of the machine.

To avoid excessive or rapid wear, make adjustments when their need first becomes apparent. It is difficult to produce good work on a machine in need of adjustment.

Arm Clamps

To adjust arm clamps, remove screws A at front and rear (Fig. 48), then loosen front and rear screws B so clamp lever C is vertical or slightly ahead when clamped. While lever C is still clamped, tighten rear screw B. Loosen lever C and replace screws A. When clamps are adjusted correctly, arms will be clamped tighter in front than in rear.

Spindle Bearings

To adjust the spindle bearing center first remove the cover plate and threaded plug on the right-hand side of the column. Turn the speed selector lever until the spindle driving gears slide into a neutral position to permit free rotation of the spindle. Loosen the set screw A (Fig. 49), tighten the nut

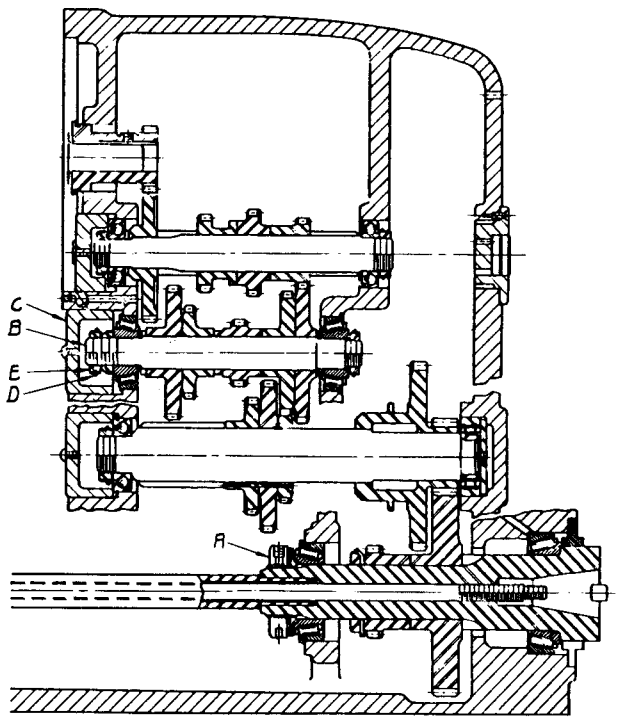


Fig. 49. Developed section through spindle drive.

until play is removed (one eighth of a turn will usually be enough) and clamp the set screw to lock the nut.

To adjust bearings on speed change gear shaft B (Fig. 49), remove speed control bracket and cover C then straighten lockwasher D and tighten nut E. Lock with cleat of washer after adjustment.

The other bearings throughout the machine should seldom if ever require adjustment.

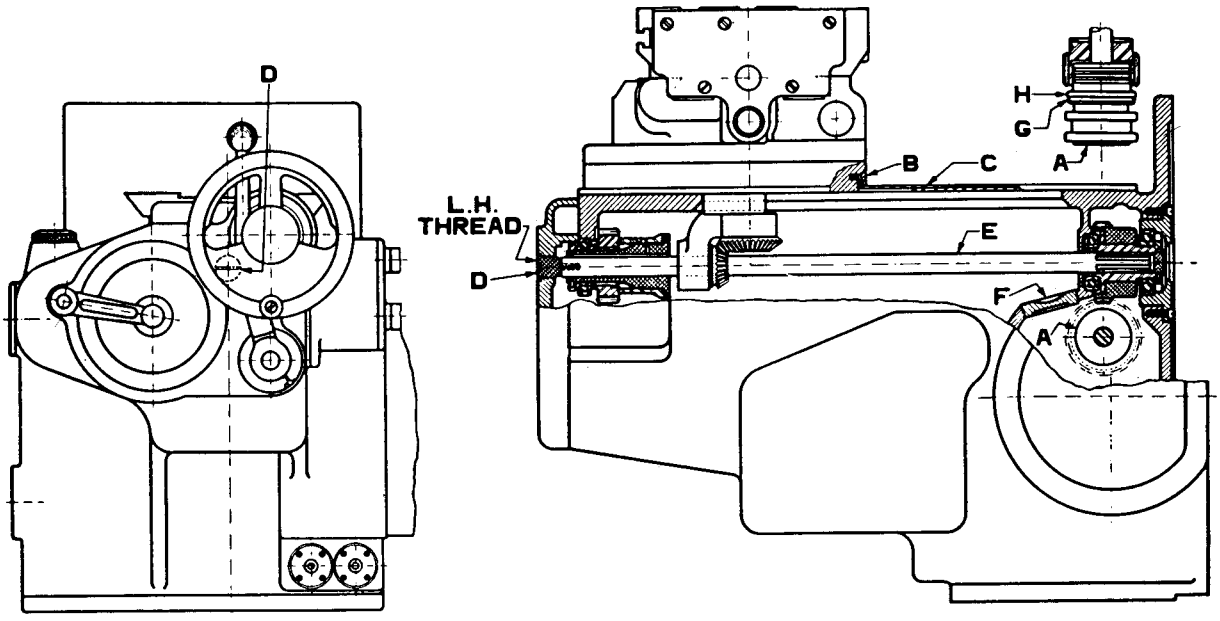


Fig. 50. Adjustment of fast travel clutch.

Fast Travel Clutch

This friction clutch is at the left of the spiral gear at the top of the feed case (Fig. 51) and is controlled by the fast travel lever. Take-up for wear is made as follows:

Referring to Fig. 50, run the saddle to the front of the knee, remove screw B at the rear of the saddle and slide back guard C. Remove the feed shaft thrust screw D, which has a *left-hand thread,* and withdraw feed shaft E from the machine. Take out plug F, turn the clutch body until the loop on the end of flat locking spring G can be reached, and lift the end of spring G with a stiff bent wire or offset screwdriver. Press with a thin rod against the small-diameter portion at the right of spring G to hold this member stationary, and turn knurled collar H toward the rear a little at a

Fig. 51. Feed case.

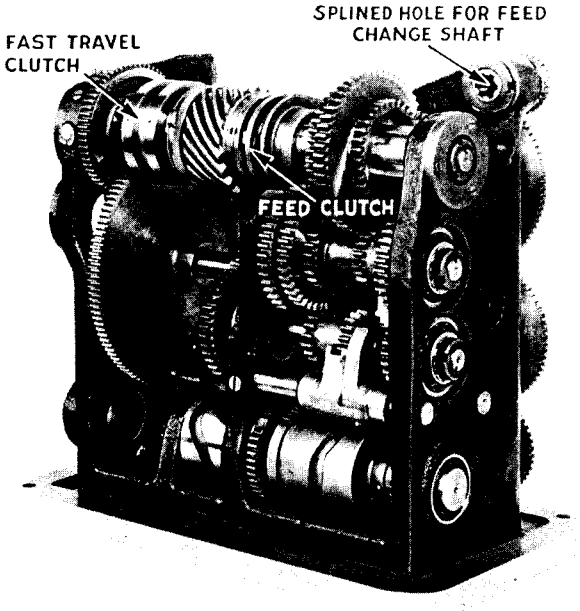
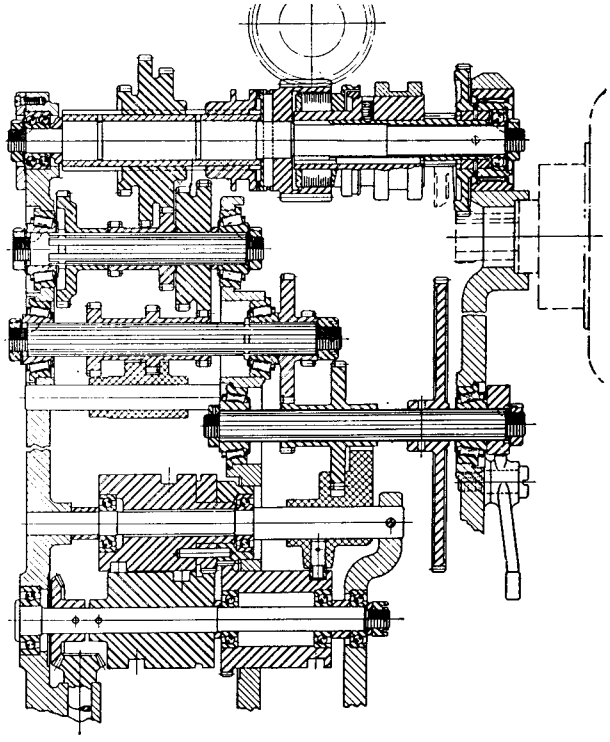


Fig. 52. Developed section through feed case mechanism.



time until the clutch can be felt to engage as the fast travel lever is pulled to the left. (One notch is usually sufficient.) Make sure the end of spring G enters a locking notch before reassembling.

Removing the Feed Case

The feed and fast travel clutches and complete feed change mechanism are included in the feed case unit in the knee. This unit is illustrated in Fig. 51 and is removed as follows:

Set the mechanism for the lowest rate of feed. Then drive the taper pin out of the hub of the feed selector lever, reach up under the knee to grasp the feed change shaft and pull the shaft forward an inch or so to disengage it from the feed case.

Next disconnect the wires at the table motor, unscrew the conduit bushing in the motor junction box, and swing the conduit downward to clear the motor. Then take out the motor mounting screws and remove the motor.

Drain the knee oil reservoir. The drain plug is in the bottom of the feed case.

Loosen the screws in the bottom of the feed case and remove all but two at opposite corners. Lower the knee and rest the bottom of the feed case on boards or low blocks (not over 1½" high) on the base of the machine. Take out the two remaining screws and raise the knee off of the feed case, jockeying the case a little if necessary to free it; then swing the case around on the base and remove it from the right side of the machine.

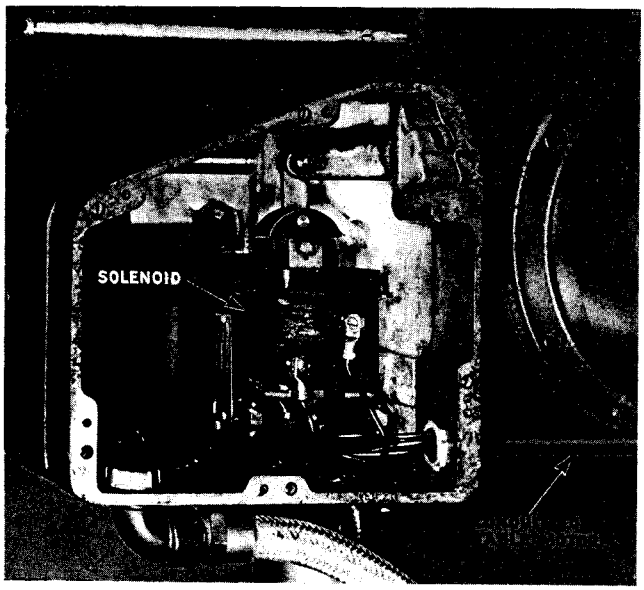


Fig. 53. Solenoid in knee compartment (cover removed). Solenoid is energized while spindle motor magnetic switch is closed. When the motor is stopped, spring in feed case brings linkage to position shown.

If it is ever necessary to manipulate the gear-shifting mechanism with the feed case out of the machine, set the mechanism for the lowest rate of feed before replacing, to make sure that the dial will correctly indicate the rate engaged. The gears are set for the lowest rate when, in all mating gear clusters, the smallest gear is used as the driver. (The first pair of sliding gears in the train is on the shaft which carries the largest-diameter gear at the right of the feed case.) Also, the pin in the splined hole in which the feed change shaft fits should be at the top.

Before replacing the feed case, make sure the gasket is in good condition. Lower the knee over the feed case and when bringing the feed case to final position shake the fast travel lever slightly to enter the shifter on the end of the fast travel lever shaft into the slot in the fast travel clutch shoe. If difficulty is encountered in getting the feed case all the way into the knee, remove plug F (Fig. 50) as described under "Fast Travel Clutch" and working through the hole with a screwdriver, enter the shifter in the slot.

With the feed case installed in the knee, replace the feed change shaft with the line scratched on the outer end in the top position, see that the rotating dial shows the lowest rate of feed and insert the pin in the hub of the feed selector lever.

Knee Clamp

The knee clamp is tightened by a clamp nut and check nut on the back of the knee gib at the end of the clamp lever shaft. Tighten the nuts so that firm clamping is provided without the lever rotating far enough to strike the machine on its outward movement, making sure also that the lever has a little free movement when at its inner position to assure full release of the clamp.

Electrical Controls

Connecting to Power Supply. The machine should be connected to the power line through the disconnect switch and should be properly grounded. The power wires are led into the machine through a hole in the electrical control compartment (Fig. 54), and should be connected to the top of the disconnect switch.

Unless otherwise specified the disconnect switch is of the non-fusible type. If fuses are desired they can be mounted on the disconnect switch.

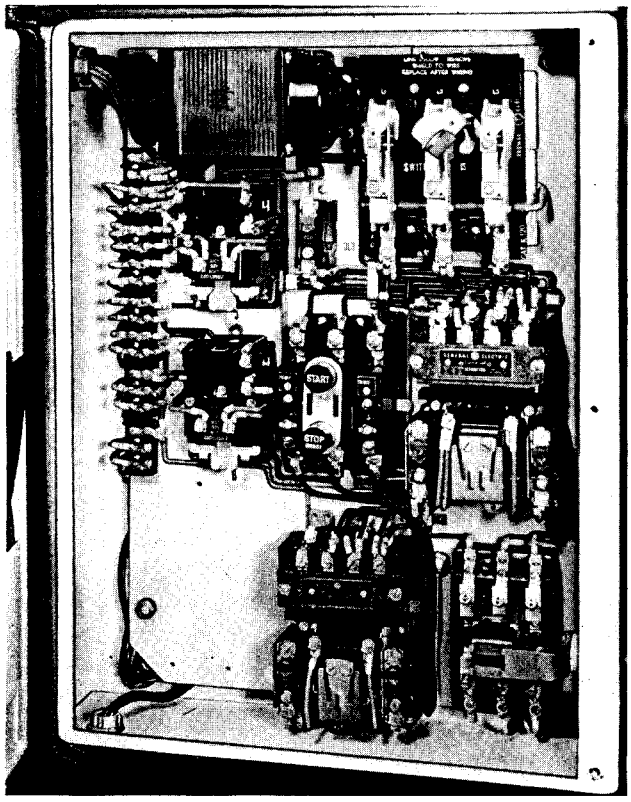


Fig. 54. Electrical controls in compartment at the rear of machine.

Checking Motor Rotation. Before using a newly-connected machine, check the direction of rotation of the motors as follows:

See that the three feed control levers (identified in Fig. 9, page 11), are in neutral position and start the machine. Then throw the longitudinal feed control lever to the right or left to engage table feed. If the table moves in the direction in which the lever is thrown, the wiring is correct. If the table moves in a direction *opposite* to the direction in which the lever is thrown, stop the machine and reverse one phase of the power supply to correct the rotation of all the motors. (This is conveniently done by transposing two of the wires at the line disconnect switch.) Do not under any circumstances change the internal wiring of the machine.

Clutch Solenoid. The clutch solenoid in the right-hand side of the knee (Fig. 53) operates a linkage to engage the feed clutch when the machine is started in cutting feed. When the machine is stopped, the solenoid is de-energized and a spring disengages the clutch to assure rapid stopping of the table. In case fast travel operates as usual but feed movement is not obtainable, check the solenoid and linkage. The solenoid is protected by an overload relay shown in Fig. 55.

Fast Travel Switch. For power fast travel, the table motor is controlled by a switch operated by the fast travel lever. This switch is located in the knee just back of the fast travel lever and is removed for inspection by taking off a plate on the underside of the knee. The switch is mounted on a bracket on the plate.

Transformer. The transformer (Fig. 54) provides a control circuit voltage of 110 volts on 60-cycle power supply, and is protected by a manually-reset overload relay which is reset by pushing the red button. The transformer has sufficient extra capacity to supply power for a 100-watt light on 60 cycles.

Magnetic Switches and Overload Relays. These units, illustrated in Fig. 54 are mounted on a panel behind a hinged cover in a compartment at the rear of the machine column. Note: Overload relays are normally set at automatic reset position.

Trouble-Shooting. Except for the coolant pump motor circuit, overload of any circuit stops the entire machine. In case of repeated stopping due to overload, determine which circuit is causing

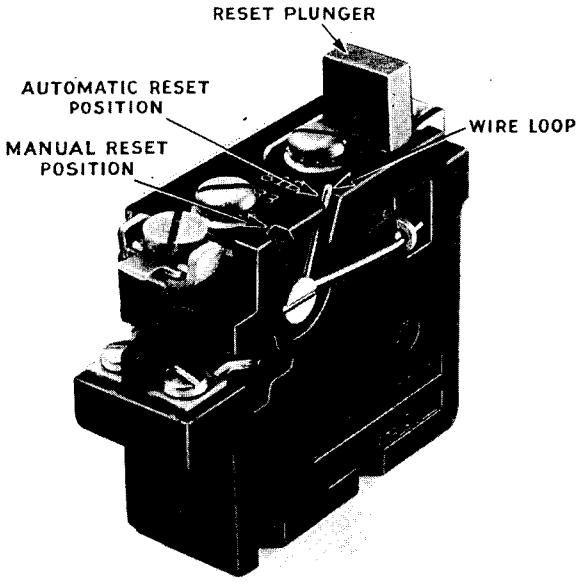


Fig. 55. Overload relay.

the trouble, as follows: Change all overload relays to manual reset by moving wire loop (Fig. 55) from automatic reset position to manual reset position. Operate machine until overload occurs. After overload relays have had time to cool, reset

overload relays by pressing each reset plunger until one is found that clicks as it is pushed in, or until pushing a given plunger enables the machine to be started by means of the starting lever. That relay is in the overloaded circuit.

The elementary and wiring diagrams sent with the machine will aid in further tracing of the trouble. If it becomes necessary to disconnect any wires, be careful to replace them properly according to the wiring diagram sent with the machine and the numbers on the terminals.

Cleaning the Contacts. The electrical equipment should be inspected about twice a year. At this time, or in trouble-shooting, the contacts of the manually-operated and magnetic switches may be cleaned with a rag if necessary. Never use sand paper or emery for this purpose, since particles might adhere to the surface of the contacts and give serious trouble during operation. If an instance should occur where cleaning with a rag is not sufficient, use a very fine file. Note that the black substance on the contacts does no harm, and that removing this deposit will merely shorten the life of the contacts.

Caution. To prevent the possibility of the table and coolant pump motors running for long periods unnoticed, do not leave the machine with the spindle reversing switch in the Off position.

