

Operation and Maintenance
(Including Repair Parts)
of the
No. 2 Universal, No. 2 Plain and
No. 2 Vertical Milling Machines
Light Type



BROWN & SHARPE MFG. CO.
PROVIDENCE, R. I., U. S. A.

FOREWORD

The purpose of this book is to give a thorough practical working knowledge of the Brown & Sharpe No. 2 Universal, Plain and Vertical Milling Machines (Light Type).

The book explains in detail each set-up adjustment and operating control of the machines and their 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 machines, lubrication, mechanical adjustments and electrical maintenance including wiring diagram. Finally there is a repair parts section, with the parts of the machines 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 Light Type Milling Machines in detail rather than milling in general. Those interested in a discussion of the elements of milling practice will find much valuable information in our "Practical Treatise on Milling and Milling Machines", a copy of which is shipped with each machine.

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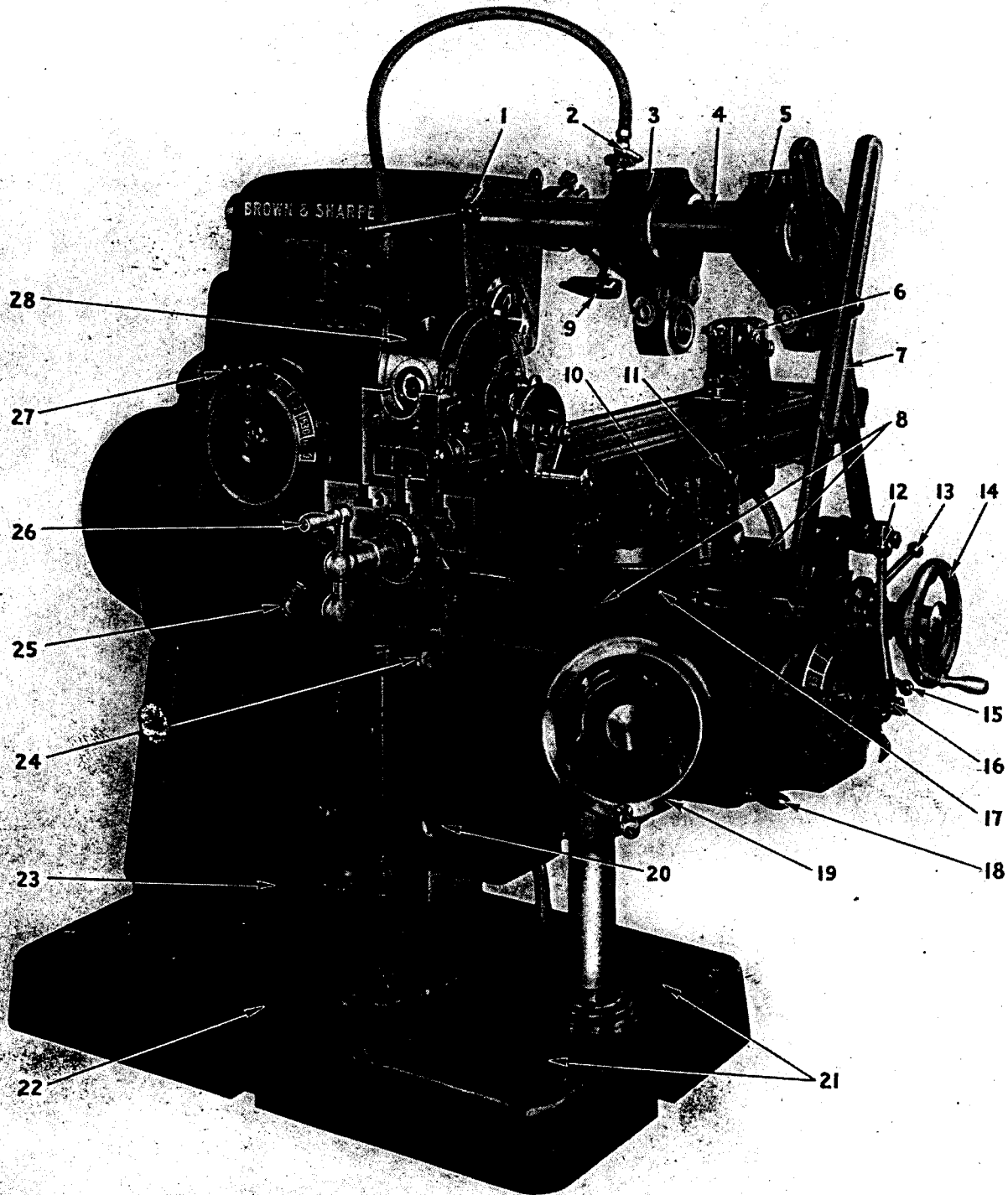
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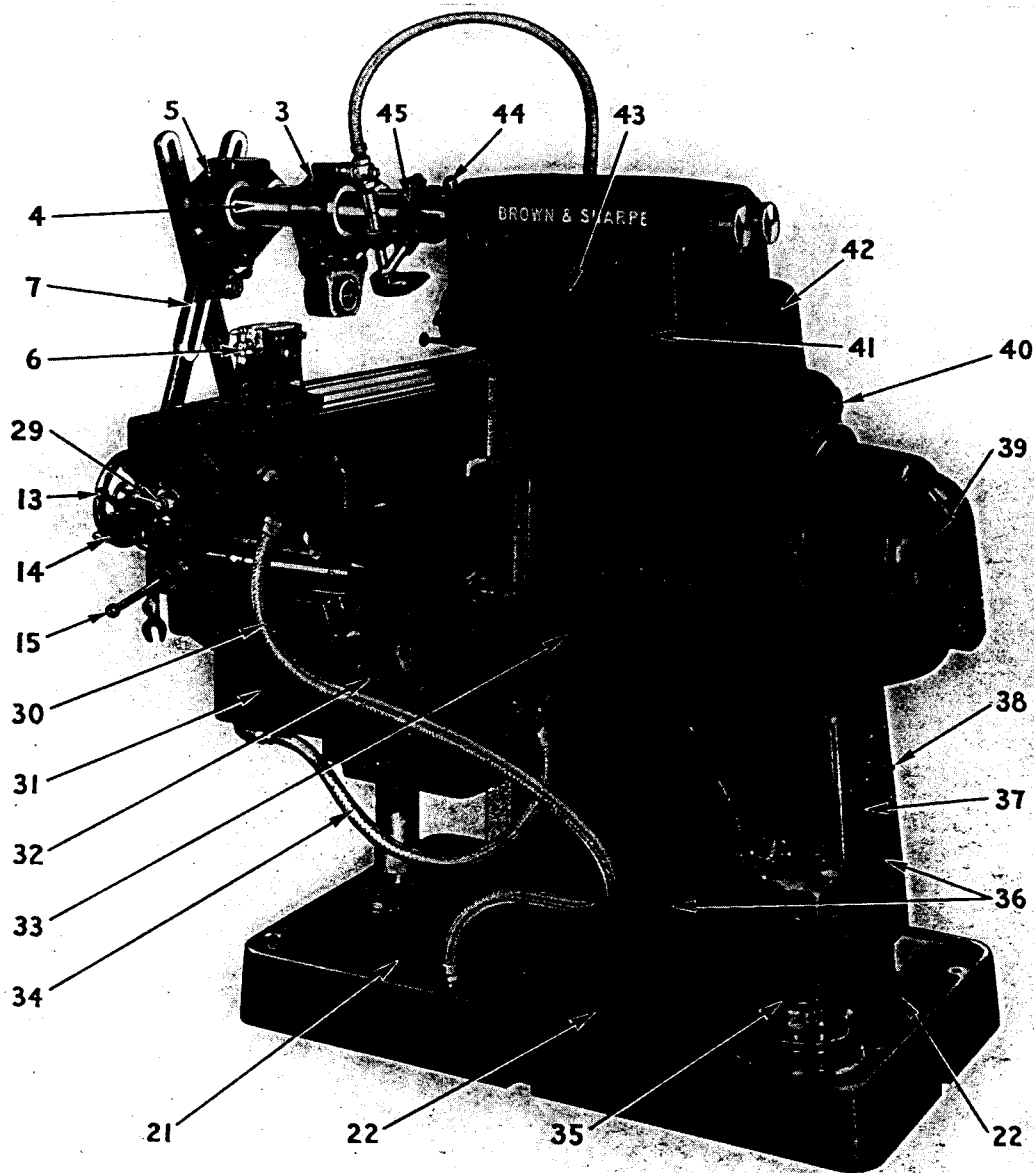
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Operating Controls and Principal Parts of the No. 2 Universal and No. 2 Plain Milling Machines

Light Type

(Universal Machine illustrated. Plain Machine is identical except
Universal Spiral Index Centers are not regularly furnished and
saddle is like that of Vertical Machine shown on pages 6 and 7.)



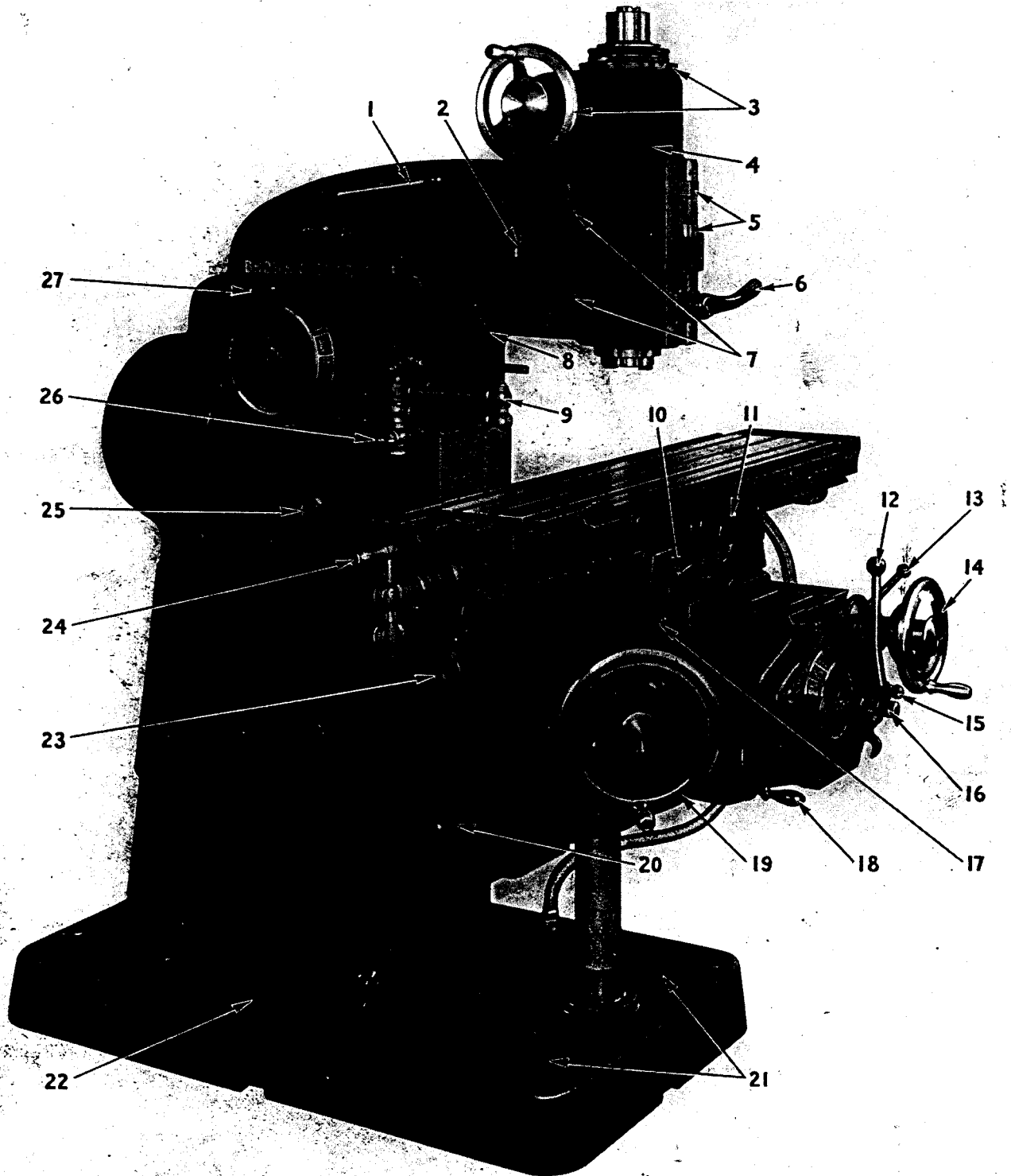


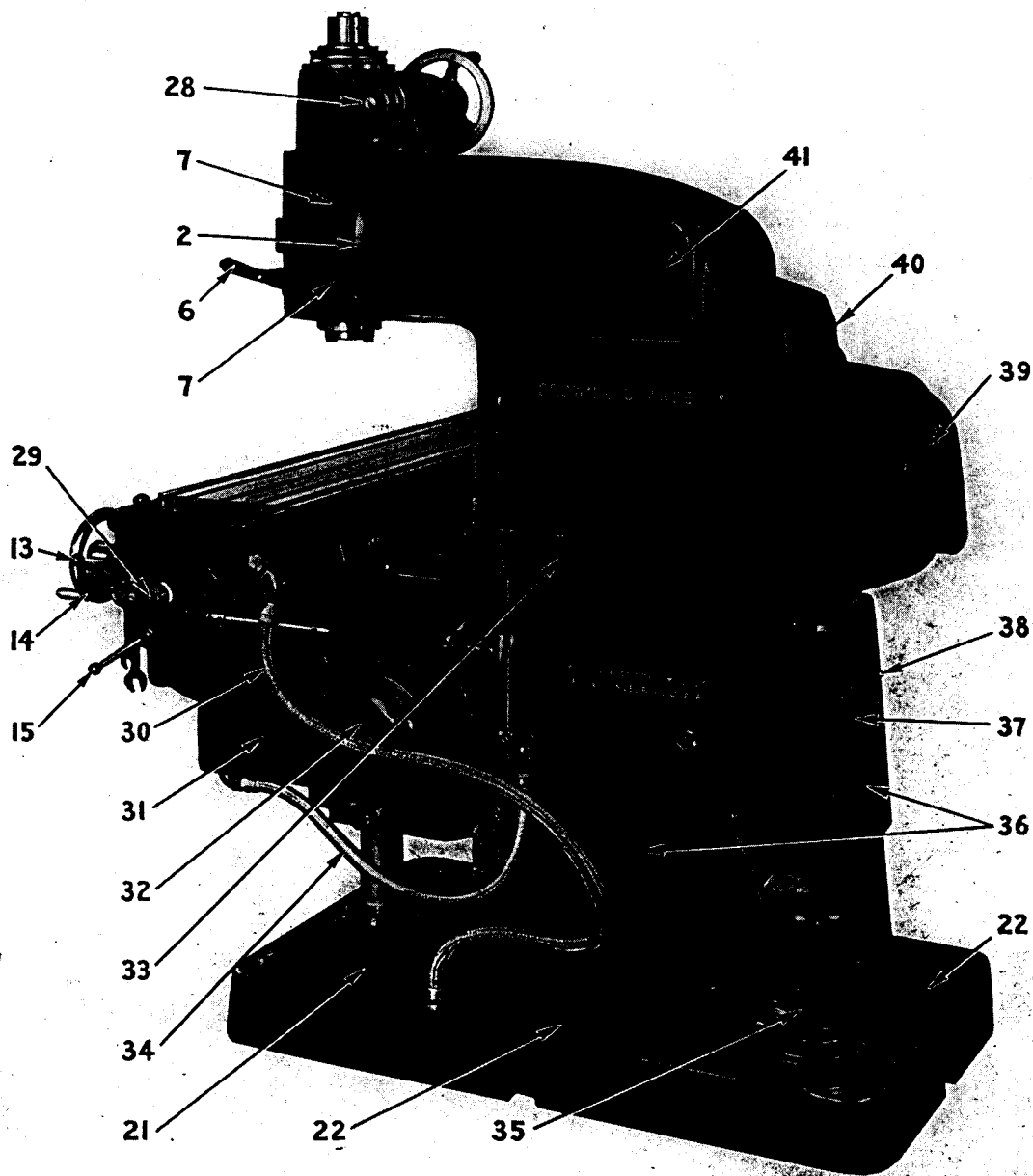
- | | |
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*Coolant System is furnished as an extra when specified.
 **Universal machine only.