Suggestions to the Operator

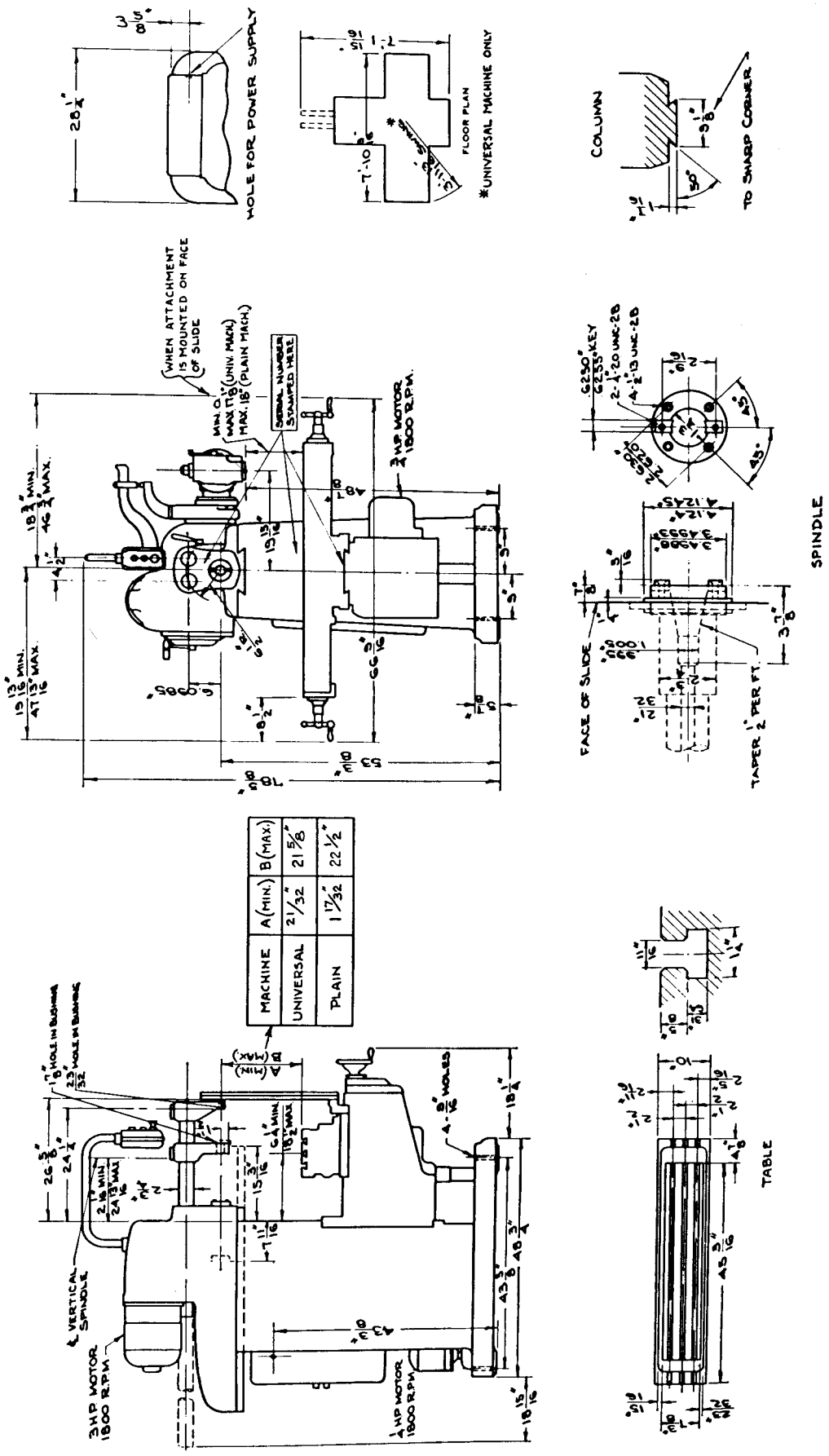
Much maintenance work can be avoided by keeping the machine clean and in good condition. Furthermore, on a machine which is given proper care the operator will produce accurate work with much less trouble and effort than on a machine which has been neglected.

Do not allow chips to pile too high around the work or fixture, or to clog the T-slots and channels of the table.

Keep the bearing surfaces free of chips and dirt; for this material is abrasive, and particles of such foreign matter which get between bearing surfaces will quickly score or wear the bearings and will also make the machine hard to manipulate.

The use of compressed air for cleaning work and fixtures is not recommended, since the force of the blast and the resultant air currents will very likely carry dirt to parts of the machine which it otherwise could never reach — parts which cannot be protected by guards. If compressed air is used at all, be careful not to blow chips aud dirt into the machine or into other machines nearby. In general, it is much better to flush with coolant or, if necessary, to clean with a brush.

For production work, chips and coolant can often be taken care of most effectively by making special guards to suit the particular job.



MACHINE	A (MIN.)	B (MAX.)
UNIVERSAL	21/32"	21 5/8"
PLAIN	1 17/32"	22 1/2"

Floor Plan & Machine Dimension Diagram

PART II

REPAIR PARTS

for

No. 20 UNIVERSAL MILLING MACHINE SLIDING-HEAD TYPE

For Machines Beginning Serial No. 506-20-1

THE parts are arranged in the illustrations so far as possible in the same relative positions as in the machine. This is to facilitate stripping and assembling as well as identifying the parts.

The parts are shown separated to make the construction of the machine more readily understood and to show each part to best advantage. In some cases, when a particular part is ordered, not only that part but one or more supplementary parts also may be sent when, from our experience, this is known to be advisable for a more satisfactory repair job.

Repair parts, in some cases, will require fitting and therefore may need holes to be drilled, shoulders to be squared or similar machining in order to make them fit properly.

A scale of inches is located at the lower part of each Repair Parts illustration. This scale will be useful in determining the approximate size of the parts illustrated on that particular page.

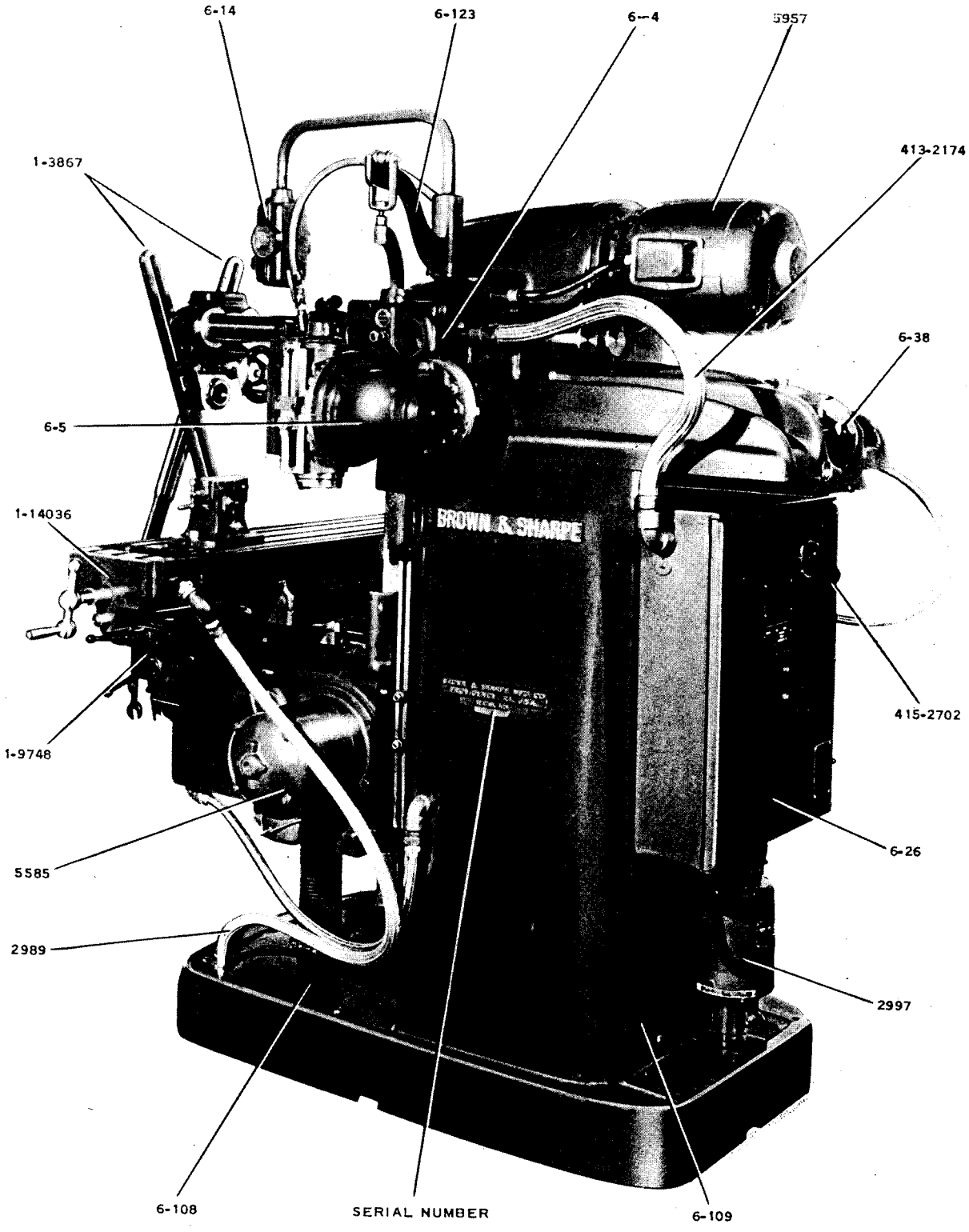
HOW TO ORDER REPAIR PARTS

This information is essential:

1 — Quantity, Part Number and Name

2 — Size and Style of Machine
This will be found on the front or side of the machine.

3 — Serial Number of Machine or Attachment
(Give both when ordering attachment parts)
This number will be found stamped on parts as designated in Repair Parts Book.


6-14
6-123
6-4
5957
1-3867
413-2174
6-38
6-5
1-14036
BROWN & SHARPE
415-2702
1-9748
6-26
5585
2989
2997
6-108
SERIAL NUMBER
6-109

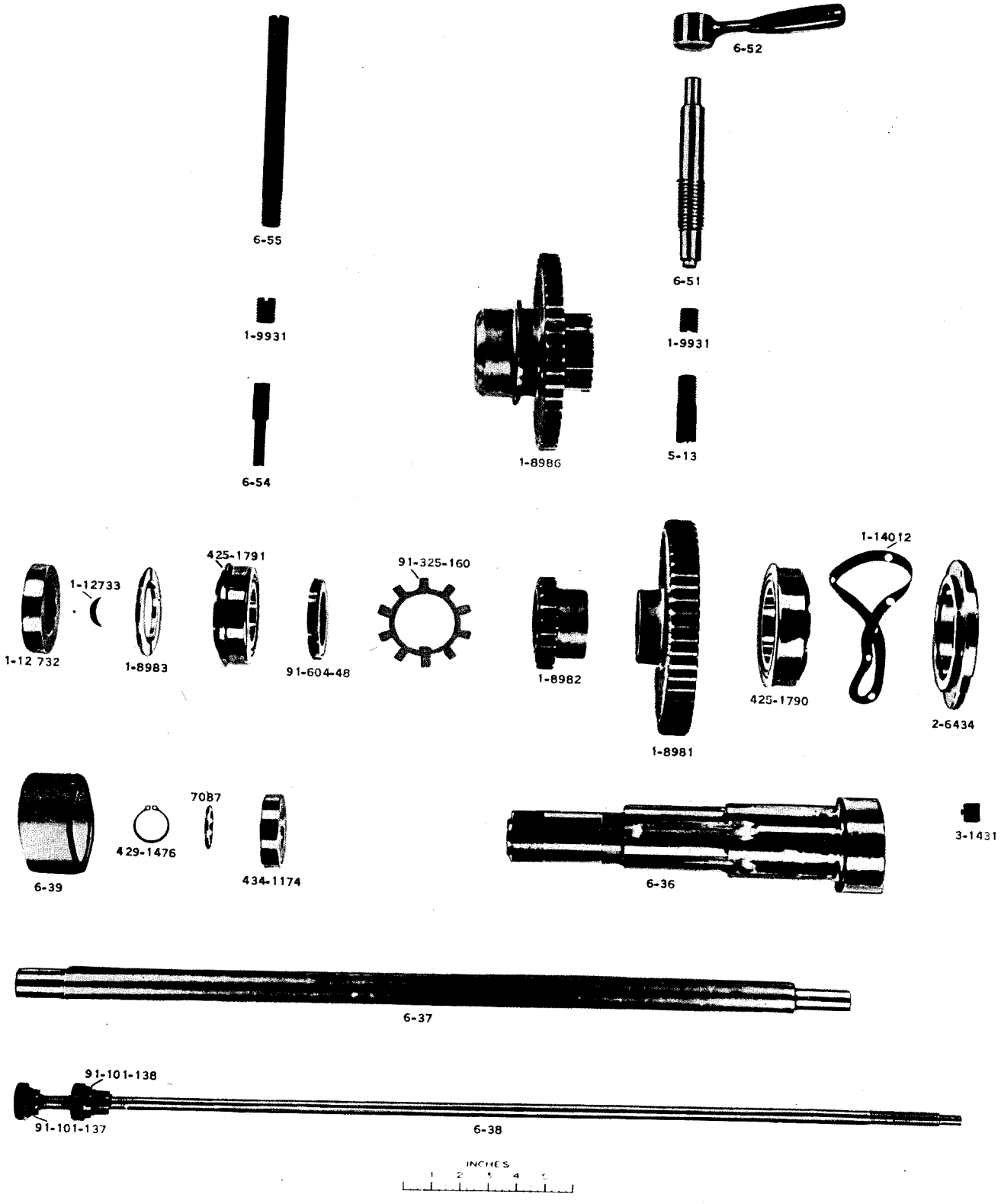
Rear View

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Rear View

2989	Table Flexible Tube
*2997	Motor Driven Centrifugal Pump
†5585	Table Motor
†5957	Spindle Motor
1-3867	Arm Support
1-9748	Cross and Vertical Feed Trip Bracket
1-14036	Table Screw Bearing, Right
6-4	Swivel Bracket
6-5	Horizontal Swivel
6-14	Pendant Control Box
6-26	Electrical Control Cabinet
6-38	Draw-in-Bolt
6-108	Base Tank Cover
6-109	Stand Cover, Rear
6-123	Crane Arm
413-2174	Spindle Conduit
415-2702	Disconnect Switch Handle

*See also "Repair Parts for Brown & Sharpe Pumps."
†Give complete Motor Name Plate Data



Spindle and Arm Clamp Parts

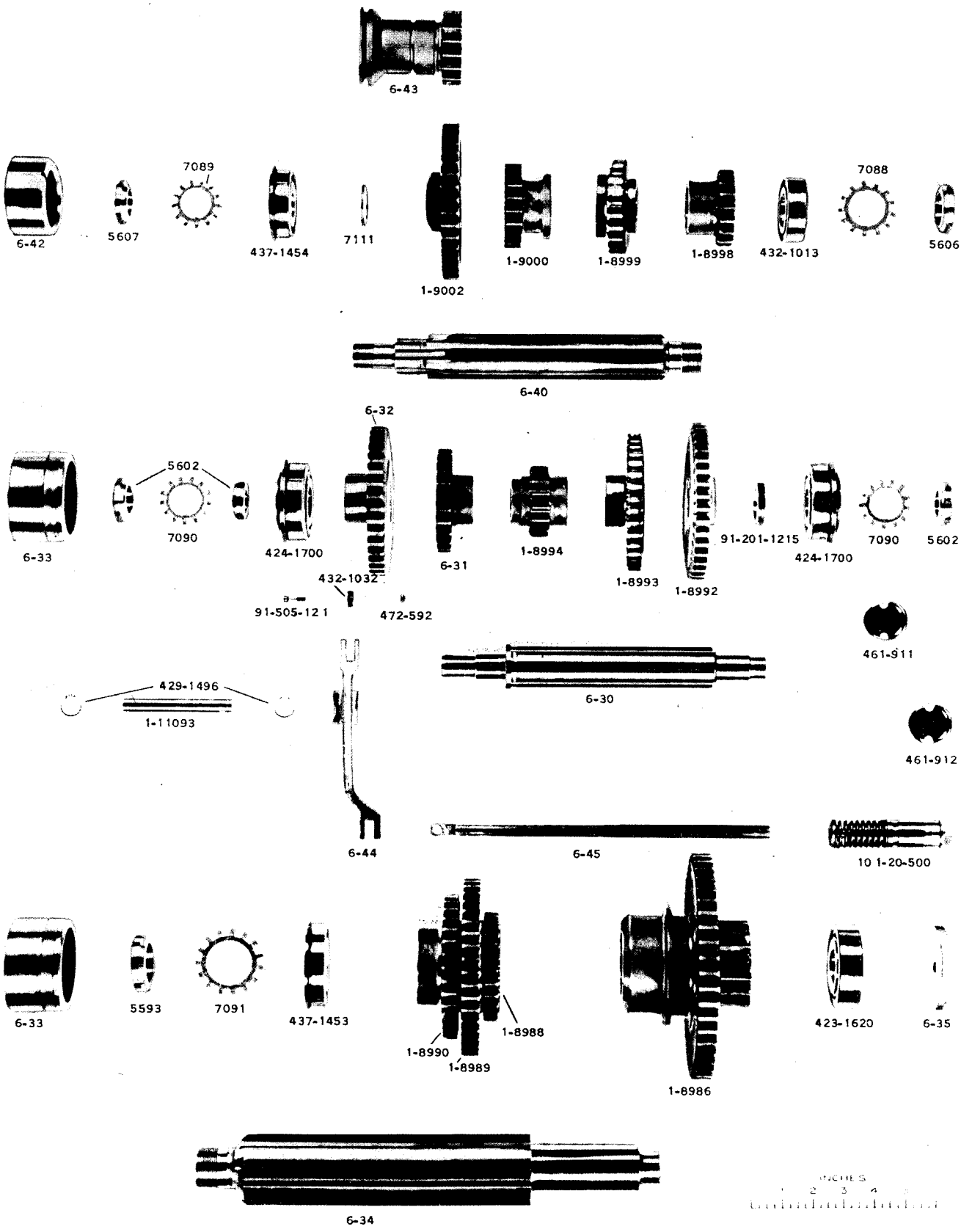
ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Spindle and Arm Clamp Parts

7087	Spindle Extension Washer
1-8981	Spindle Gear, Large (Paired with 1-8986; Order together as 1-12778)
1-8982	Spindle Gear, Small
1-8983	Spindle Gear Thrust Washer
1-8986	Spindle Intermediate Gear (Paired with 1-8981; Order together as 1-12778)
1-9931	Arm Clamp Adjusting Screw
1-12732	Spindle Bearing Nut (Includes 1-12733)
1-12733	Spindle Bearing Nut Shoe
1-14012	Spindle Dust Guard Gasket
2-6434	Spindle Bearing Front Dust Guard
3-1431	Spindle Nose Key
5-13	Arm Clamp Stud Locking Screw
6-36	Spindle (Includes 1-12732, 3-1431 and 91-604-48)
6-37	Spindle Extension
6-38	Draw-in Bolt (Includes 91-101-137 and 91-101-138)
6-39	Spindle Rear Bearing Retainer
6-51	Arm Clamp Screw
6-52	Arm Clamp Screw Lever
6-54	Arm Clamp Adjusting Screw Stop
6-55	Arm Clamp Adjusting Screw, Rear
91-101-137	Draw-in Bolt Knob
91-101-138	Draw-in Bolt Nut
91-325-160	Spindle Adjusting Nut Lockwasher
91-604-48	Spindle Adjusting Nut
425-1790	Spindle Roller Bearing, Front
425-1791	Spindle Roller Bearing, Rear
429-1476	Spindle Extension Retaining Ring
434-1174	Spindle Extension Ball Bearing

NOT SHOWN

6280	Spindle Nose Key Screw
6-15	Spindle Slide Cover, Right
91-3-145	Holding Screw (For Face Mills and Cutter Adapters)

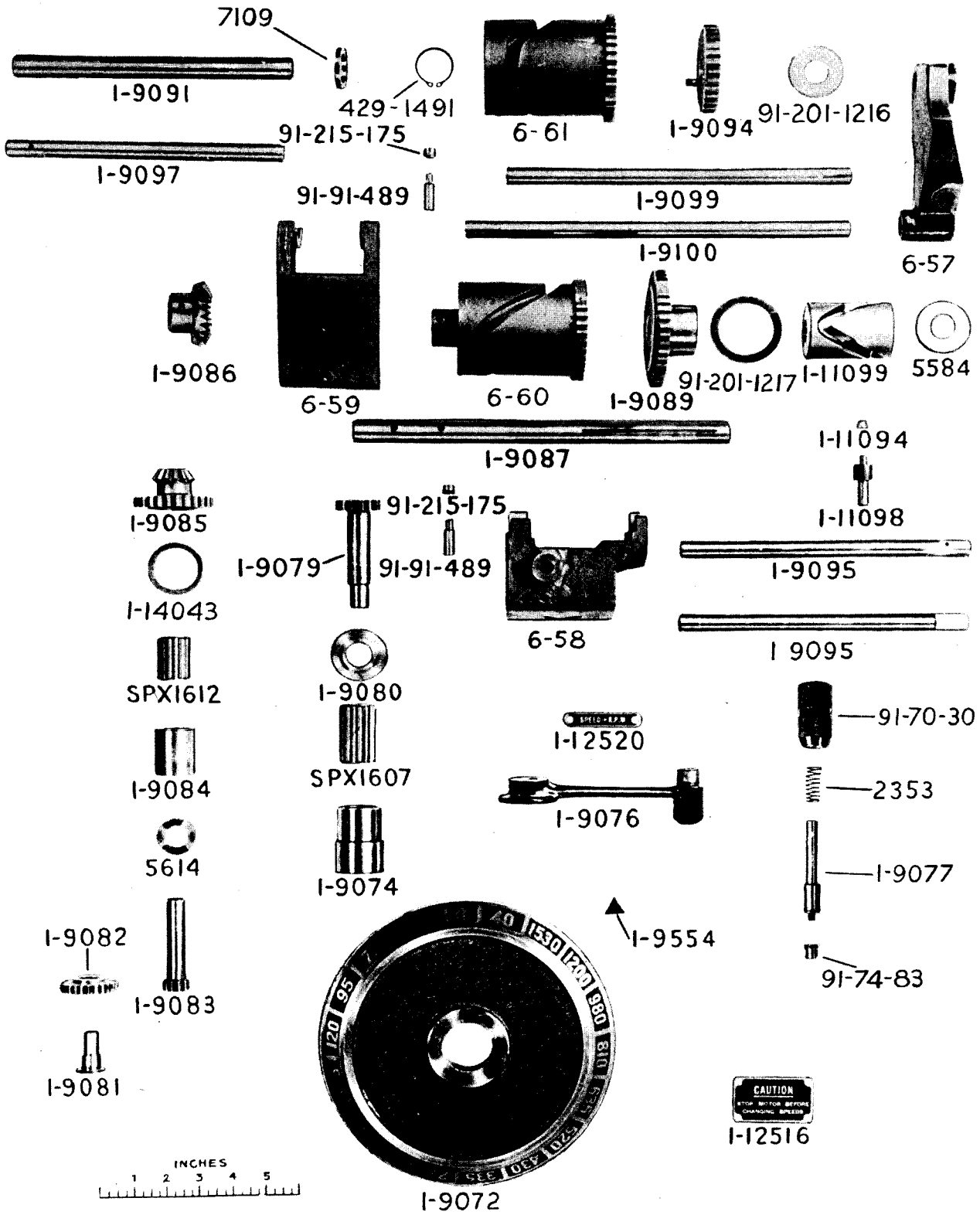


Speed Change Gears

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Speed Change Gears

5593	Spindle Intermediate Gear Shaft Nut
5602	Speed Change Gear Shaft Nut
5606	Speed Sliding Gear Shaft Nut, Front
5607	Speed Sliding Gear Shaft Nut, Rear
7088	Speed Sliding Gear Shaft Lockwasher, Front
7089	Speed Sliding Gear Shaft Lockwasher, Rear
7090	Speed Change Gear Shaft Lockwasher
7091	Spindle Intermediate Gear Shaft Lockwasher
7111	Speed Driving Gear Washer
1-8986	Spindle Intermediate Gear (Paired with 1-8981 on previous page; Order together as 1-12778)
1-8988	Intermediate Sliding Gear
1-8989	Intermediate Sliding Gear No. 2
1-8990	Intermediate Sliding Gear No. 3
1-8992	Speed Change Gear No. 1
1-8993	Speed Change Gear No. 2
1-8994	Speed Change Gear No. 3
1-8998	Speed Sliding Gear No. 1
1-8999	Speed Sliding Gear No. 2
1-9000	Speed Sliding Gear No. 3
1-9002	Speed Driving Gear
1-11093	Pump Operating Lever Stud
6-30	Speed Change Gear Shaft
6-31	Speed Change Gear No. 4
6-32	Speed Change Gear No. 5
6-33	Intermediate Shaft Bearing Retainer, Rear
6-34	Spindle Intermediate Gear Shaft
6-35	Intermediate Shaft Bearing Retainer, Front
6-40	Speed Sliding Gear Shaft
6-42	Speed Sliding Gear Shaft Bearing Retainer
6-43	Spindle Motor Gear
6-44	Pump Operating Lever (Includes 91-505-121, 432-1032 and 472-592)
6-45	Pump Operating Lever Link
91-201-1215	Speed Change Gear Shaft Spacer
91-505-121	Pump Operating Lever Roller Screw
101-20-500	Lubricating Pump, Assembled
423-1620	Spindle Intermediate Gear Ball Bearing
424-1700	Speed Change Gear Shaft Ball Bearing
429-1496	Pump Lever Stud Retaining Ring
432-1013	Speed Sliding Gear Shaft Ball Bearing, Front
432-1032	Pump Operating Lever Ball Bearing
437-1453	Spindle Intermediate Gear Shaft Ball Bearing, Rear
437-1454	Speed Sliding Gear Shaft Ball Bearing, Rear
461-911	Oil Window Level Type
461-912	Oil Window Unit
472-592	Pump Operating Lever Screw Stop Nut

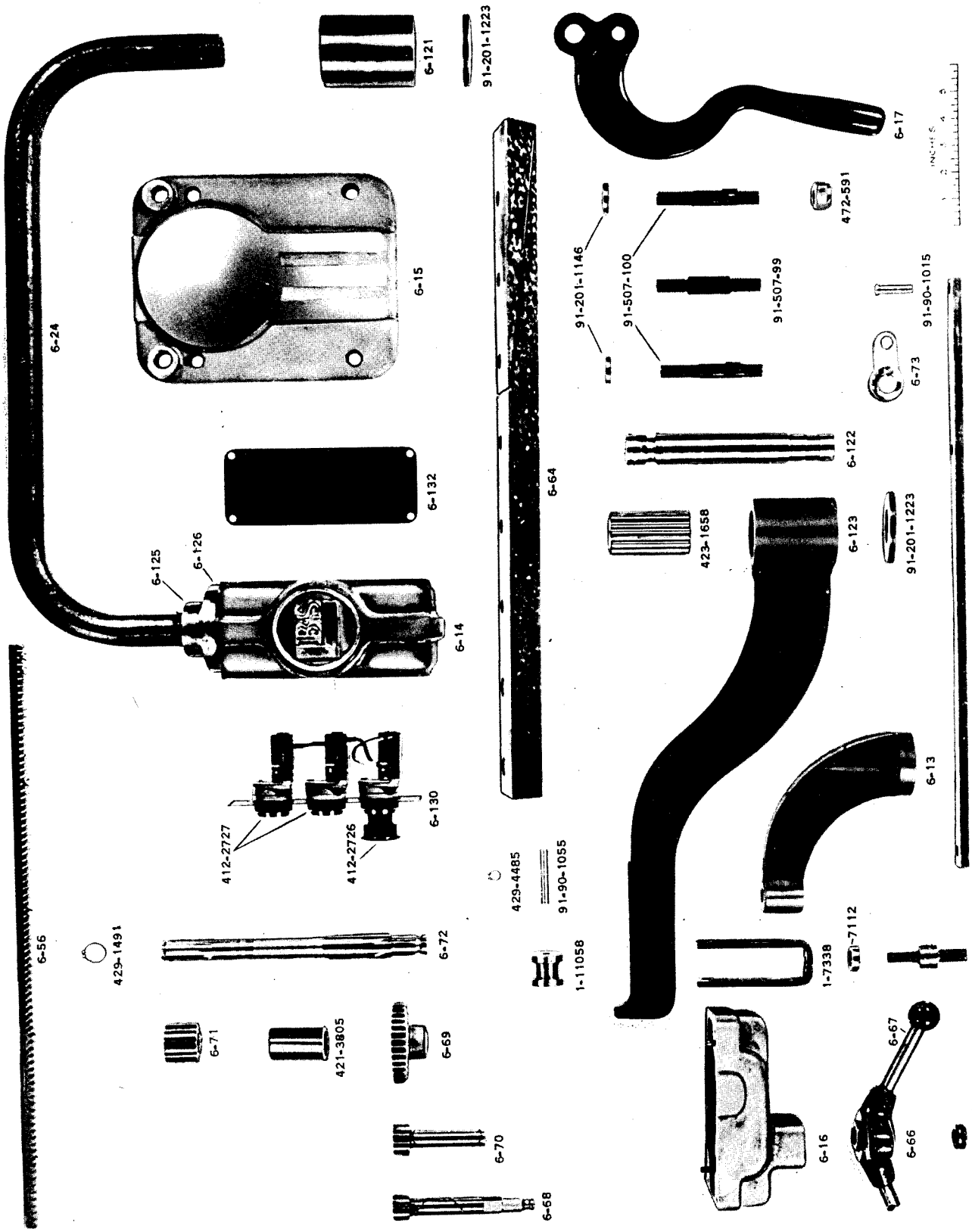


Speed Change Mechanism

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Speed Change Mechanism

2353	Speed Change Lever Handle Spring
4184	Speed Bevel Gear Washer
5584	Speed Control Cam Shaft (Lower) Washer
5614	Speed Change Dial Pinion Washer
5617	Speed Intermittent Gear (Driven) Washer
5624	Dial Pinion Bearing Sleeve Washer
7109	Speed Control Cam Shaft (Upper) Washer, Left
1-9072	Speed Dial
1-9074	Speed Change Dial Sleeve
1-9076	Speed Change Lever (Includes 2353, 1-9077 and 91-70-30)
1-9077	Speed Change Lever Plunger
1-9079	Speed Change Operating Pinion
1-9080	Speed Change Operating Pinion Washer
1-9081	Dial Intermediate Gear Stud
1-9082	Speed Change Dial Intermediate Gear
1-9083	Speed Change Dial Pinion
1-9084	Dial Pinion Bearing Sleeve
1-9085	Speed Change Dial Operating Gear
1-9086	Speed Bevel Gear
1-9087	Speed Control Cam Shaft, Lower
1-9089	Speed Intermittent Gear, Driven
1-9091	Speed Control Cam Shaft, Upper
1-9094	Speed Intermittent Gear, Driver
1-9095	Speed Sliding Gear Shoe Shaft, Upper
1-9097	Intermediate Sliding Gear Shoe Shaft
1-9100	Spindle Intermediate Gear Shoe Shaft, Lower
1-9554	Dial Pointer
1-9736	Speed Sliding Gear Shoe Shaft, Lower
1-11094	Speed Control Cam Roll
1-11098	Speed Cam Shoe Stud
1-11099	Speed Control Cam No. 3
1-12516	Speed Change Caution Plate
1-12520	Speed Change Lever Plate
1-14043	Dial Pinion Bearing Sleeve Washer
6-57	Intermediate Gear Shoe
6-58	Speed Sliding Gear Shoe
6-59	Intermediate Sliding Gear Shoe
6-60	Speed Control Cam No. 1
6-61	Speed Control Cam No. 2
6-62	Spindle Intermediate Gear Shoe Shaft, Upper
91-70-30	Speed Change Lever Knob
91-74-83	Plunger Stop Bushing
91-91-489	Cam Shoe Stud
91-201-1216	Speed Control Cam Shaft (Upper) Washer
91-201-1217	Speed Intermittent Gear (Driven) Washer
91-215-175	Speed Cam Roll
429-1491	Cam Shaft (Upper) Retaining Ring
SPX1607	Speed Change Operating Pinion Bearing
SPX1612	Speed Change Dial Pinion Bearing

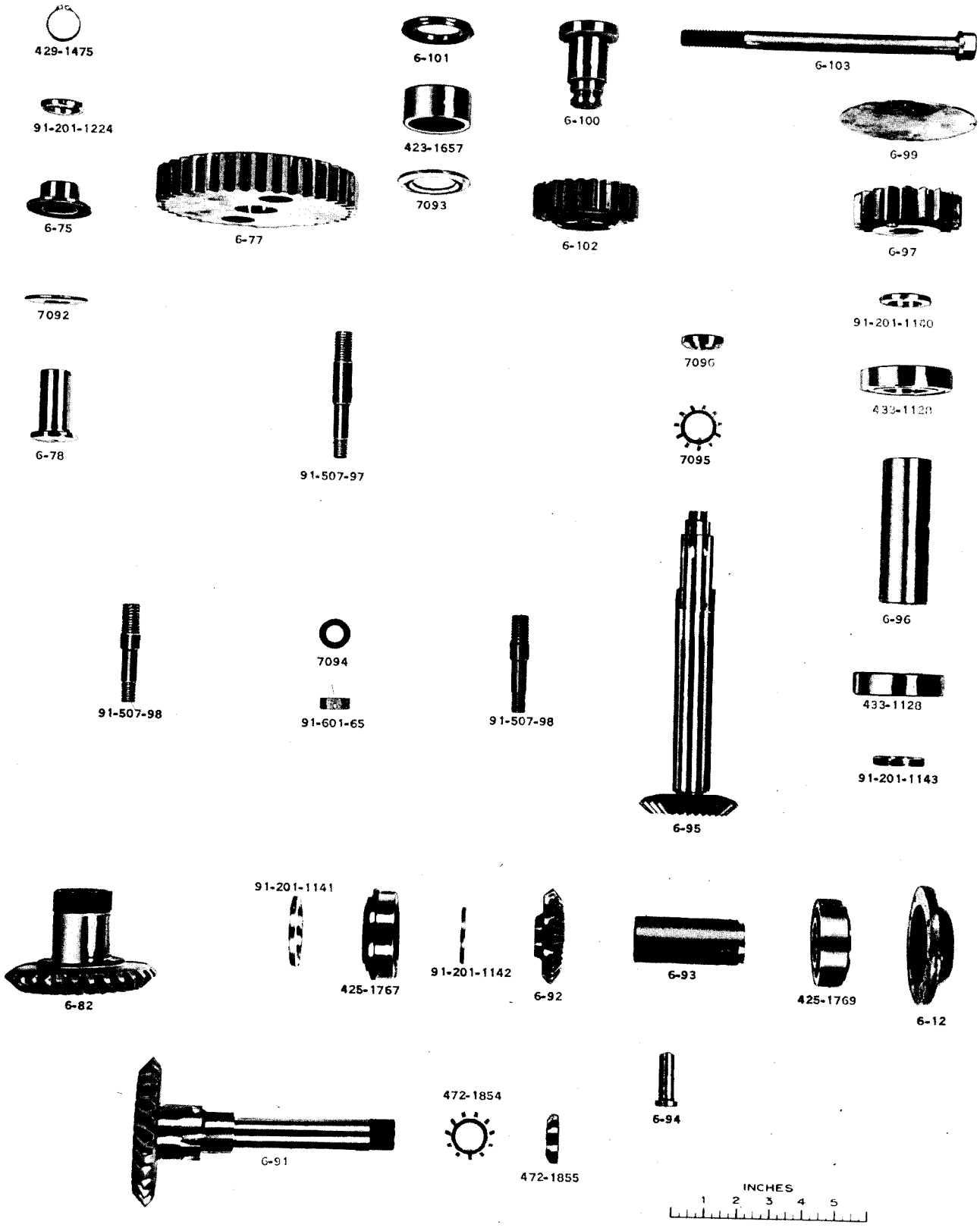


Miscellaneous Sliding Head and Operating Parts

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Miscellaneous Sliding Head and Operating Parts

7112	Attachment Support Swivel Washer
1-7338	Attachment Support
1-11058	Attachment Support Roller
6-13	Universal Milling Attachment Crane Bracket
6-14	Pendant Control Box (Includes 6-125, 6-126, 6-130, 6-132, 412-2726 and 412-2727)
6-15	Spindle Slide Cover, Right
6-16	Spindle Slide Rack Driving Gear Bracket
6-17	Spindle Slide Gib Locking Lever
6-24	Pendant Station Conduit
6-56	Spindle Slide Rack
6-64	Spindle Slide Gib
6-66	Spindle Slide Rack Lever (Includes 6-67)
6-67	Handle
6-68	Spindle Slide Rack Lever Shaft
6-69	Spindle Slide Rack Drive Gear
6-70	Spindle Slide Rack Driving Gear (Intermediate)
6-71	Spindle Slide Rack Pinion
6-72	Spindle Slide Rack Pinion Shaft
6-73	Spindle Slide Gib Strap Link
6-74	Spindle Slide Gib Clamp Strap
6-121	Swivel
6-122	Crane Arm Stud
6-123	Crane Arm
6-124	Universal Milling Attachment Stud
6-125	Pendant Control Box Connector
6-126	Pendant Control Box Cap
6-130	Control Selector Plate
6-132	Pendant Control Box Cover
91-90-1015	Clamp Strap Link and Locking Lever Pin
91-90-1055	Attachment Support Roller Stud
91-201-1146	Link and Locking Lever Screw Washer
91-201-1223	Roller Assembly Retainer Washer
91-204-557	Rack Lever Retainer Washer
91-507-99	Spindle Slide Gib Stud
91-507-100	Gib Strap Link and Locking Lever Screw
412-2726	Push Button, Red
412-2727	Push Button, Black
421-3805	Rack Pinion Shaft Bearing
423-1658	Crane Arm Roller Assembly
429-1491	Rack Pinion Retaining Ring
429-4485	Roller Stud Retaining Ring
472-591	Spindle Slide Gib Stop Nut
NOT SHOWN	
414-2382	Midget Plug-In Receptacle