Operating Controls and Principal Parts of the No. 2 Vertical Milling Machine

Light Type

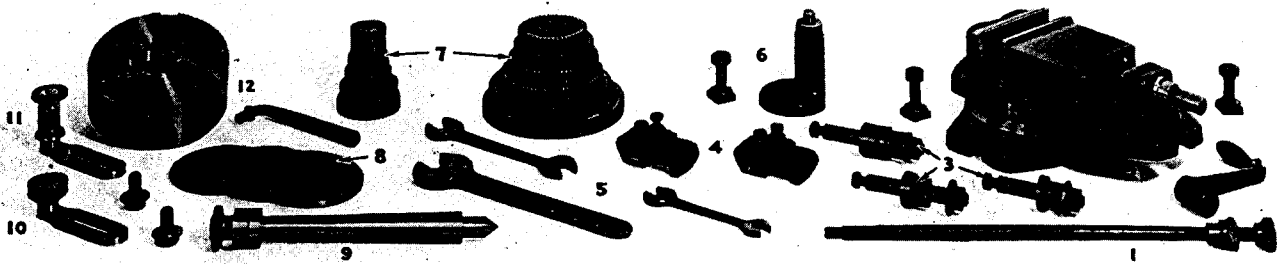




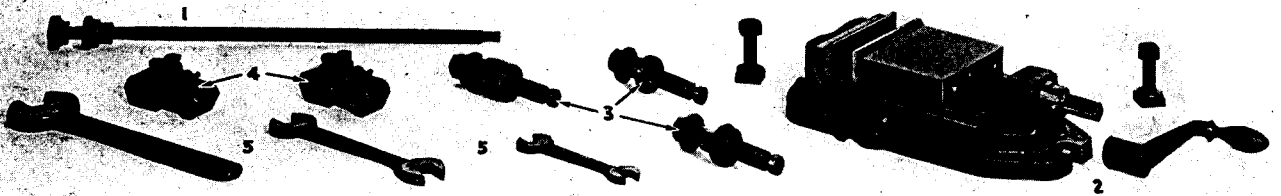
- 1 Machine start-stop lever
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- 3 Spindle feed handwheel and adjustable dial
- 4 Swiveling spindle head
- 5 Spindle stops
- 6 Spindle sleeve clamp lever
- 7 Spindle head clamp bolts
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- 9 Adjustable coolant distributor*
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- 16 Feed selector lever and dial
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- 18 Knee clamp lever
- 19 Vertical adjustment handwheel
- 20 Knee oil reservoir sight gage
- 21 Coolant reservoir cover plates
- 22 Coolant reservoir strainer

- 23 Sight indicator for knee oiling system
- 24 Longitudinal adjustment handcrank
- 25 Sight indicator for column oiling system
- 26 Coolant valve*
- 27 Speed selector lever and dial
- 28 Alternate position of spindle feed handwheel
- 29 Power take-off for driving Rotary Attachment
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- 31 Feed clutch solenoid compartment
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- 33 Filler for oil reservoir in column
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- 37 Coolant pump switch*
- 38 Spindle motor reversing switch
- 39 Spindle motor
- 40 Spindle jog button
- 41 Lever-operated main start-stop switch (behind cover plate)

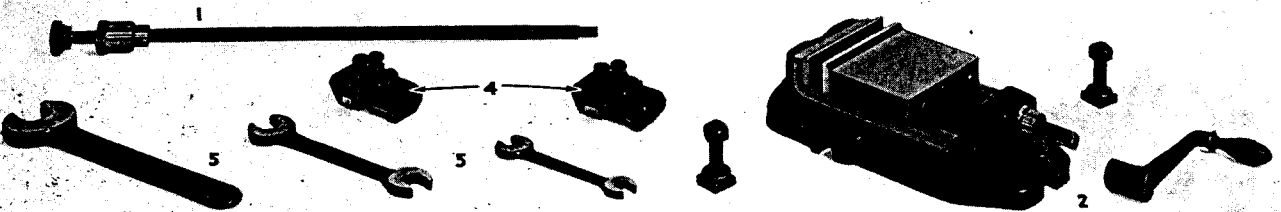
*Coolant System is furnished as an extra when specified.



Equipment regularly furnished with No. 2 Universal Milling Machine (Light Type)



Equipment regularly furnished with No. 2 Plain Milling Machine (Light Type)



Equipment regularly furnished with No. 2 Vertical Milling Machine (Light Type)

Standard Equipment

- | | | | |
|---|------------------------|----|------------------------------|
| 1 | Draw-in bolt | 7 | Headstock change gears |
| 2 | Vise | 8 | Index plates |
| 3 | Arm brace clamp bolts | 9 | Differential indexing center |
| 4 | Table stops | 10 | Reverse gear plate |
| 5 | Set of wrenches | 11 | Intermediate gear plate |
| 6 | Adjustable center rest | 12 | Chuck |

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 Light Type Milling Machines and their standard equipment. Unless otherwise noted, the following material applies equally to Universal, Plain and Vertical machines.

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

Machine Start-Stop Lever

This lever is located on the upper left side of the machine (see Fig. 1) and operates the main start-stop switch in the right-hand side of the column. Pushing the lever upward a few degrees starts both spindle rotation and table feed drive. When released, the lever assumes a slightly lower position; and pulling the lever downward from this running or neutral position stops both spindle and table. (On machines equipped with a Coolant System, the lever will also start and stop the coolant pump.)

On the downward movement, the lever first operates the Stop switch and then applies a brake on the spindle motor for rapid and positive stopping of the cutter. This braking action can also be used to keep the spindle from turning while setting-up or replacing cutters.