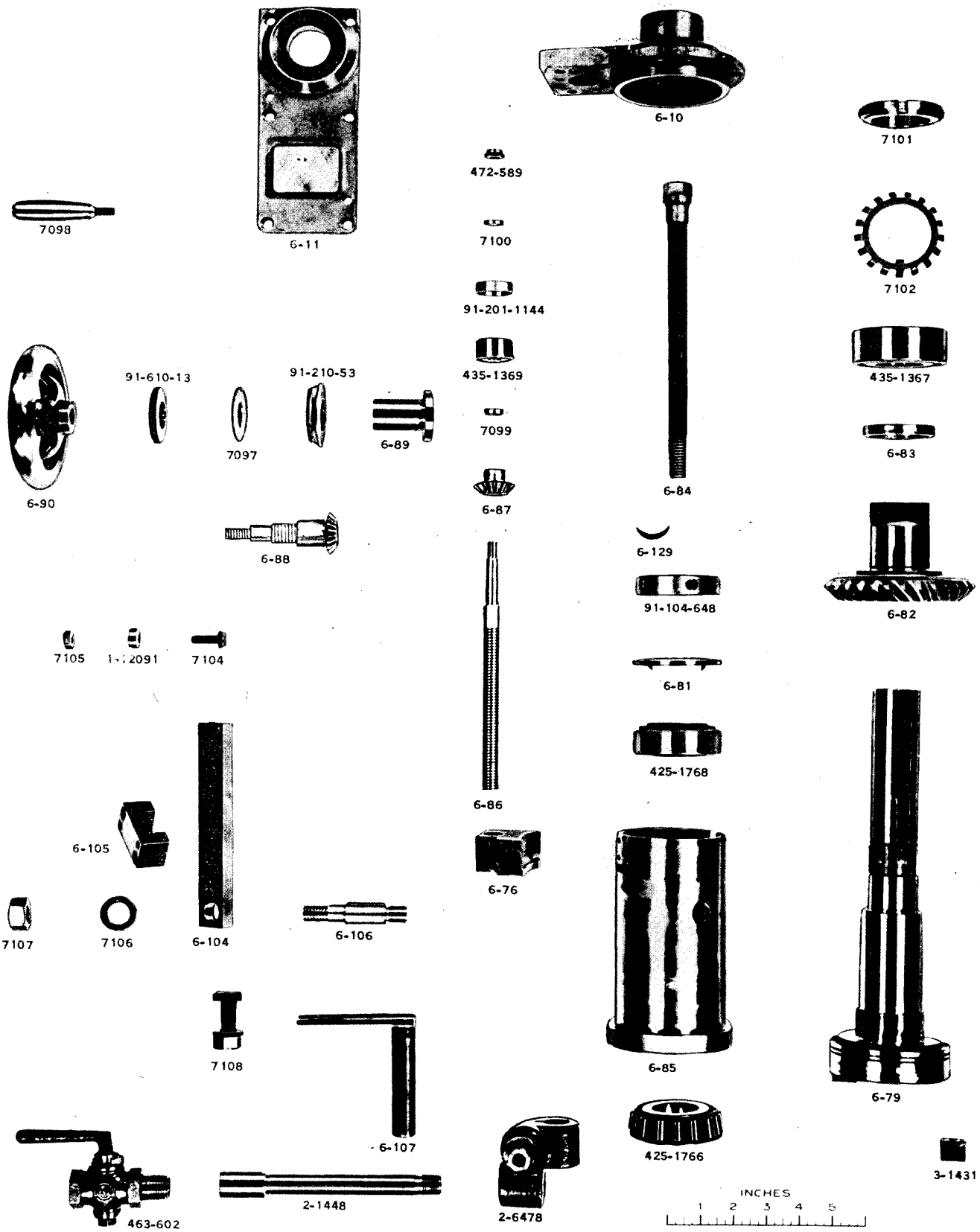


Universal Milling Head

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Universal Milling Head

7092	Attachment Driving Gear Stud Washer
7093	Attachment Driving Intermediate Stud Washer
7094	Swivel Bracket Stud Washer
7095	Intermediate Bevel Gear Lockwasher
7096	Intermediate Bevel Gear Nut
6-12	Attachment Spindle Driving Gear Cover
6-75	Attachment Driving Gear Bushing
6-77	Attachment Driving Gear
6-78	Attachment Driving Gear Stud
6-82	Attachment Spindle Pinion
6-91	Attachment Spindle Driving Gear (Includes 6-82)
6-92	Intermediate Driven Gear
6-93	Attachment Spindle Driving Gear Bearing Spacer
6-94	Intermediate Driven Gear Grease Bushing
6-95	Intermediate Bevel Gear (Includes 6-92)
6-96	Intermediate Bevel Gear Bearing Spacer
6-97	Attachment Safety Gear
6-99	Swivel Bracket Cover, Small
6-100	Attachment Driving Gear Intermediate Stud
6-101	Attachment Driving Gear Intermediate Washer
6-102	Attachment Driving Gear, Intermediate
6-103	Attachment Arm Clamp Bolt
91-201-1140	Attachment Safety Gear Washer
91-201-1141	Attachment Spindle Driving Gear Washer
91-201-1142	Intermediate Driven Gear Fitting Washer
91-201-1143	Intermediate Bevel Gear Fitting Washer
91-201-1224	Attachment Driving Gear Fitting Washer
91-507-97	Swivel Bracket Stud, Long
91-507-98	Swivel Bracket Stud, Short
91-601-65	Swivel Bracket Stud Nut
423-1657	Attachment Driving Gear (Intermediate) Roller Bearing
425-1767	Attachment Spindle Driving Gear Roller Bearing, Flanged Cup
425-1769	Attachment Spindle Driving Gear Roller Bearing
429-1475	Attachment Driving Gear Stud Retaining Ring
433-1128	Intermediate Bevel Gear Ball Bearing
472-1854	Attachment Spindle Driving Gear Lockwasher
472-1855	Attachment Spindle Driving Gear Locknut

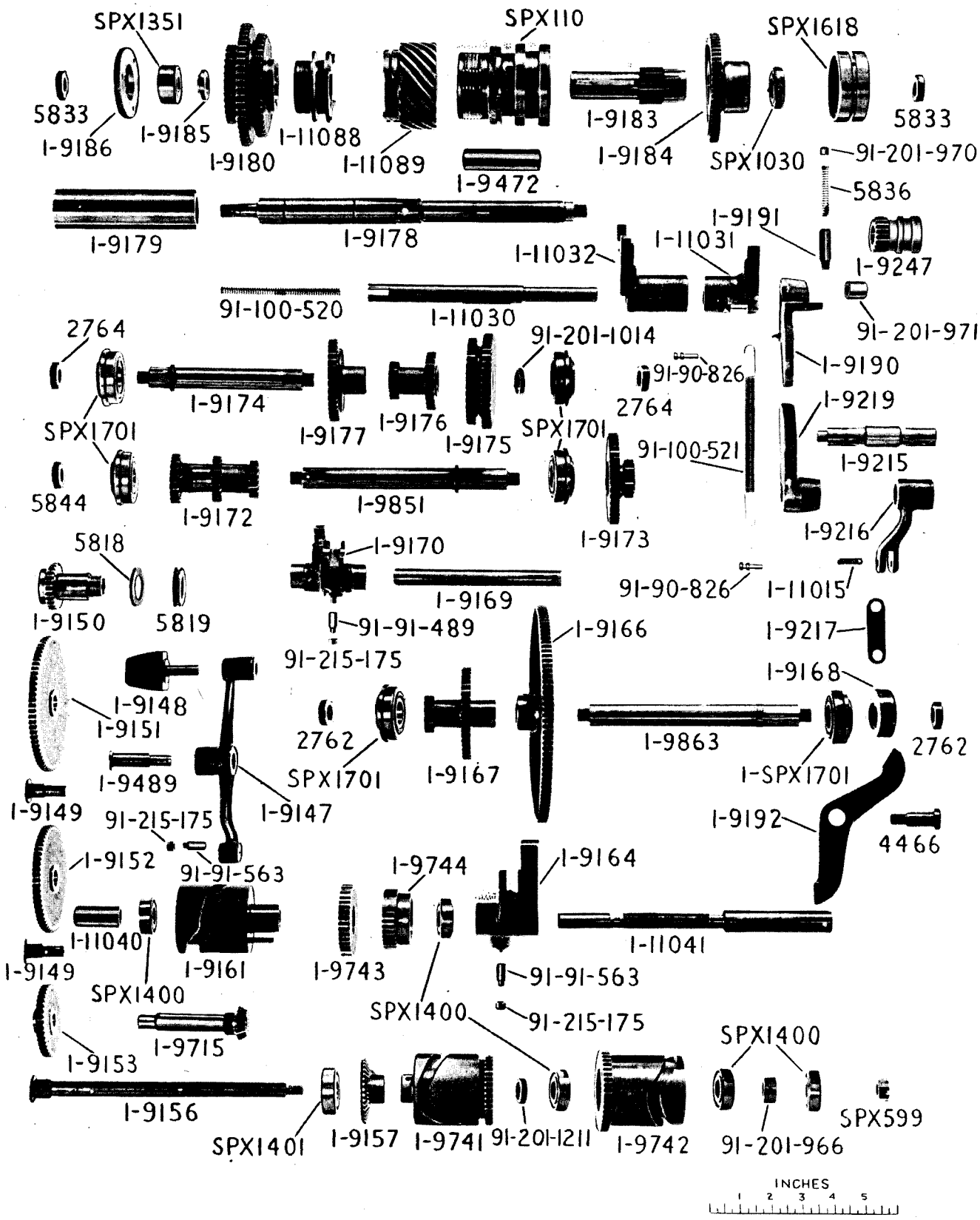


Universal Milling Head (Cont'd)

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Universal Milling Head (Cont'd)

7097	Feed Screw Dial Washer
7098	Handwheel Handle
7099	Feed Screw Pinion Washer
7100	Feed Screw Bearing Washer
7101	Attachment Spindle Nut
7102	Attachment Spindle Lockwasher
7104	Spindle Stop T-Bolt
7105	Spindle Stop T-Bolt Nut
7106	Spindle Lock Stud Washer
7107	Spindle Lock Stud Nut
7108	Horizontal Swivel Bolt, Washer and Nut
1-12091	Spindle Stop Washer
2-1448	Distributor
2-6478	Distributor Swivel
3-1431	Spindle Nose Key
6-10	Attachment Spindle Bearing Cover, Rear
6-11	Feed Screw Dial Bracket
6-76	Attachment Spindle Feed Screw Nut
6-79	Attachment Spindle (Includes 3-1431 and 91-104-648)
6-81	Attachment Spindle Thrust Washer
6-82	Attachment Spindle Pinion
6-83	Attachment Spindle Pinion Fitting Washer
6-84	Draw-in Bolt
6-85	Attachment Spindle Sleeve
6-86	Attachment Spindle Feed Screw
6-87	Attachment Spindle Feed Screw Pinion
6-88	Attachment Spindle Feed Screw Driving Gear
6-89	Feed Screw Driving Gear Bushing
6-90	Attachment Spindle Feed Screw Handwheel
6-104	Attachment Spindle Stop Slide
6-105	Spindle Stop Slide Bracket
6-106	Spindle Lock Stud
6-107	Distributor Pipe Swivel Arm
6-129	Spindle Bearing Nut Shoe
91-104-648	Spindle Bearing Adjusting Nut (Includes 6-129)
91-201-1144	Feed Screw Bearing Spacer
91-210-53	Attachment Spindle Feed Screw Dial
91-610-13	Feed Screw Driving Gear Nut
425-1766	Attachment Spindle Roller Bearing, Front
425-1768	Attachment Spindle Roller Bearing, Center
435-1367	Attachment Spindle Ball Bearing
435-1369	Attachment Spindle Feed Screw Ball Bearing
463-602	Distributor Lever Handle Cock
472-589	Attachment Spindle Feed Screw Stop Nut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SPX110
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SPX1618
5833
SPX1030
91-201-970
5836
1-9191
1-9247
1-9179
1-9178
1-11032
1-11031
91-100-520
1-11030
91-201-971
2764
91-201-1014
1-9190
91-90-826
2764
1-9219
SPX1701
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1-9177
1-9176
1-9175
SPX1701
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1-9173
1-9216
5818
1-9170
91-90-826
1-11015
1-9150
5819
1-9169
91-91-489
1-9166
1-9217
91-215-175
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1-9148
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SPX1401
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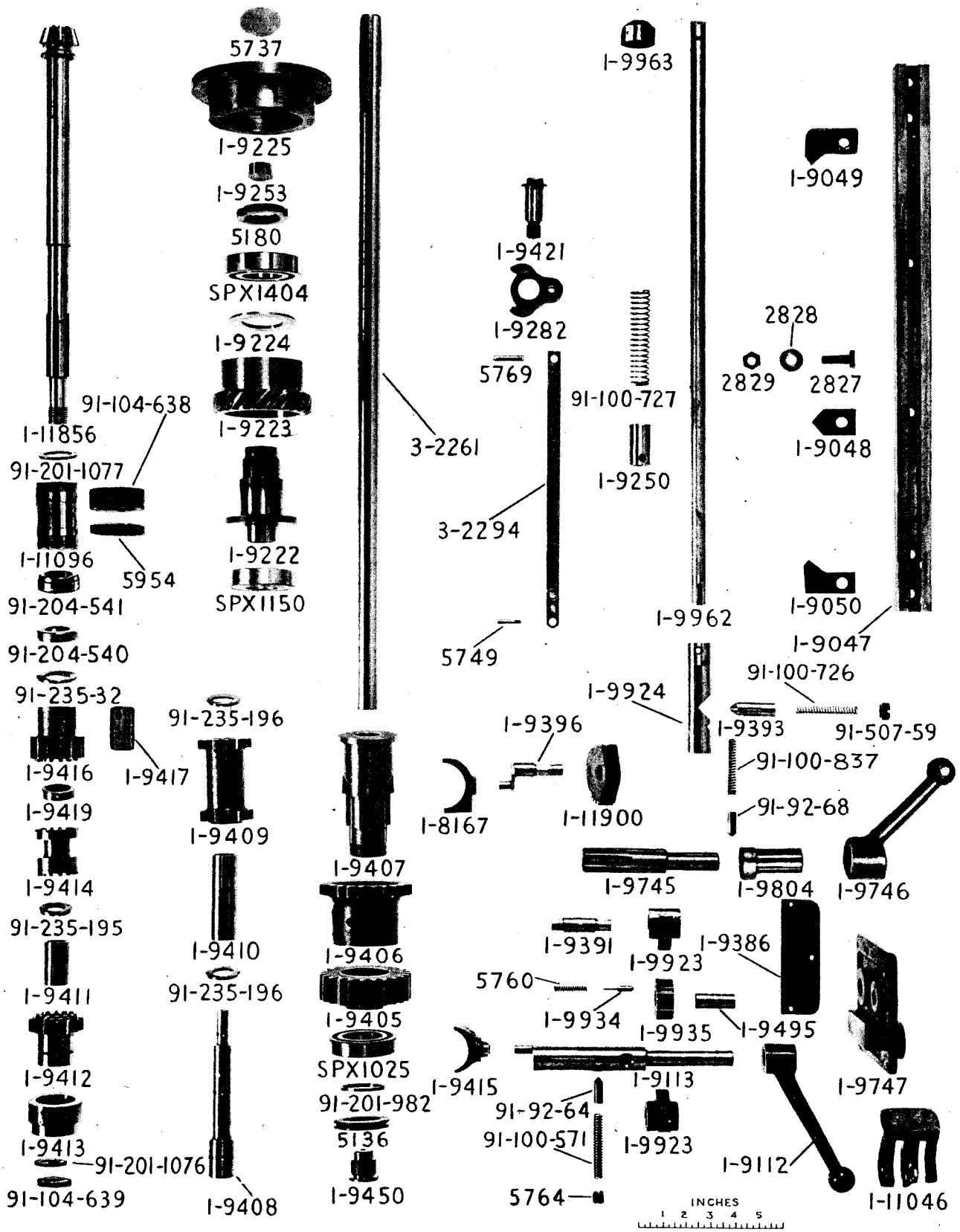
91-201-1211
1-9742
91-201-966
SPX599
INCHES
1 2 3 4 5

Feed Case

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Feed Case

2762	Feed Driving Shaft Nut
2764	Feed Change Gear Shaft Nut
4466	Pump Operating Lever Stud
5818	Feed Control Gear (Driver) Washer
5819	Feed Control Gear (Driver) Nut
5833	Feed Fast Travel Clutch Shaft Nut
5836	Feed Thowout Lever Locking Pin Spring
5844	Feed Sliding Gear Shaft Nut, Left
1-9147	Feed Case Cam Lever (Includes 91-91-563)
1-9148	Feed Case Cam Shoe, Upper
1-9149	Feed Control Intermediate Gear Stud
1-9150	Feed Control Gear, Driver
1-9151	Feed Control Intermediate Gear, Large
1-9152	Feed Control Intermediate Gear, Small
1-9153	Feed Control Gear, Driven
1-9156	Feed Cam Shaft, Lower
1-9157	Feed Case Bevel Gear
1-9161	Feed Case Cam No. 2 (Includes 1-9743 and 1-9744)
1-9164	Feed Case Cam Shoe, Lower (Includes 91-91-563)
1-9166	Feed Driving Shaft Gear
1-9167	Feed Driving Shaft Sliding Gear
1-9168	Pump Cam
1-9169	Feed Sliding Gear Shoe Shaft
1-9170	Feed Sliding Gear Shoe (Includes 91-91-489)
1-9172	Feed Sliding Gear
1-9173	Sliding Gear Shaft Driving Gear
1-9174	Feed Change Gear Shaft
1-9175	Feed Change Gear No. 3
1-9176	Feed Change Gear No. 2
1-9177	Feed Change Gear No. 1
1-9178	Feed Fast Travel Clutch Shaft (Includes 1-9472)
1-9179	Feed Clutch Sleeve
1-9180	Feed Gear
1-9183	Feed Driving Pinion
1-9184	Fast Travel Driving Gear
1-9185	Clutch Sleeve Spacer
1-9186	Clutch Shaft Bearing Retainer
1-9190	Feed Throwout Lever
1-9191	Feed Throwout Lever Locking Pin
1-9192	Pump Operating Lever
1-9215	Feed Throwout Operating Lever Shaft
1-9216	Feed Throwout Solenoid Lever
1-9217	Solenoid Lever Link
1-9219	Feed Thowout Operating Lever
1-9247	Table Motor Pinion
1-9472	Feed Driving Pinion Bushing
1-9489	Feed Case Cam Lever Stud
1-9715	Feed Case Bevel Pinion
1-9741	Feed Case Cam No. 1
1-9742	Feed Case Cam No. 3
1-9743	Feed Intermittent Gear, Driven
1-9744	Feed Intermittent Gear, Driver
1-9851	Feed Sliding Gear Shaft
1-9863	Feed Driving Shaft (Includes 1-9166)
1-11015	Link Pin
1-11030	Feed Clutch Shoe Shaft
1-11031	Fast Travel Clutch Shoe
1-11032	Feed Clutch Shoe (Includes 1-9190, 1-11030 and 1-11031)
1-11040	Feed Cam Shaft Sleeve, Upper
1-11041	Feed Cam Shaft, Upper
1-11088	Feed Clutch
1-11089	Fast Travel Clutch Gear
91-90-826	Feed Throwout Lever Spring Pin
91-91-489	Feed Cam Shoe Stud
91-91-563	Feed Cam Shoe Stop
91-100-520	Feed Clutch Shoe Shaft Spring
91-100-521	Feed Throwout Lever Shaft Spring
91-201-966	Cam Shaft (Lower) Bearing Spacer
91-201-970	Locking Pin Spring Collar
91-201-971	Feed Clutch Shoe Shaft Spacer
91-201-1014	Feed Change Gear Shaft Washer
91-201-1211	Feed Case Cam (Nos. 1 & 3) Spacer
91-215-175	Feed Cam Roll
SPX110	Fast Travel Clutch
SPX599	Feed Cam Shaft (Lower) Nut
SPX1030	Feed Fast Travel Clutch Shaft Bearing, Right
SPX1351	Feed Fast Travel Clutch Shaft Bearing, Left
SPX1400	Feed Case Cam Bearing
SPX1401	Feed Cam Shaft, Lower
SPX1618	Fast Travel Driving Gear Bearing
SPX1701	Feed Change Gear Shaft Bearing
SPX1701	Feed Sliding Gear Shaft Bearing
SPX1701	Feed Driving Shaft Bearing

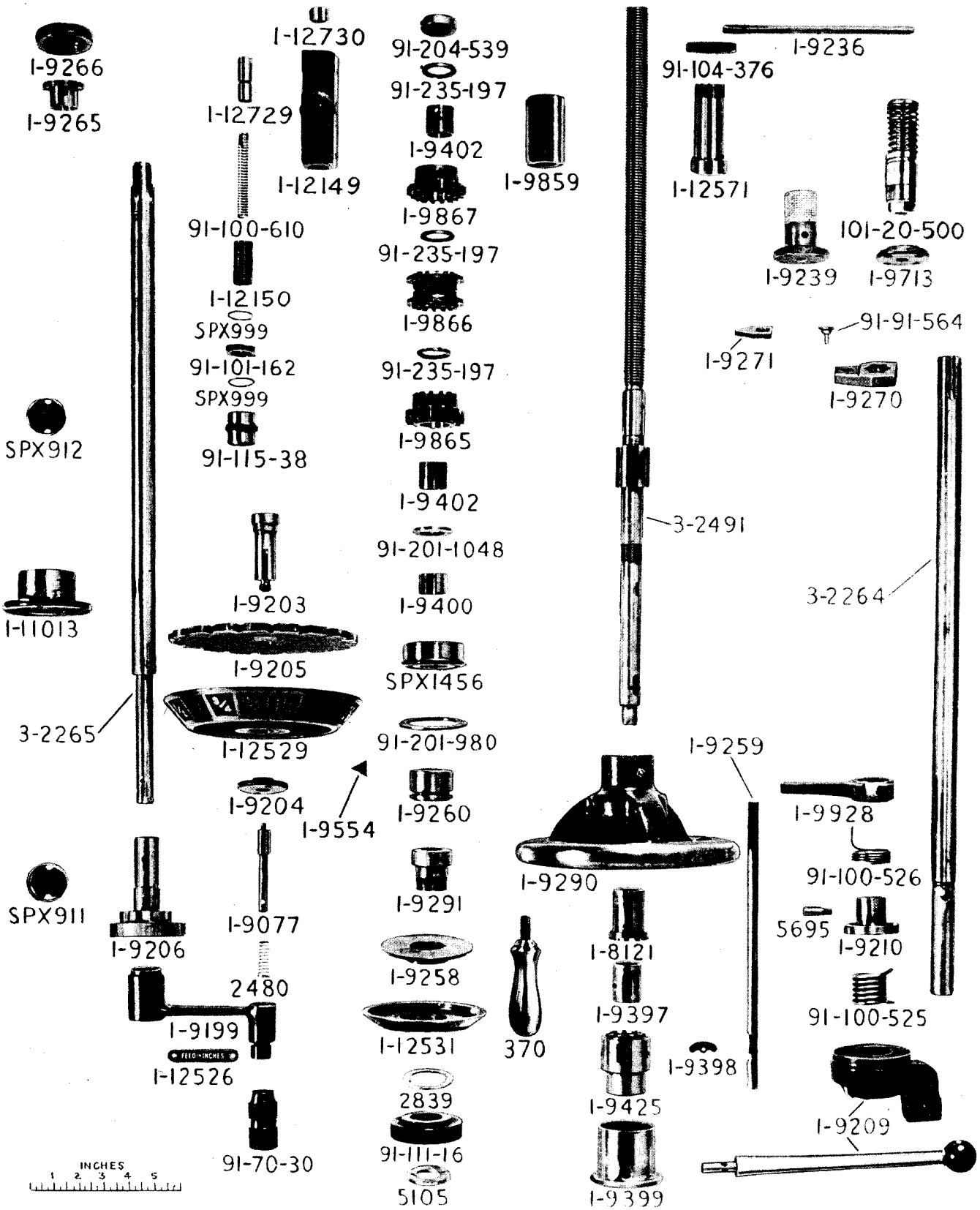


Transverse and Vertical Feed Control Parts

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Transverse and Vertical Feed Control Parts

2827	Vertical Feed Trip Dog Bolt
2828	Vertical Feed Trip Dog Washer
2829	Vertical Feed Trip Dog Nut
5136	Feed Shaft Gear Sleeve Nut
5180	Feed Safety Clutch Nut
5737	Feed Shaft Rear Bearing Holder Plug
5749	Cross Feed Trip Segment Screw
5760	Vertical Feed Control Gear Detent Spring
5764	Vertical Feed Clutch Shaft Detent Plug
5769	Cross Feed Trip Lever Link Pin
5954	Power Knee Shaft Bushing Nut, Front
1-8167	Cross Feed Clutch Gear Shoe
1-9047	Vertical Feed Trip Dog Bracket
1-9048	Vertical Feed Trip Dog
1-9049	Vertical Feed Safety Stop, Upper
1-9050	Vertical Feed Safety Stop, Lower
1-9112	Vertical Feed Control Lever
1-9113	Vertical Feed Control Eccentric Shaft
1-9222	Feed Safety Clutch Hub (Includes 5180, 1-9223, 1-9224, 1-9253 and SPX1404)
1-9223	Feed Safety Clutch Gear
1-9224	Feed Safety Clutch Washer
1-9225	Feed Shaft Rear Bearing Holder
1-9250	Trip Rod Spring Collar
1-9253	Feed Safety Clutch Plug
1-9282	Cross Feed Trip Lever
1-9386	Trip Bracket Cover
1-9391	Vertical Feed Control Segment Stud
1-9393	Vertical Feed Trip Rod Detent
1-9396	Cross Feed Clutch Eccentric Shaft
1-9405	Feed Shaft Gear, Front
1-9406	Gross Feed Reverse Idler Gear
1-9407	Feed Shaft Gear Sleeve
1-9408	Feed Reverse Gear Shaft
1-9409	Feed Reverse Gear
1-9410	Feed Reverse Gear Bushing
1-9411	Power Knee Shaft Clutch Gear Bushing
1-9412	Power Knee Shaft Clutch Gear, Front
1-9413	Power Shaft Clutch Gear Bearing
1-9414	Power Knee Shaft Reverse Clutch
1-9415	Power Shaft Clutch Shoe
1-9416	Power Knee Shaft Clutch Gear, Rear (Includes 1-9417)
1-9417	Power Shaft Clutch Gear Bushing
1-9419	Power Knee Shaft Gear Collar
1-9421	Cross Feed Trip Lever Stud
1-9450	Feed Shaft Thrust Screw
1-9495	Vertical Feed Control Gear Stud
1-9745	Cross Feed Trip Pinion
1-9746	Cross Feed Control Lever
1-9747	Trip Bracket Cap
1-9804	Cross Feed Trip Pinion Sleeve
1-9923	Vertical Feed Control Segment
1-9924	Vertical Feed Trip Rod End
1-9934	Control Segment Detent
1-9935	Vertical Feed Control Gear
1-9962	Vertical Feed Trip Rod (Includes 1-9963)
1-9963	Vertical Feed Trip Rod Collar
1-11046	Wrench Rack, Small
1-11096	Power Knee Shaft Bushing
1-11856	Power Knee Shaft
1-11900	Cross Feed Trip Segment
3-2261	Feed Shaft
3-2294	Cross Feed Trip Lever Link
91-92-64	Vertical Feed Clutch Shaft Detent
91-92-68	Cross Feed Trip Pinion Detent
91-100-571	Trip Pinion Detent Spring
91-100-726	Trip Rod Detent Spring
91-100-727	Vertical Feed Trip Rod Spring
91-100-837	Vertical Feed Clutch Shaft Detent Spring
91-104-638	Power Knee Shaft Bushing Nut, Rear
91-104-639	Power Knee Shaft Nut
91-201-982	Feed Shaft Sleeve Bearing Washer
91-201-1076	Power Knee Shaft Washer, Front
91-201-1077	Power Knee Shaft Washer, Rear
91-204-540	Power Knee Shaft Collar, Front
91-204-541	Power Knee Shaft Collar, Rear
91-235-32	Power Shaft Clutch Gear (Rear) Washer
91-235-195	Power Shaft Clutch Gear Washer
91-235-196	Feed Reverse Gear Shaft Washer
91-507-59	Trip Rod Detent Plug
SPX1025	Feed Shaft Gear Sleeve Bearing
SPX1150	Feed Shaft Bearing
SPX1404	Feed Shaft Rear Bearing



Miscellaneous Knee Parts

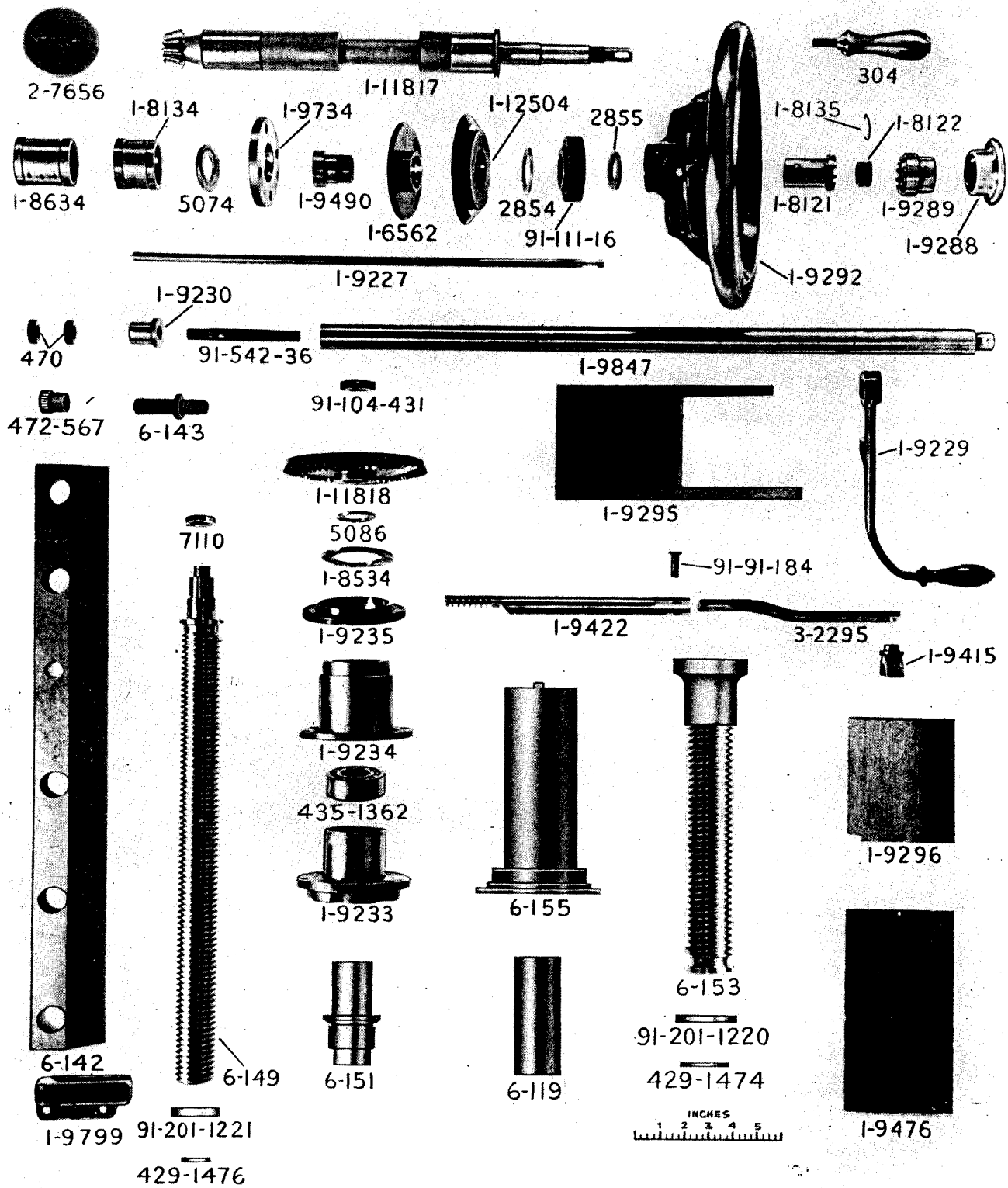
ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Miscellaneous Knee Parts

370	Cross Feed Handwheel Handle, Complete
2480	Feed Change Lever Handle Spring
2839	Cross Feed Screw Dial Washer
5105	Cross Feed Screw Washer
5695	Fast Travel Control Shaft Screw
1-8121	Cross Feed Handwheel Sleeve
1-9077	Feed Change Lever Plunger
1-9199	Feed Change Lever (Includes 2480, 1-9077 and 91-70-30)
1-9203	Feed Change Dial Stud
1-9204	Feed Change Dial Stud Nut
1-9205	Feed Change Dial Disk
1-9206	Feed Change Dial Disk Driver
1-9209	Fast Travel Handle, Complete
1-9210	Switch Lever Spring Retainer
1-9236	Knee Oil Pipe
1-9239	Round Strainer
1-9258	Cross Feed Screw Dial Back
1-9259	Cross Feed Screw Clutch Pin
1-9260	Cross Feed Screw Bearing Nut
1-9265	Oil Filler Insert
1-9266	Oil Filler Cap
1-9270	Fast Travel Shoe Shifter Lever (Includes 1-9271 and 91-91-564)
1-9271	Fast Travel Shoe Shifter
1-9290	Cross Feed Handwheel (Includes 370)
1-9291	Cross Feed Screw Dial Sleeve
1-9397	Cross Feed Handwheel Clutch Sleeve
1-9398	Cross Feed Handwheel Clutch Lever
1-9399	Cross Feed Handwheel Clutch Knob
1-9400	Cross Feed Screw Bearing Sleeve
1-9402	Cross Feed Clutch Gear Bushing
1-9425	Cross Feed Handwheel Clutch
1-9554	Dial Pointer
1-9713	Lubricating Pump Cap
1-9859	Cross Feed Stop Collar
1-9865	Cross Feed Clutch Gear, Front
1-9866	Cross Feed Reverse Clutch
1-9867	Cross Feed Clutch Gear, Rear
1-9928	Fast Travel Switch Lever
1-11013	Oil Sight Gage (Includes SPX912)
1-12149	Automatic Feed Valve Body
1-12150	Automatic Feed Valve Adjustment Screw
1-12526	Feed Change Lever Plate
1-12529	Feed Dial
1-12531	Cross Feed Screw Dial (Includes 1-9258)
1-12571	Cross Feed Screw Nut
1-12729	Automatic Feed Valve Piston
1-12730	Automatic Feed Valve Bushing
3-2264	Fast Travel Control Shaft
3-2265	Feed Change Control Shaft
3-2491	Cross Feed Screw (Includes 1-12571)
91-70-30	Feed Change Lever Handle
91-91-564	Shifter Stud
91-100-525	Fast Travel Handle Spring
91-100-526	Fast Travel Switch Lever Spring
91-100-610	Automatic Feed Valve Spring
91-101-162	Adjustment Screw Nut
91-104-376	Cross Feed Screw Nut Locknut
91-111-16	Cross Feed Screw Dial Nut
91-115-38	Adjustment Screw Cap
91-201-980	Cross Feed Screw Fitting Washer, Front
91-201-1048	Cross Feed Clutch Gear Washer
91-204-539	Cross Feed Screw Collar
91-235-197	Clutch Gear Washer
101-20-500	Lubricating Pump
SPX911	Oil Level Window
SPX912	Oil Sight Window
SPX999	Feed Valve Adjustment Screw Washer
SPX1456	Cross Feed Screw Bearing

NOT SHOWN

101-20-501	Automatic Feed Valve, Assembled (Includes 1-12149, 1-12150, 1-12729, 1-12730, 91-100-610, 91-101-162, 91-115-38 and SPX999)



Knee Elevating Mechanism

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Knee Elevating Mechanism

304	Knee Elevating Shaft Handwheel Handle, Complete
470	Knee Clamp Stud Nut
2854	Knee Elevating Shaft Dial Washer
2855	Knee Elevating Shaft Washer
5074	Knee Elevating Shaft Thrust Washer
5086	Knee Screw Washer
7110	Knee Screw Inner Gear Nut
1-6562	Knee Elevating Shaft Dial Back
1-8121	Knee Elevating Shaft Handwheel Sleeve
1-8122	Knee Elevating Handwheel Nut
1-8134	Knee Elevating Shaft Bushing, Front
1-8135	Handwheel Nut Lock Spring
1-8534	Power Feed Interlock Cap
1-8634	Knee Elevating Shaft Bushing, Rear
1-9227	Knee Elevating Shaft Clutch Pin
1-9229	Knee Clamp Crank
1-9230	Knee Clamp Shaft Bushing
1-9233	Knee Screw Nut Sleeve
1-9234	Knee Screw Bearing Holder
1-9235	Knee Power Feed Interlock
1-9288	Knee Elevating Handwheel Clutch Knob
1-9289	Knee Elevating Shaft Handwheel Clutch
1-9292	Knee Elevating Shaft Handwheel (Includes 304)
1-9295	Knee Dust Guard Rear, Lower
1-9296	Knee Dust Guard Rear, Upper
1-9415	Power Shaft Clutch Shoe
1-9422	Power Feed Interlock Rack
1-9476	Knee Dust Guard, Front
1-9490	Knee Elevating Shaft Dial Sleeve
1-9734	Knee Elevating Shaft Spacer
1-9799	Wrench Rack
1-9847	Knee Clamp Shaft (Includes 470, 1-9229 and 91-542-36)
1-11817	Knee Elevating Shaft
1-11818	Knee Screw Gear
1-12504	Knee Elevating Shaft Dial (Includes 1-6562)
2-7656	Feed Case Opening Plug
3-2295	Power Feed Interlock Link
6-119	Knee Screw Outer Cap
6-142	Knee Gib
6-143	Knee Gib Screw
6-149	Knee Screw, Inner (Includes 6-151)
6-151	Knee Screw Nut, Inner
6-153	Knee Screw, Outer (Includes 6-155)
6-155	Knee Screw Nut, Outer
91-91-184	Power Feed Interlock Link Pin
91-104-431	Knee Screw Gear Nut
91-111-16	Knee Elevating Shaft Dial Nut
91-201-1220	Knee Screw Washer, Outer
91-201-1221	Knee Screw Washer, Inner
91-542-36	Knee Clamp Stud
429-1474	Knee Screw Retaining Ring, Outer
429-1476	Knee Screw Retaining Ring, Inner
435-1362	Knee Screw Bearing
472-567	Knee Gib Nut