The start-stop lever is friction-mounted (without a key) on a tapered bushing on the end of its shaft and can be quickly adjusted to the position most convenient for the operator. To do this, loosen the retaining nut a couple of turns, pull down on the lever to free it on the taper, position the lever as desired and tighten the nut, using a normal pull on the wrench.

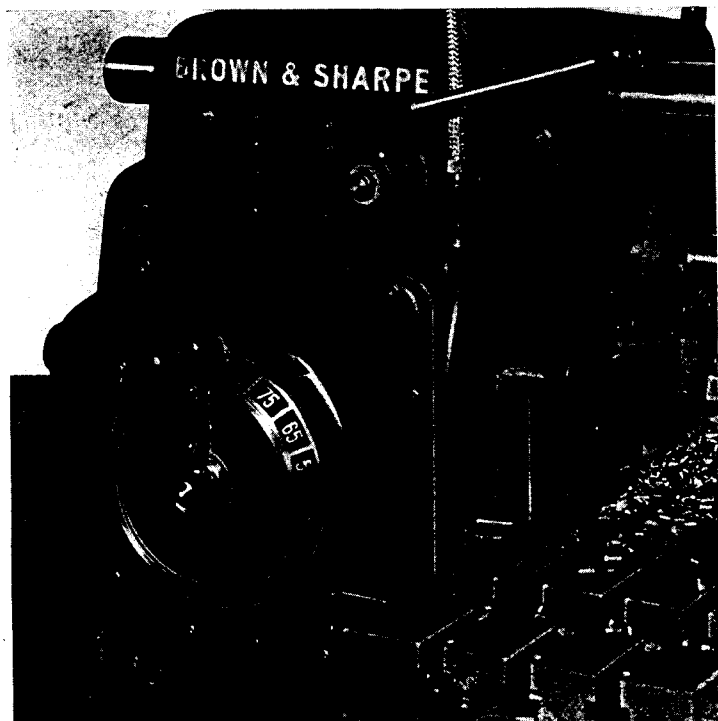
Spindle

Drive. The spindle is gear-driven from a constant-speed motor on the rear of the machine. The various spindle speeds are obtained through sliding gears in the column controlled by the speed selector lever. Section drawings of the driving mechanism are shown on pages 33 and 34.

Selecting Rate of Speed. Eighteen rates of spindle speed are provided on all three machines—40 to 1530 r.p.m. on the Universal and Plain machines (with 60-cycle motor) and 50 to 1800 r.p.m. on the Vertical machine (with 60-cycle motor).

To change the speed, rotate the speed selector lever on the left side of the machine (Fig. 1). The lever can be rotated in either direction and each complete turn gives a change in speed, the rate engaged being shown in revolutions per minute on the large rotating dial. Always stop the machine before changing speed.

Fig. 1. Machine start-stop lever and speed selector lever. Dial and triangular marker show rate of speed engaged.



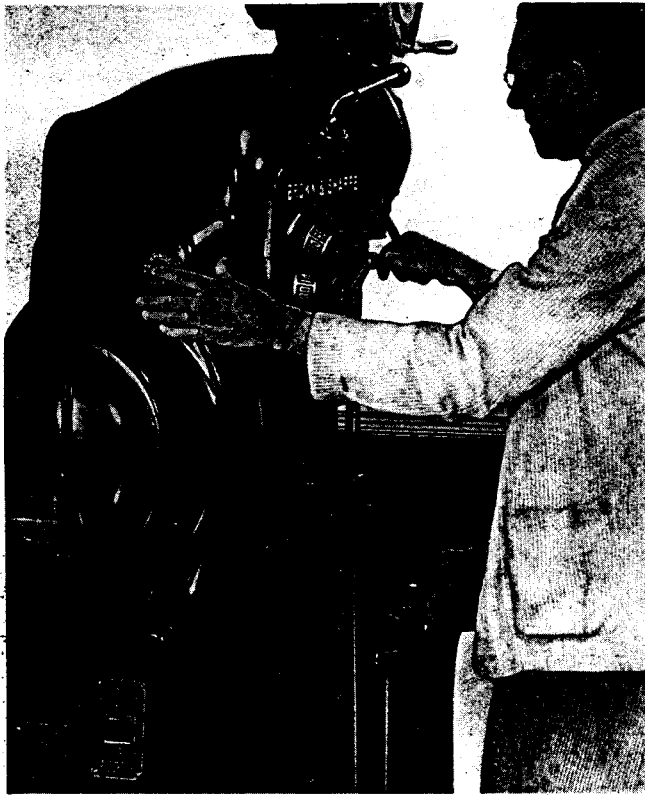


Fig. 2. Using the spindle jog button.

The spindle jog button is adjacent to the speed selector lever as shown in Fig. 2. If occasional difficulty should be encountered in changing speed, a touch of the jog button will remedy the situation.

Reversing the Spindle. The direction of spindle rotation is governed by a reversing switch at the

Fig. 3. Spindle reversing switch.