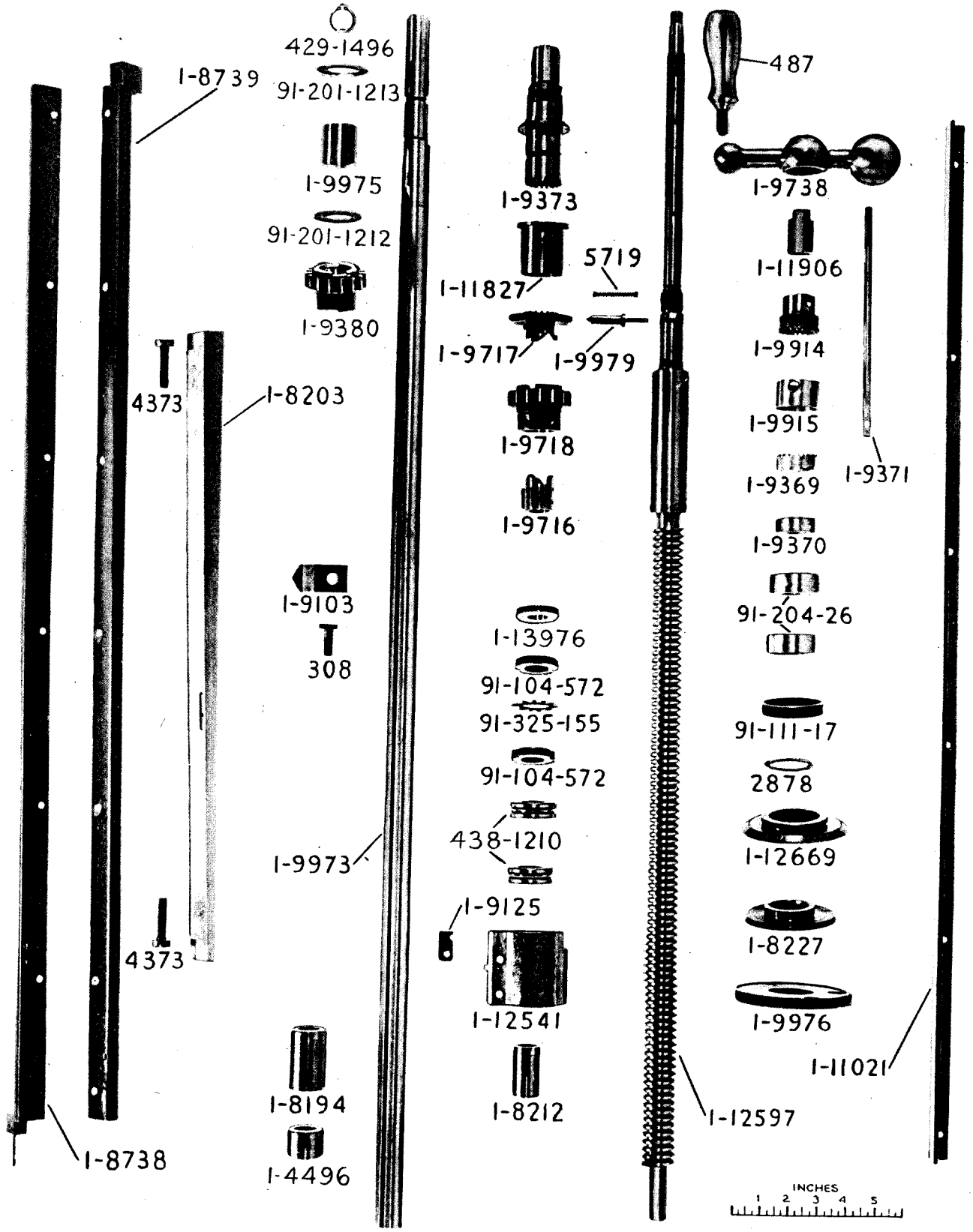
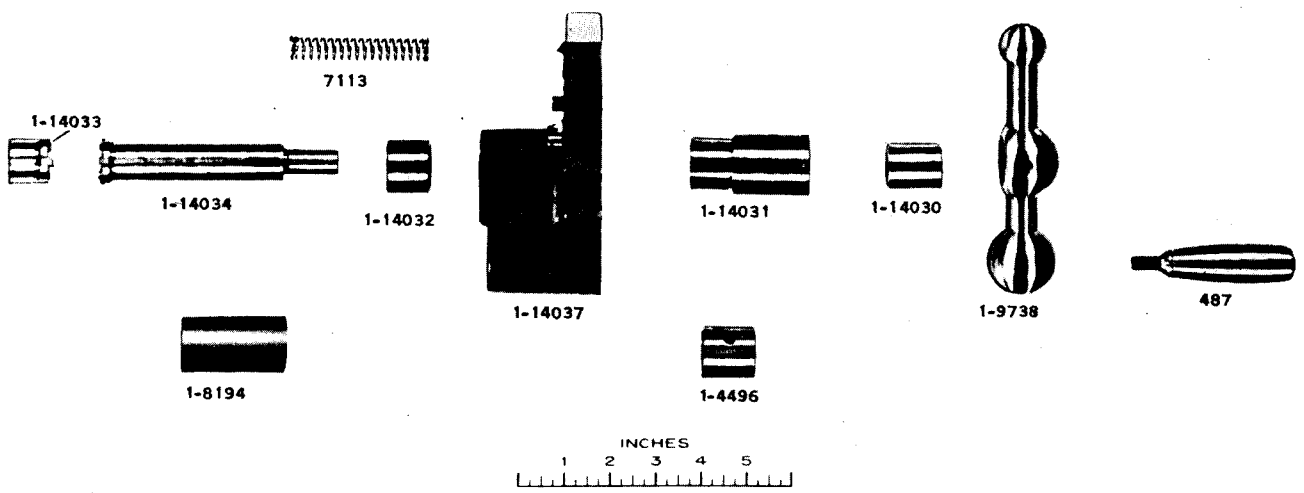

429-1496
91-201-1213
1-8739
1-9975
91-201-1212
1-9380
4373
1-8203
1-9103
308
1-9973
4373
1-8194
1-4496
1-8738
1-9373
1-11827
5719
1-9717
1-9979
1-9718
1-9716
1-13976
91-104-572
91-325-155
91-104-572
438-1210
1-9125
1-12541
1-8212
487
1-9738
1-11906
1-9914
1-9915
1-9369
1-9371
1-9370
91-204-26
91-111-17
2878
1-12669
1-8227
1-9976
1-11021
1-12597
INCHES
1 2 3 4 5

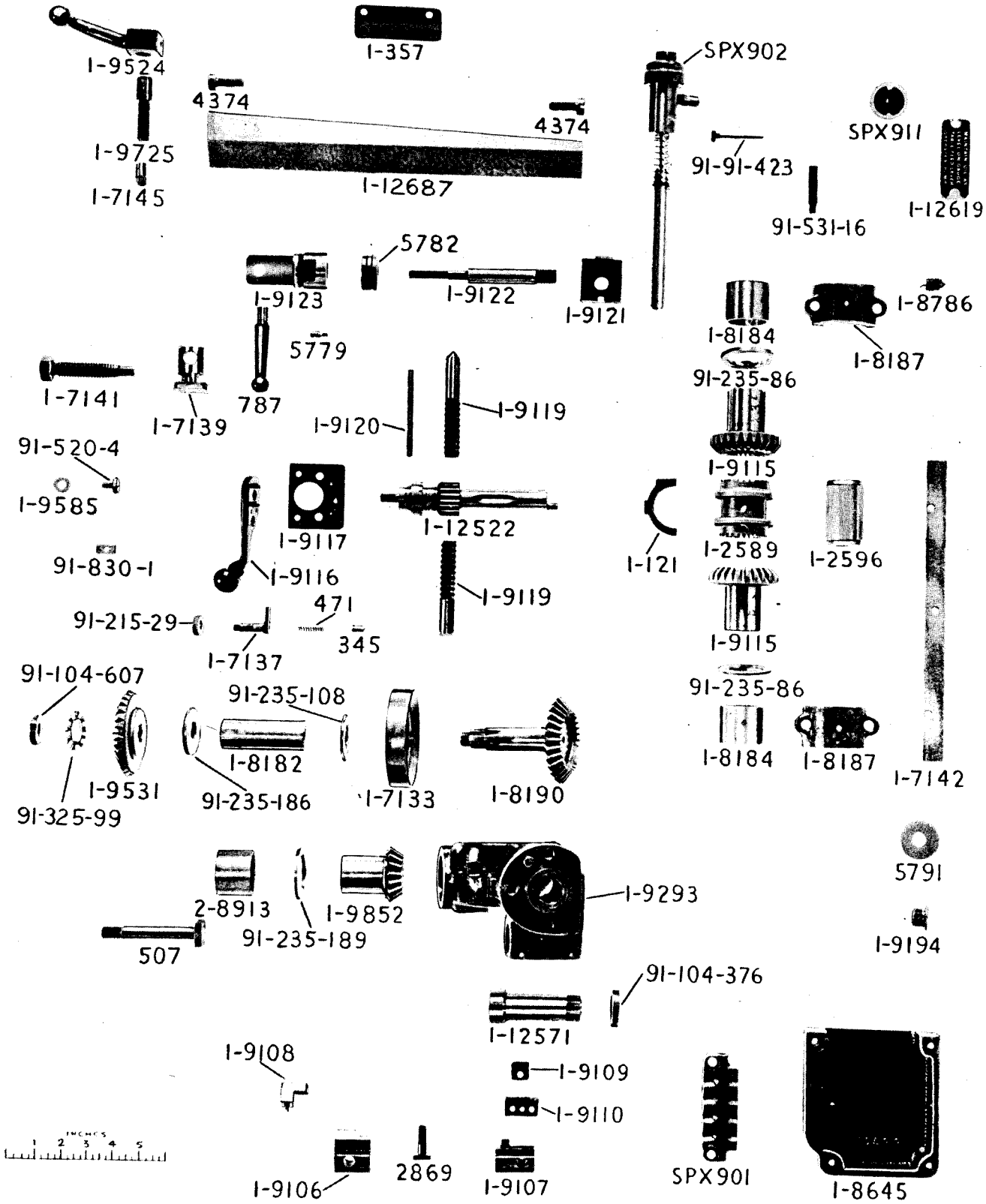
Table Parts

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Table Parts

308	Table Feed Trip Dog Bolt
487	Table Screw Ball Crank Handle, Complete
2878	Table Screw Dial Sleeve Washer
4373	Table Gib Screw
5719	Ball Crank Knockout Plunger Spring
7113	Ball Crank Extension Spring
1-4496	Table Feed Shaft Collar, Right
1-8194	Table Screw Bearing Bushing, Large (Right)
1-8203	Table Gib
1-8212	Table Screw Bearing Bushing, Small
1-8227	Table Screw Dial Back
1-8738	Table Oil Trough, Front
1-8739	Table Oil Trough, Rear
1-9103	Table Feed Trip Dog
1-9125	Tube Retainer Plate, Rear
1-9369	Table Screw Hand Clutch
1-9370	Table Screw Driving Collar
1-9371	Ball Crank Knockout Rod
1-9373	Table Screw Dial Sleeve
1-9380	Table Feed Shaft Gear
1-9716	Table Screw Gear Clutch
1-9717	Ball Crank Knockout Clutch
1-9718	Table Screw Gear (Includes 1-9716 and 1-9717)
1-9738	Ball Crank, Left End (Includes 487, 1-9914 and 1-9915)
1-9738	Ball Crank, Right End (Includes 487)
1-9914	Ball Crank Clutch
1-9915	Ball Crank Clutch Guard
1-9973	Table Feed Shaft
1-9975	Table Feed Shaft Bushing, Left
1-9976	Table Screw Dial Bracket
1-9979	Ball Crank Knockout Clutch Plunger
1-11021	Table Dog Guard
1-11827	Table Screw Dial Sleeve Bushing
1-11906	Table Screw Hand Clutch Nut
1-12541	Table Screw Nut
1-12597	Table Screw (Includes 1-12541)
1-12669	Table Screw Dial (Includes 1-8227)
1-13976	Adjusting Nut
1-14030	Ball Crank Bushing
1-14031	Ball Crank Extension Bushing
1-14032	Ball Crank Clutch Bushing
1-14033	Ball Crank Clutch
1-14034	Ball Crank Extension
1-14037	Table Screw Bearing, Right
91-104-572	Table Screw Thrust Bearing Nut
91-111-17	Dial Nut
91-201-1212	Table Feed Shaft Bushing Washer, Inner
91-201-1213	Table Feed Shaft Bushing Washer, Outer
91-204-26	Table Screw Gear Collar
91-325-155	Thrust Bearing Nut Lockwasher
429-1496	Table Feed Shaft Retaining Ring
438-1210	Table Thrust Bearing



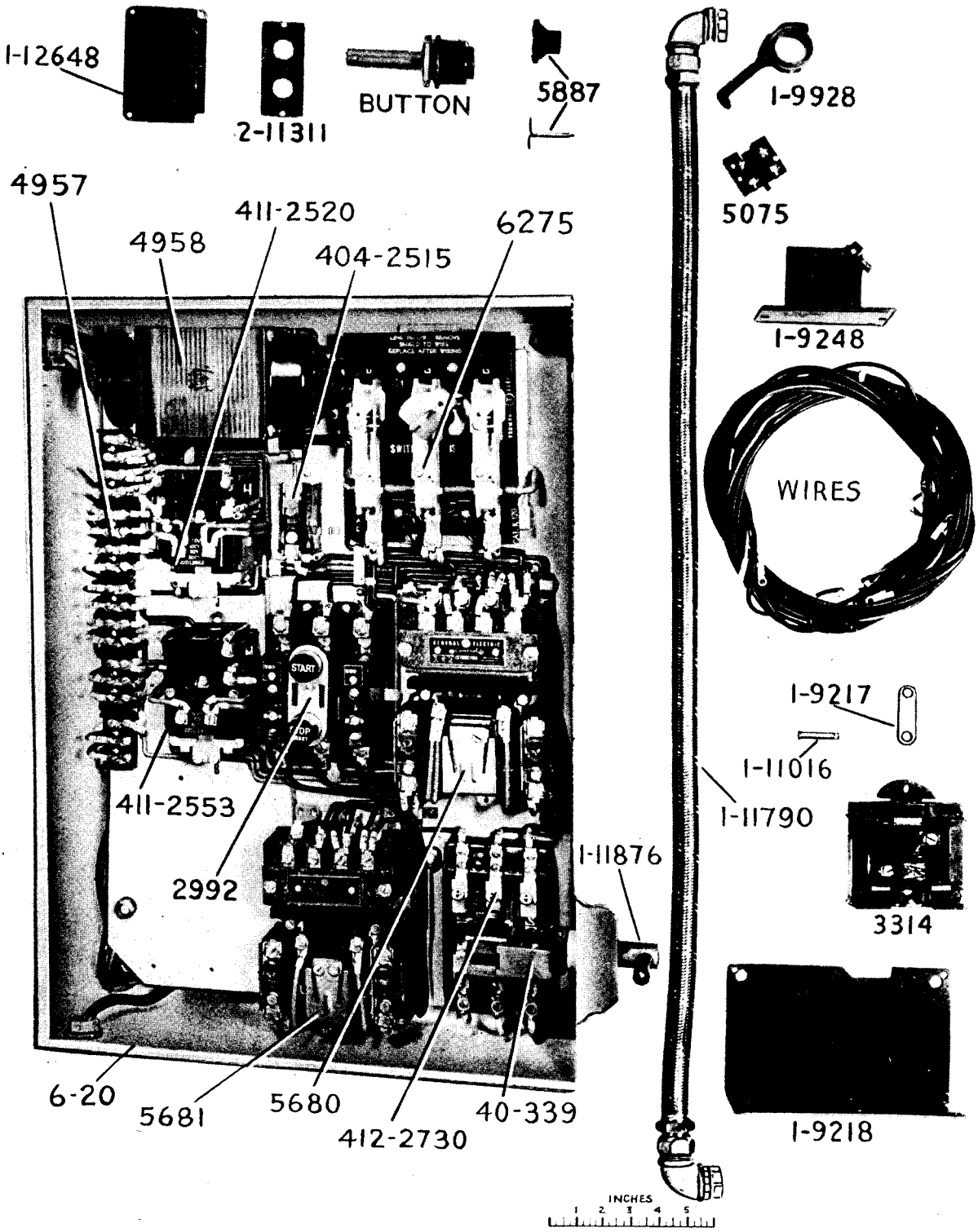


Saddle Parts

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Saddle Parts

345	Table Feed Trip Lever Stop Detent
471	Table Feed Trip Lever Stop Spring
507	Saddle Clamp Bolt
787	Table Clamp Lever Handle
2869	Cross Feed Trip Dog Bolt
4374	Clamp Bed Gib Screw
5779	Table Clamp Screw Stop
5782	Table Clamp Thrust Bearing
5791	Saddle Oil Reservoir Plug
1-121	Table Feed Clutch Shoe
1-357	Clamp Bed Gib Plate
1-2589	Table Feed Clutch (Includes 1-2596)
1-2596	Table Feed Clutch Sleeve
1-7133	Cross Feed Screw Bracket Collar
1-7137	Table Feed Trip Lever Stop (Includes 91-215-29)
1-7139	Saddle Clamp Stud
1-7141	Saddle Clamp Screw
1-7142	T-Slot Cover
1-7145	Clamp Bed Gib Shoe
1-8182	Saddle Swivel Gear Bushing
1-8184	Table Feed Clutch Gear Bushing
1-8187	Table Clutch Gear Bearing Cap
1-8190	Saddle Swivel Gear (Includes 91-104-607)
1-8645	Oil Pump Header Cover
1-8786	Saddle Air Vent Plug
1-9106	Cross Feed Trip Dog, Front
1-9107	Cross Feed Trip Dog, Rear
1-9108	Cross Feed Safety Stop, Front
1-9109	Cross Feed Safety Stop, Rear
1-9110	Cross Feed Safety Stop Holder
1-9115	Table Feed Clutch Gear
1-9116	Table Feed Trip Lever
1-9117	Table Feed Trip Lever Plate
1-9119	Table Feed Trip Plunger
1-9120	Table Clamp Locking Plunger
1-9121	Table Clamp
1-9122	Table Clamp Screw
1-9123	Table Clamp Lever Nut
1-9194	Backlash Take-up Spring Plug
1-9293	Cross Feed Screw Bracket
1-9524	Saddle Clamp Lever
1-9531	Lower Swivel Gear
1-9585	Dust Guard Stop Screw Washer
1-9725	Clamp Bed Clamp Screw
1-9852	Feed Shaft Pinion
1-12522	Table Feed Trip Lever Shaft
1-12571	Cross Feed Screw Nut
1-12619	Table Oil Plate
1-12687	Clamp Bed Gib
2-8913	Cross Feed Screw Bracket Bushing
91-91-423	Oil Pump Locking Pin
91-104-376	Cross Feed Screw Nut Clamp Nut
91-104-607	Saddle Swivel Gear Nut
91-215-29	Table Feed Trip Lever Stop Knob
91-235-86	Table Feed Clutch Gear Washer
91-235-108	Swivel Gear Washer
91-235-186	Lower Swivel Gear Washer
91-235-189	Feed Shaft Pinion Washer
91-325-99	Vertical Shaft Gear Lockwasher
91-520-4	Dust Guard Stop Screw
91-531-16	Table Stop Screw
91-830-1	Saddle Index Finger
SPX901	Saddle Oil Distributor
SPX902	Saddle Pump
SPX911	Saddle Oil Level Window