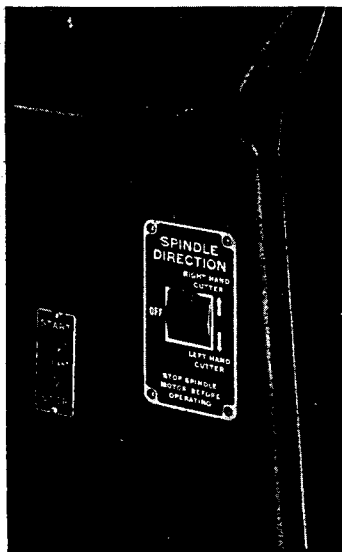
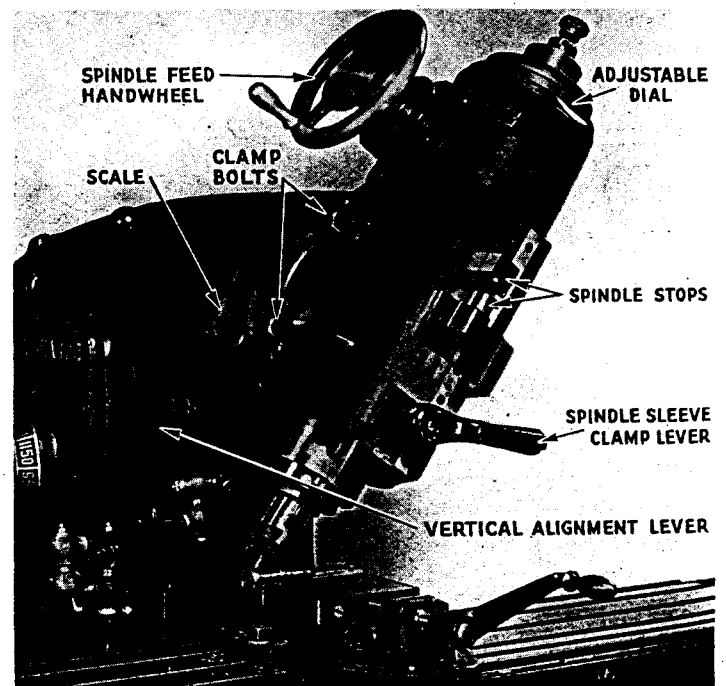


Fig. 4. Spindle head of vertical machine.



rear of the machine (Fig. 3), the setting for right-hand and left-hand rotation being shown on the switch plate. With the switch at Off position, only the spindle motor is disconnected. Stop the machine before operating the reversing switch.

Spindle Head of Vertical Machine

Angular Adjustment. The spindle head can be set at any angle to 90° each side of zero in a vertical plane parallel to the table ways. A scale reading to half-degrees shows the angular setting from either side of the head.

In setting the head at an angle, first push the vertical alignment lever to the rear to withdraw the alignment plunger from the head (see Fig. 4). Then loosen the four clamp bolts at the front of the head (two at each side). Swing the head to the desired angle and tighten the four clamp bolts. In bringing the head to a position considerably away from the vertical do not exert much more force than is necessary to move the head, as too vigorous a pull might cause the head to swing down and hit the table.

By taking advantage of the adjustments of the machine, surfaces can often be milled or holes drilled at various angles without relocating the work on the table, thus obtaining definite, correct angular relationships.

Exact vertical alignment of the spindle is obtained by means of a spring-operated tapered locking plunger controlled by the vertical alignment lever. To set the spindle vertical, first bring

the head to approximately zero setting by the angular graduations; then pull the vertical alignment lever forward, jiggle the head a few times to seat the plunger and tighten the four clamp bolts.

Spindle Feed. A 3" axial movement of the spindle is provided by the spindle feed handwheel (Fig. 4). To feed the cutter toward the work, turn the handwheel toward the front of the machine (that is, clockwise with the wheel at the left side of the head); and to withdraw the cutter, turn the handwheel toward the rear of the machine. Graduations reading to .001" on the adjustable dial at the top of the head permit fine axial adjustment, and the spindle sleeve can be clamped at any point by the lever at the lower front of the head.

The handwheel is held on its splined shaft by a spring lock and is quickly transferred for use at either side of the head. When the head is set at an angle, it is usually best to use the handwheel on the upper side of the head.

Spindle Stops. The lower spindle stop (Fig. 4) is fixed to the spindle head, while the upper stop is fastened to the spindle slide. Both stops are of hardened steel and are accurately ground on their facing surfaces to permit the use of measuring blocks for high-precision set-ups for depth of cut.

Step-Milling. Where a run of duplicate parts requires machining each piece at several different depths, the spindle stops permit a considerable speeding-up of the job through step-milling, as follows:

A set of prepared measuring blocks is used, one block for each depth of cut. With one block between and in contact with the two spindle stops, the knee is adjusted until the desired depth of cut is obtained on the part of the work corresponding to that measuring block. The knee is then clamped and the various steps of each piece are milled in succession, the correct vertical position of the cutter for each step or depth being obtained by placing the proper measuring block between the stops and feeding the spindle until the stops come firmly against the block. A typical step-milling job is shown in Fig. 5.

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 lever 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

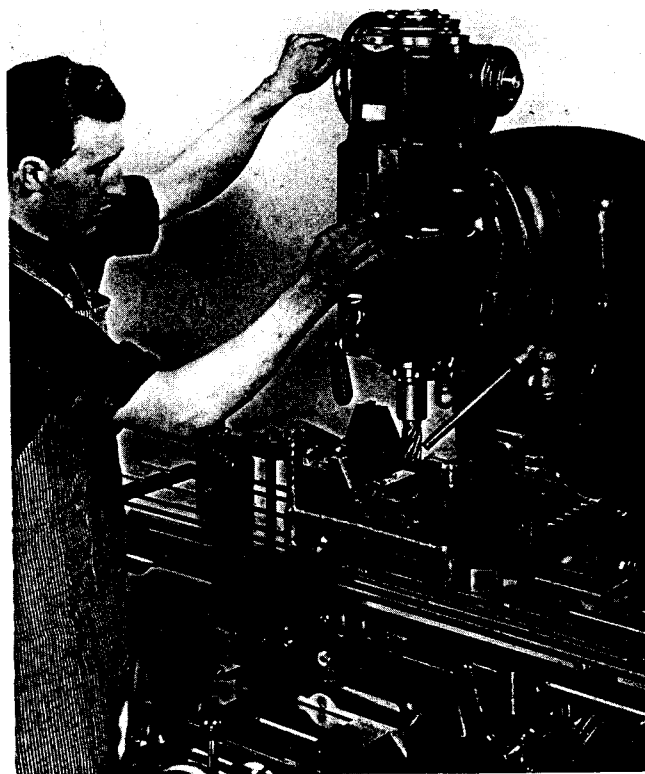


Fig. 5. A typical step-milling job. One horizontal surface has been end-milled, the gage block for that depth has been replaced by one for the next depth of cut and the operator is lowering the spindle until the stops bear against the gage block, preparatory to milling the next surface.

from the same unit. A section drawing through the feed case is shown on page 35.

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. 6, next page).

Adjustment Clamps. Clamps for longitudinal, transverse and vertical adjustments are shown in

Fig. 6. 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 of the Universal machine is clamped by a hexagonal-headed screw at the lower front of the saddle (shown in Fig. 6) 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— $1\frac{1}{2}$ " to $20\frac{1}{4}$ " per minute on all three machines (with 60-cycle motor). To change the feed rate, turn the feed selector lever on the front of the knee (Fig. 6). 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

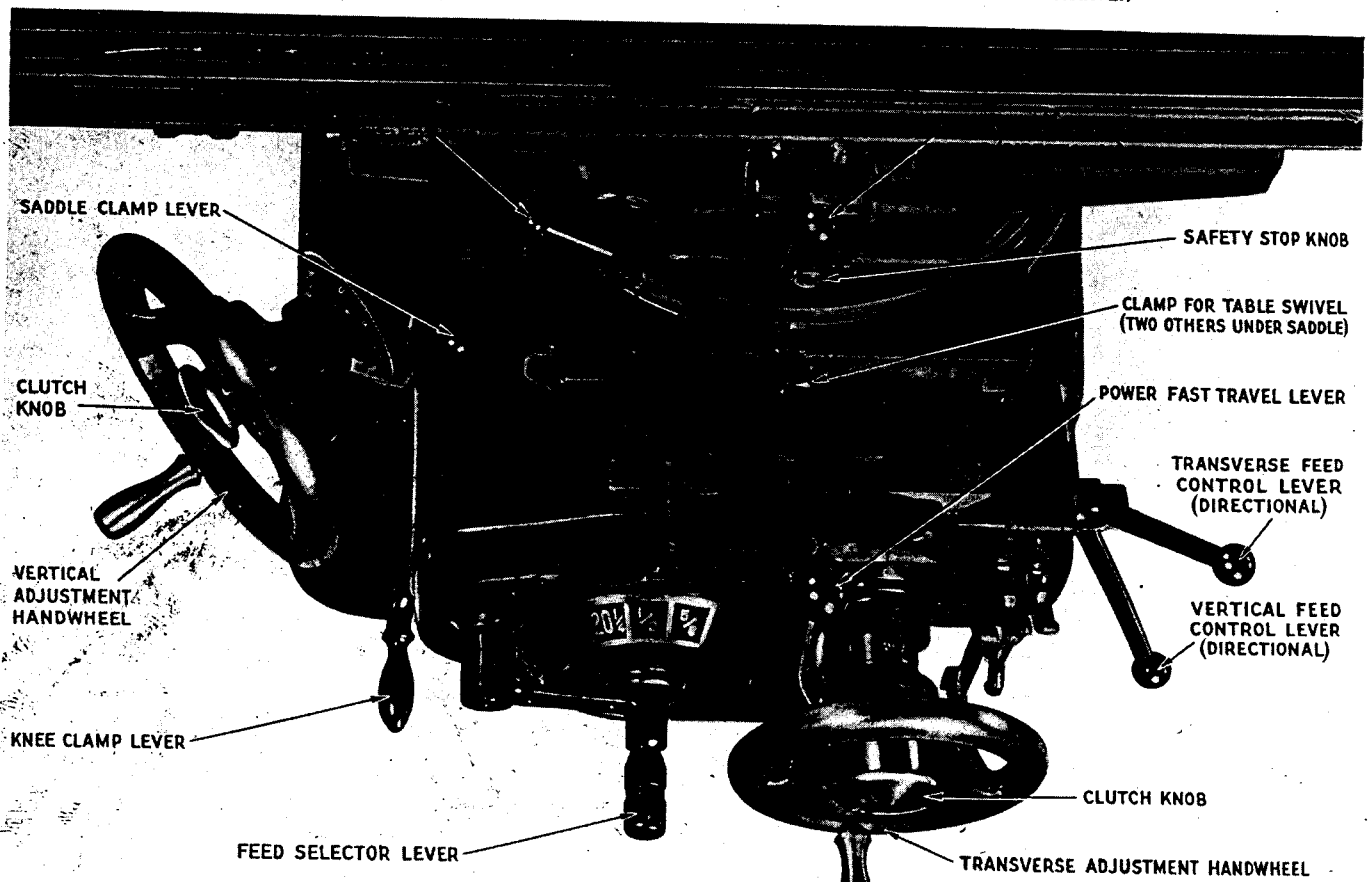
with the machine stopped, jogging with either the starting lever or the fast travel lever will remedy the situation.

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 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. 6.

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

Fig. 6. Controls and adjustments at front of machine. (Universal machine illustrated.)