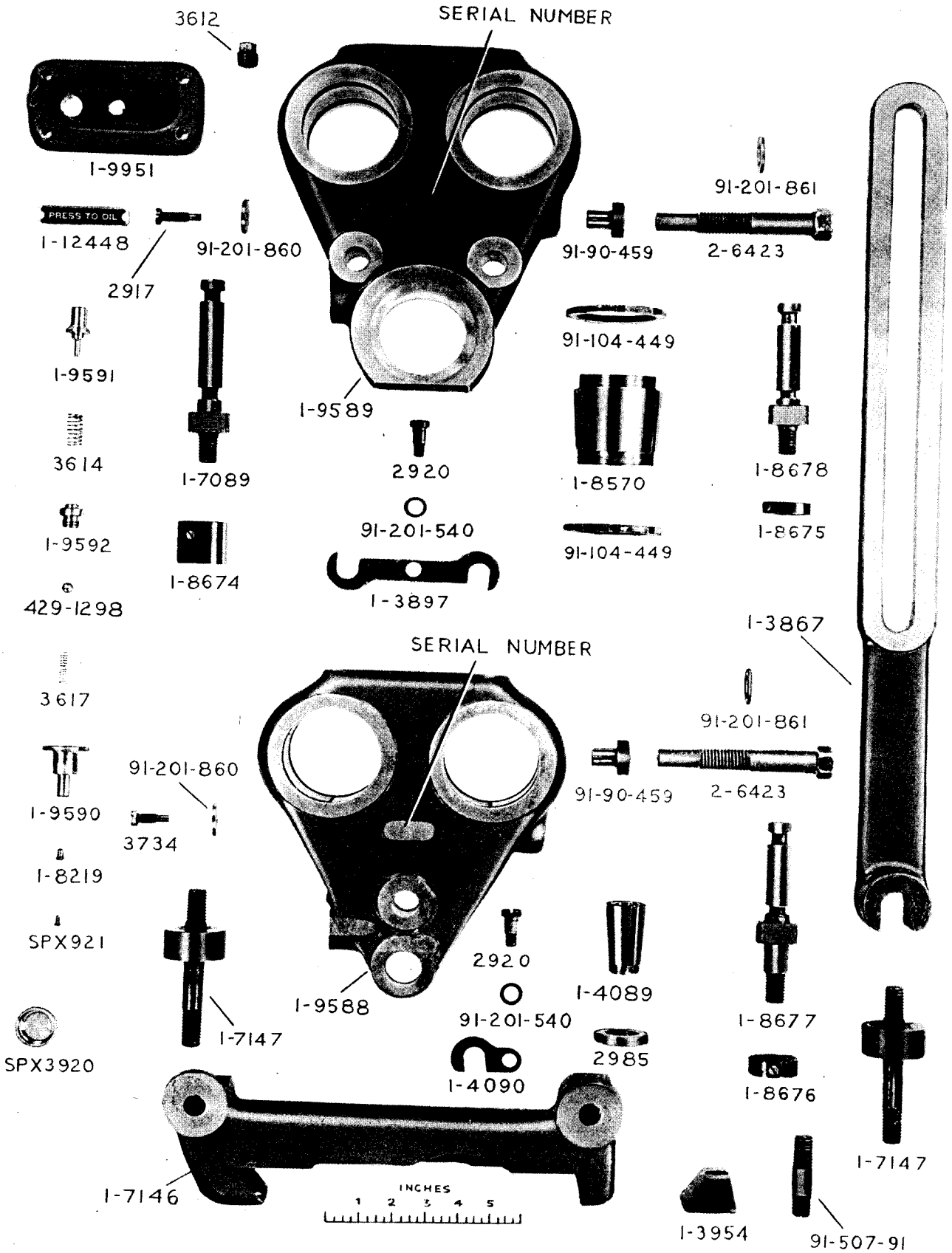
Electrical Controls

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Electrical Controls

*2992	Coolant Pump Switch
*3314	Clutch Solenoid
4957	Terminal Block
*4958	Transformer
*5680	Spindle Switch
*5681	Table Switch
5887	Overload Relay Heater (State Number Stamped on Heater)
*6275	Disconnect Switch
1-9217	Solenoid Lever Link
1-9218	Solenoid Bracket
1-9248	Fast Travel Switch Holder
1-9928	Fast Travel Switch Lever
1-11016	Solenoid Link Pin
1-11790	Knee Conduit
1-11876	Spindle Reversing Switch Operating Lever Stud (Includes 40-339)
1-12648	Spindle Direction Plate
2-11311	Coolant Switch Plate
6-20	Electrical Control Cabinet, Complete
40-339	Spindle Reversing Switch Operating Lever
404-2515	Overload Relay
411-2520	Jogging Relay
411-2553	Braking Relay
411-2724	Fast Travel Switch
412-2730	Spindle Reversing Switch
WIRES	
6-19	Knee Wires
6-21	Spindle Wires
6-23	Coolant Pump Wires
BUTTON, Complete	
81-326	Start
81-327	Stop

*State Voltage, Frequency and Phase of Power Supply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SERIAL NUMBER
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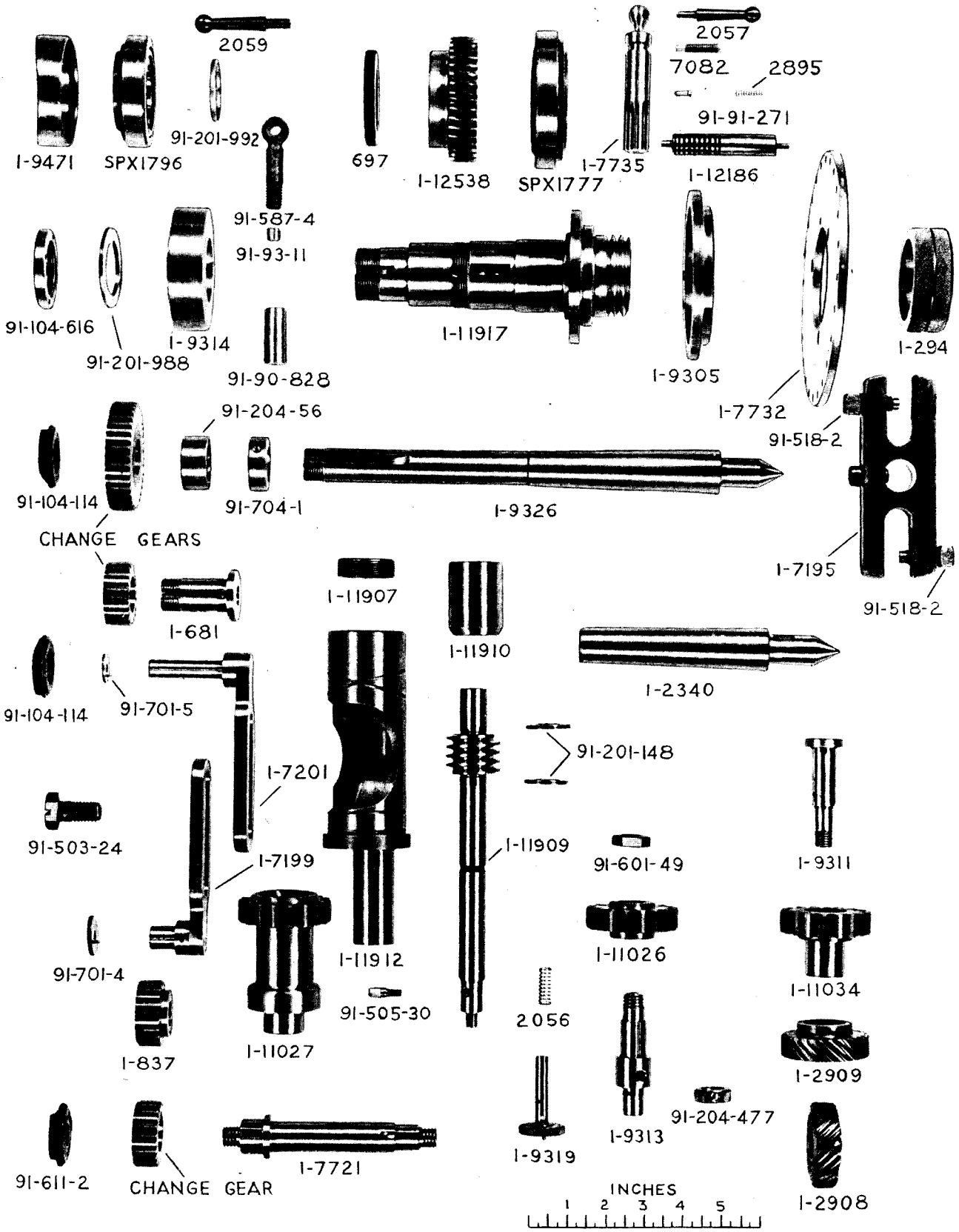
PRESS TO OIL
1-12448
2917
91-201-860
1-9591
3614
1-9592
429-1298
1-7089
1-8674
1-9589
2920
91-201-540
1-3897
91-90-459
91-201-861
2-6423
91-104-449
1-8570
91-104-449
1-8678
1-8675
1-3867
3617
1-9590
91-201-860
3734
1-8219
SPX921
SPX3920
1-7147
SERIAL NUMBER
1-9588
2920
91-201-540
1-4090
1-4089
2985
91-90-459
91-201-861
2-6423
1-8677
1-8676
1-7147
1-7146
INCHES
1 2 3 4 5
1-3954
91-507-91

Arbor Yokes

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Arbor Yokes

2917	Arbor Yoke Clamping Washer Stud
2920	Arm Support Clamp Plate Screw
2985	Arbor Yoke Bushing Nut, Outer
3612	Arbor Yoke Reservoir Plug
3614	Arbor Yoke Oil Valve Plunger Spring
3617	Abor Yoke Check Valve Spring
3734	Arbor Yoke Clamping Washer Stud, Short
1-3867	Arm Support
1-3897	Arm Support Clamp Plate, Double
1-3954	Arm Support Knee Clamp Gib
1-4089	Arbor Yoke Bushing, Outer (Includes 2985)
1-4090	Arm Support Clamp Plate, Single
1-7089	Arm Support Bolt, Long
1-7146	Arm Support Knee Clamp (Includes 1-3954, 1-7147 and 91-507-91)
1-7147	Arm Support Stud
1-8219	Oil Tube Bushing
1-8570	Arbor Yoke Bushing, Inner (Includes 91-104-449)
1-8674	Arm Support Spacing Collar, Long
1-8675	Arm Support Spacing Collar, Short
1-8676	Arm Support Spacing Collar
1-8677	Arm Support Clamp Stud
1-8678	Arm Support Bolt, Short
1-9588	Arbor Yoke, Outer (Includes 2920, 3614, 3734, 1-4089, 1-4090, 1-8219, 1-9590, 1-9591, 1-9951, 2-6423, 91-90-459, 91-201-540, 91-201-860, 91-201-861, SPX921 and SPX3920)
1-9589	Arbor Yoke, Inner (Includes 2917, 2920, 3614, 1-3897, 1-8219, 1-8570, 1-9590, 1-9591, 1-9951, 2-6423, 91-90-459, 91-201-540, 91-201-860, 91-201-861, SPX921 and SPX3920)
1-9590	Arbor Yoke Oil Valve Body (Includes 3617, 3619 and 1-9592)
1-9591	Arbor Yoke Oil Valve Plunger
1-9592	Arbor Yoke Check Valve
1-9951	Arbor Yoke Oil Well Cover (Includes 1-12448 and 91-7-171)
1-12448	Arbor Yoke Oil Notice Plate
2-6423	Arbor Yoke Clamping Screw
91-90-459	Arm Clamping Stud
91-104-449	Arbor Yoke Bushing Nut, Inner
91-201-540	Clamp Plate Screw Spring Washer
91-201-860	Yoke Clamping Washer, Small
91-201-861	Yoke Clamping Washer, Large
91-507-91	Arm Support Knee Clamp Gib Stud
429-1298	Arbor Yoke Check Valve Steel Ball
SPX921	Oil Tube Drive Bushing
SPX3920	Oil Window



Headstock

Universal Spiral Index Centers

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Headstock

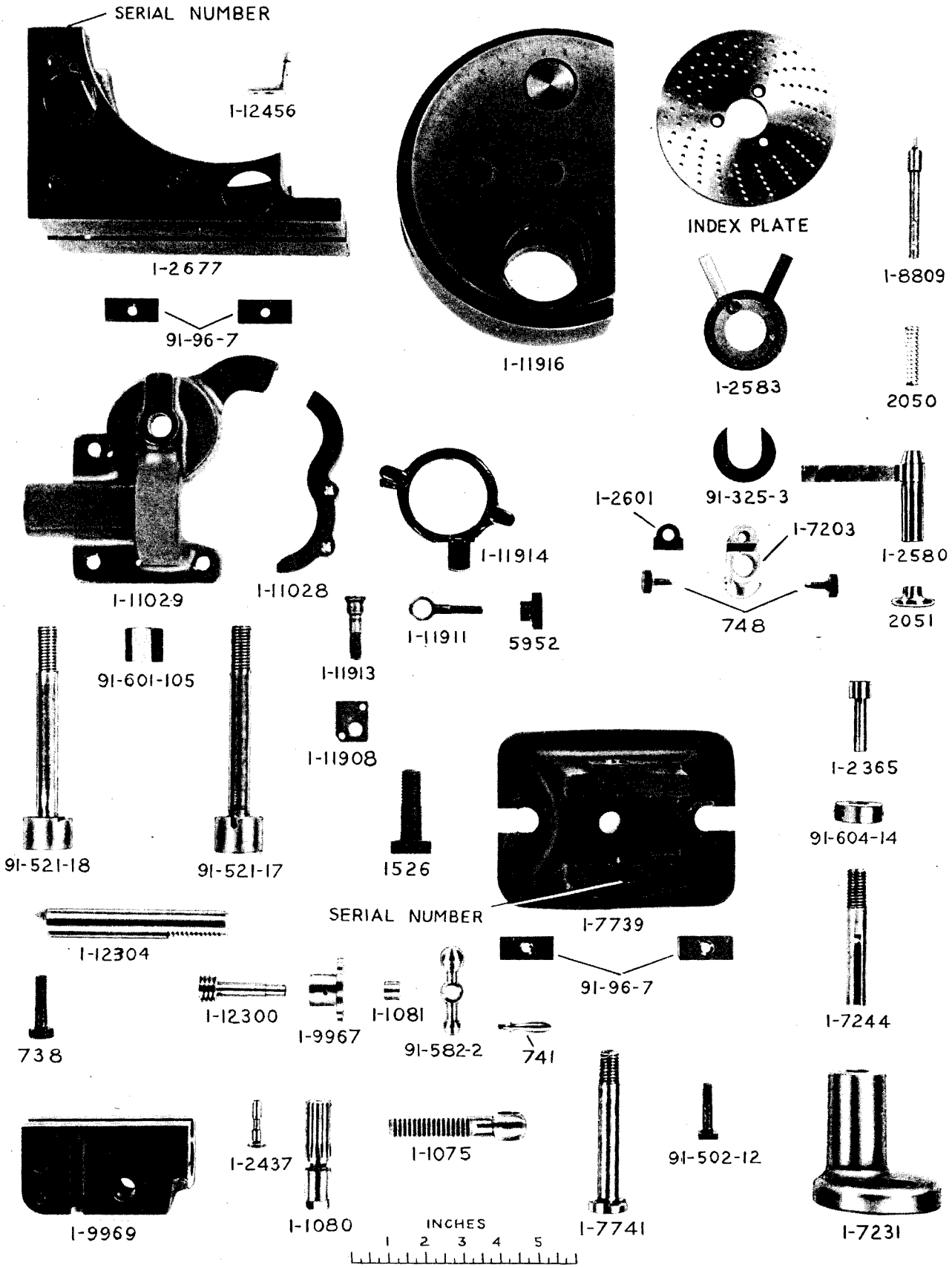
Universal Spiral Index Centers

697	Index Wormwheel Nut
2056	Index Stop Pin Spring
2057	Spindle Stop Pin Pinion Handle
2059	Spindle Clamp Screw Handle
2895	Stop Pin Plate Lock Spring
7082	Spindle Stop Pin Pinion Screw
1-294	Spindle Thread Guard
1-681	Intermediate Gear Bushing
1-837	Reverse Gear
1-2340	Headstock Center
1-2908	Spiral Gear, Driver
1-2909	Spiral Gear, Driven
1-7195	Work Driver (Includes 91-518-2)
1-7199	Reverse Gear Plate, Complete (Includes 1-837 and 91-701-4)
1-7201	Intermediate Gear Plate, Complete (Includes 1-681, 91-104-114 and 91-701-5)
1-7721	Spiral Gear Shaft (Includes 91-611-2)
1-7732	Index Plate, Large (24 Holes)
1-7735	Spindle Stop Pin Pinion
1-9305	Front Bearing Dust Guard
1-9311	Spiral Gear Stud
1-9313	Intermediate Gear Stud (On Head)
1-9314	Spindle Clamp Bushing
1-9319	Index Stop Pin
1-9326	Indexing Center (Includes 91-104-114, 91-204-56 and 91-704-1)
1-9471	Swivel Bushing, Rear
1-11026	Intermediate Gear (On Head)
1-11027	Index Plate Sleeve
1-11034	Intermediate Stud Gear
1-11907	Worm Shaft Adjusting Screw
1-11909	Worm Shaft
1-11910	Worm Shaft Bushing Sleeve
1-11912	Worm Shaft Bushing
1-11917	Spindle (Includes 91-104-616)
1-12186	Spindle Stop Pin
1-12538	Index Worm Wheel
91-90-828	Spindle Clamp Bushing Pin
91-91-271	Stop Pin Pinion Lock Plunger
91-93-11	Spindle Clamp Shoe
91-104-114	Change Gear Nut
91-104-616	Spindle Nut
91-201-148	Worm Shaft Washer
91-201-988	Spindle Rear Washer
91-201-992	Rear Bearing Spacer Washer
91-204-56	Indexing Center Collar
91-204-477	Index Stop Pin Collar
91-503-24	Intermediate Gear Stud Plate Screw
91-505-30	Worm Shaft Stud
91-518-2	Face Plate Screw
91-587-4	Spindle Clamp Screw
91-601-49	Intermediate Gear Stud Nut
91-611-2	Spiral Gear Shaft Nut
91-701-4	Reverse Gear Washer
91-701-5	Change Gear Stud Washer
91-704-1	Index Center Adjusting Collar
SPX1777	Spindle Bearing, Front
SPX1796	Spindle Bearing, Rear

Change Gears

24 Teeth	1-825
28 Teeth	1-12204
32 Teeth	1-12205
40 Teeth	1-12206
44 Teeth	1-12213
48 Teeth	1-12207
56 Teeth	1-12208
64 Teeth	1-12209
72 Teeth	1-12210
86 Teeth	1-12211
100 Teeth	1-12212

(Continued on next page)



Headstock (continued) and Footstock

Universal Spiral Index Centers

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Headstock (continued) and Footstock

Universal Spiral Index Centers

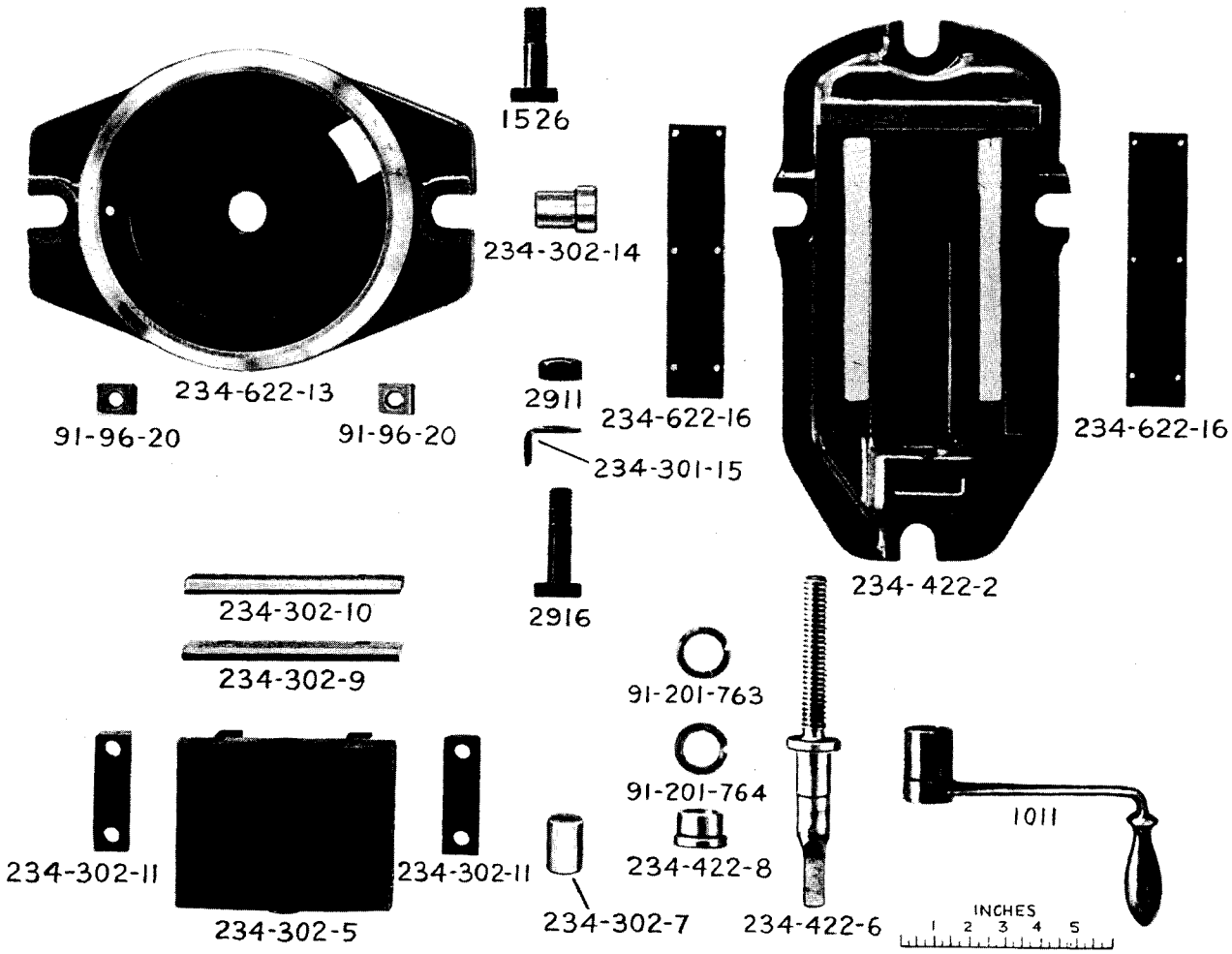
738	Footstock Center Clamp Bolt
741	Footstock Center Ball Crank Handle
748	Index Adjustment Screw
1526	Clamp Bolt
2050	Index Crank Spring
2051	Index Crank Knob
5952	Bushing Clamp Bolt Nut
1-1075	Footstock Rack Bolt
1-1080	Footstock Pinion
1-1081	Footstock Center Adjusting Worm Bushing
1-2365	Center Rest Piston
1-2437	Footstock Taper Pin
1-2580	Index Crank (Includes 2050, 2051 and 1-8809)
1-2583	Index Sectors, Complete
1-2601	Index Crank Clamp
1-2677	Swivel Base
1-7203	Index Crank Collar (Includes 748 and 1-2601)
1-7231	Center Rest Stand (Includes 1-2365, 1-7244 and 91-604-14)
1-7244	Center Rest Shell
1-7739	Footstock Base
1-7741	Footstock Clamp Bolt
1-8809	Index Crank Plunger Pin
1-9967	Footstock Center Adjusting Worm Bearing
1-9969	Footstock Adjusting Block
1-11028	Intermediate Gear Guard
1-11029	Spiral Gear Guard
1-11908	Bushing Adjustment Collar Stop
1-11911	Worm Shaft Bushing Clamp Bolt
1-11913	Bushing Clamp Bolt Stud
1-11914	Worm Shaft Bushing Adjusting Collar
1-11916	Swivel (Includes 1-2677)
1-12300	Footstock Center Adjusting Worm
1-12304	Footstock Center
1-12456	Index Finger
91-96-7	Base Tongue
91-325-3	Sector Spring
91-502-12	Footstock Adjusting Block Guide Bolt
91-521-17	Swivel Clamp Bolt, Lower
91-521-18	Swivel Clamp Bolt, Upper
91-582-2	Footstock Center Ball Crank (Includes 741)
91-601-105	Swivel Clamp Bolt Nut
91-604-14	Center Rest Shell Nut

Index Plate (Give Serial No. of Head)

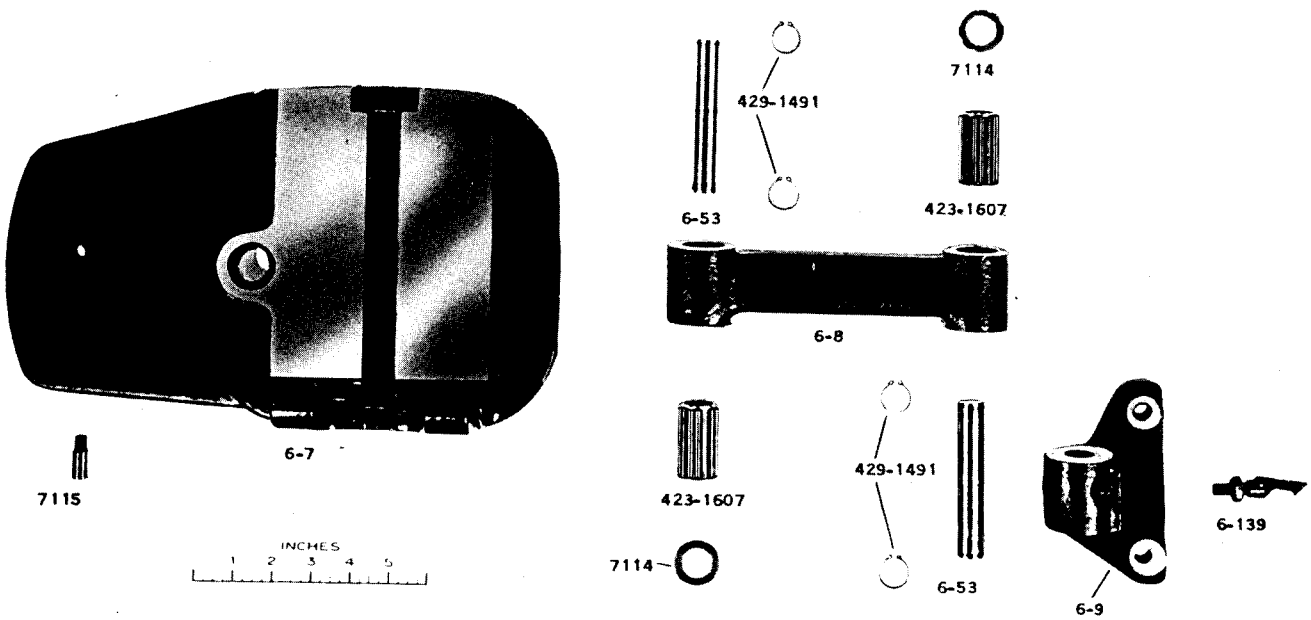
1-12660	15 to 20 Holes
1-12661	21 to 33 Holes (Not shown)
1-12662	37 to 49 Holes (Not shown)

NOT SHOWN

1-12431	Chuck, 3 Jaw



Swivel Vise



Spiral Head Platform Parts

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

Swivel Vise

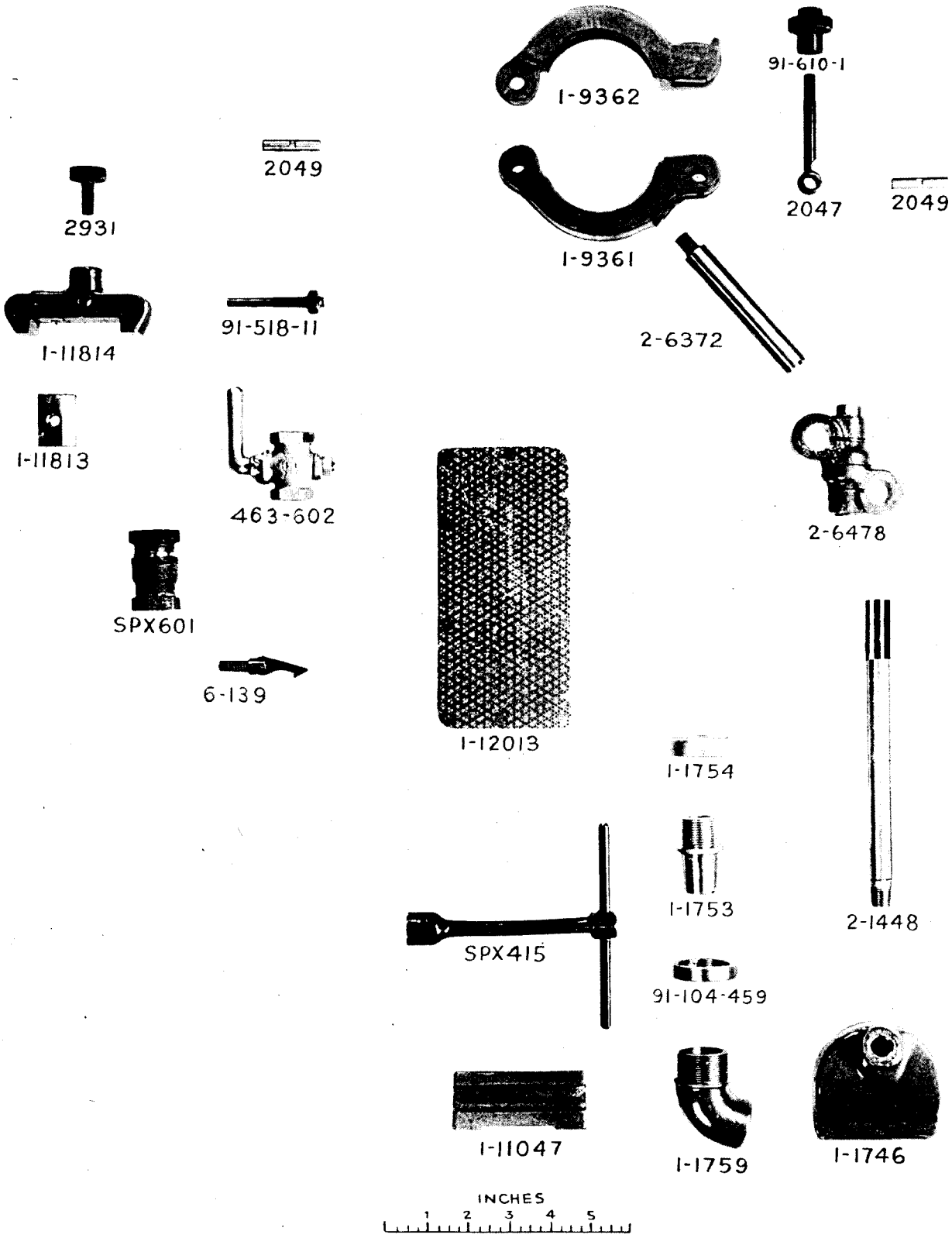
1011	Crank
1526	Clamp Bolt
2916	Swivel Base Clamp Bolt
234-301-15	Swivel Base Washer
234-302-5	Vise Slide
234-302-7	Vise Screw Nut
234-302-9	Loose Jaw
234-302-10	Fixed Jaw
234-302-11	Vise Strap
234-302-14	Swivel Pin
234-422-2	Vise Bed
234-422-6	Vise Screw (Includes 234-302-7)
234-422-8	Vise Screw Collar
234-622-13	Swivel Base (Includes 91-96-20)
234-622-16	Bed Guard
91-96-20	Swivel Base Tongue (State Width of T-Slot)
91-201-763	Screw Thrust Washer, Small
91-201-764	Screw Thrust Washer, Large

NOT SHOWN

7006	Loose Jaw Screw
7008	Fixed Jaw Screw

Spiral Head Platform Parts

7114	Roller Assembly Retaining Washer
7115	Spiral Head Platform Screw
6-7	Spiral Head Platform
6-8	Spiral Head Platform Arm
6-9	Spiral Head Platform Arm Support
6-53	Pivot
6-139	Cover Catch, Complete (Spiral Head Compartment Door)
423-1607	Platform Arm Roller Assembly
429-1491	Roller Assembly Retaining Ring



Coolant and Miscellaneous Parts

ORDER BY PART NUMBER AND NAME ALSO GIVE *SIZE, STYLE* AND *SERIAL NUMBER* OF MACHINE.
(See instructions "How to order Repair Parts" in this book.)

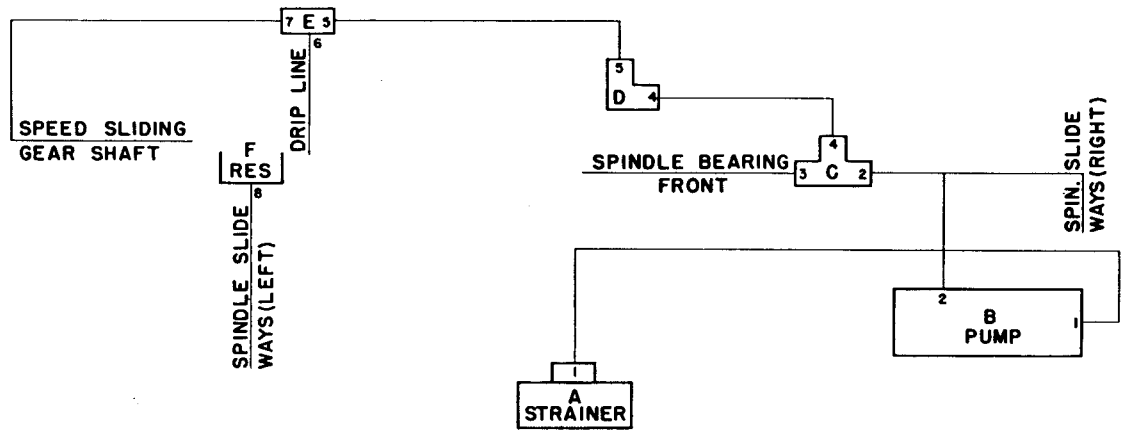
Coolant and Miscellaneous Parts

2047	Swing Bolt
2049	Distributor Bracket Fulcrum
2049	Swing Bolt Fulcrum
2931	Adjusting Screw Clamp Bolt
1-1746	Distributor
1-1753	Flexible Tube Swivel Sleeve
1-1754	Flexible Tube Swivel Sleeve Nut
1-1759	Flexible Tube Swivel, Lower (Includes 1-1753, 1-1754 and 91-104-459)
1-9361	Distributor Bracket, Complete (Includes 2047, 2049, 1-9362 and 91-610-1)
1-9362	Distributor Bracket, Upper
1-11047	Table Dog Wrench Rack
1-11813	Table Stop Gib
1-11814	Table Stop (Includes 2931, 1-11813 and 91-518-11)
1-12013	Chip Strainer, Right
2-1448	Distributor Pipe
2-6372	Distributor Stud
2-6478	Distributor Swivel
6-139	Cover Catch
91-104-459	Flexible Tube Swivel Check Nut
91-518-11	Table Stop Screw
91-610-1	Swing Bolt Nut
SPX415	Socket Wrench
SPX601	Vertical Check Valve
SPX602	½" Lever Handle Cock

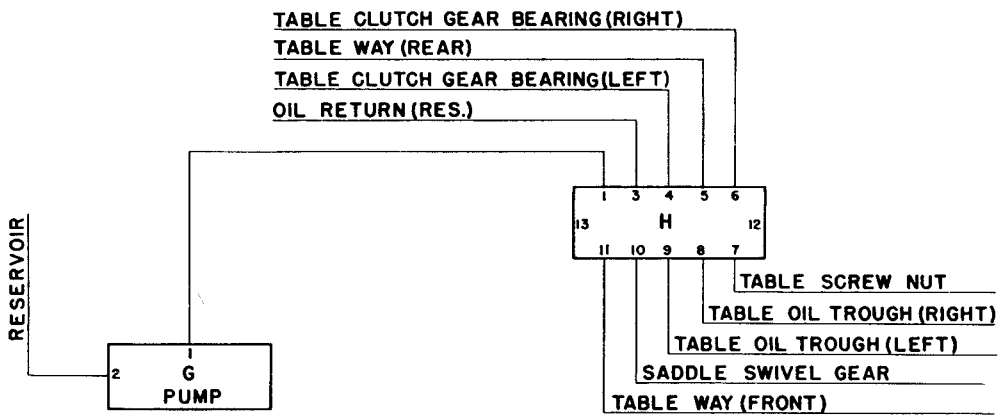
How to Order Lubrication Fittings

1. Give size, style and serial number of machine.
2. When ordering Junction bar, specify letter.
3. When ordering fittings located at Junction bars, specify the Junction bar by letter and the line by number. Example: Fitting required for Junction bar A, Line 1.
4. Order fittings at end of open lines by naming Junction bar with letter and line number.—Specify for "open end" of line. Example: Fitting required for open end of line 7, Junction bar A.
5. When ordering specify if the compression sleeve, nut or bushing to complete the fitting is wanted.

SPINDLE SLIDE LUBRICATION



CLAMP BED, SADDLE & TABLE LUBRICATION



KNEE LUBRICATION