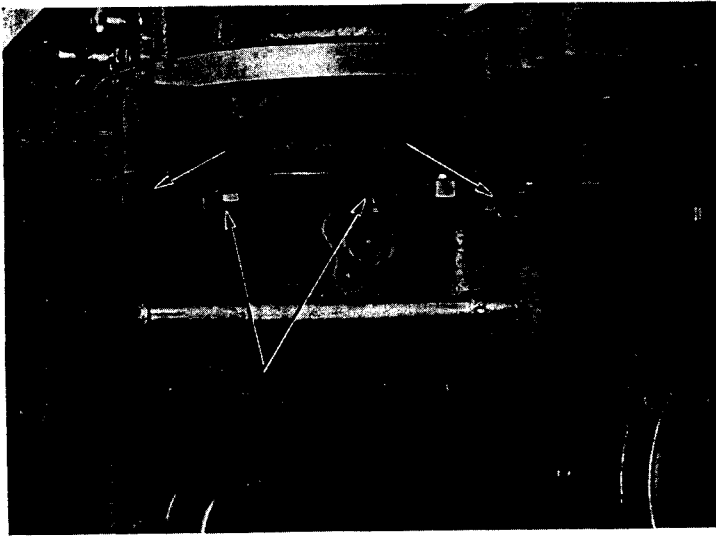


Fig. 7. Transverse feed trip dogs.

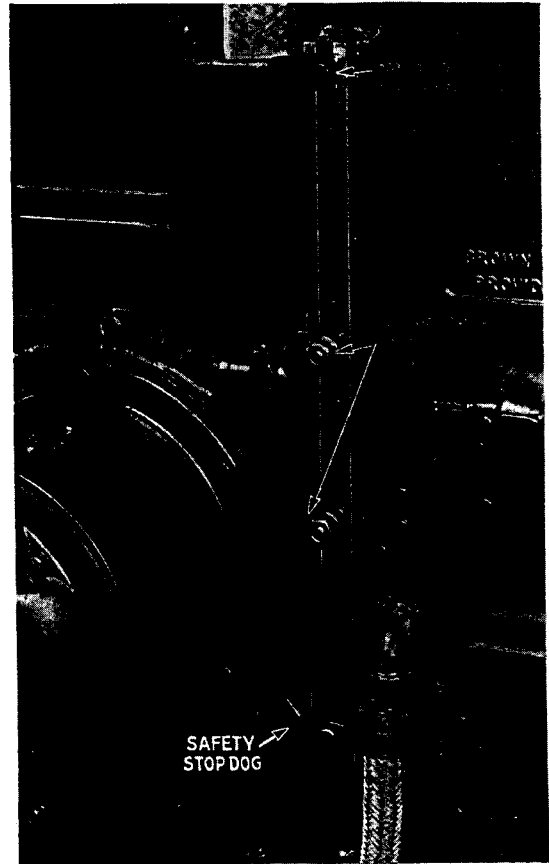


Fig. 8 (right). Vertical feed trip dogs.

—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. 6. 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.

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. 7 and 8 respectively.

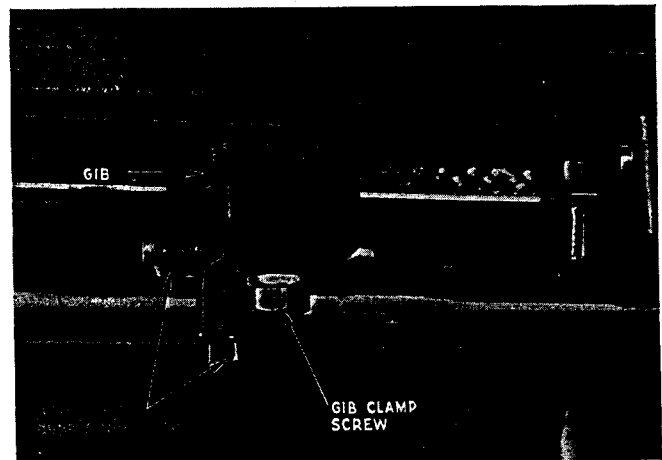
When longitudinal or transverse feed has been disengaged by a dog, power movement in the opposite direction can be engaged by the respective feed control lever. When vertical feed has been tripped out by a dog, the knee must be moved by hand a short distance in the opposite direction until the plunger 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. 9. 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.

Fig. 9. Adjustable table stop.



Arbor Support

Provision is made for ample rigidity of arbor support on the Universal and Plain machines; 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.

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 set-back column face permits the cutter to be located several inches 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.

Overarms. The two solid steel cylindrical overarms are clamped evenly at both front and rear of the column by a small forward movement of the

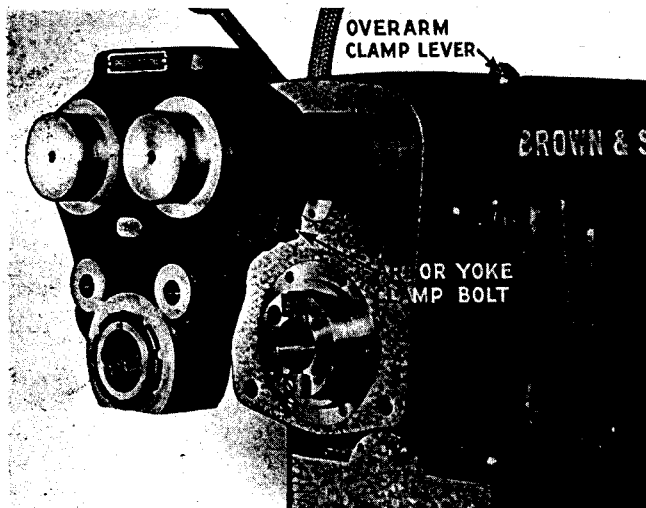


Fig. 10. Overarm clamp lever and arbor yoke. (Inner arbor yoke illustrated.)

overarm clamp lever (illustrated in Fig. 10). When the clamp is released, the overarms can be moved in or out of the column from the front of the machine.

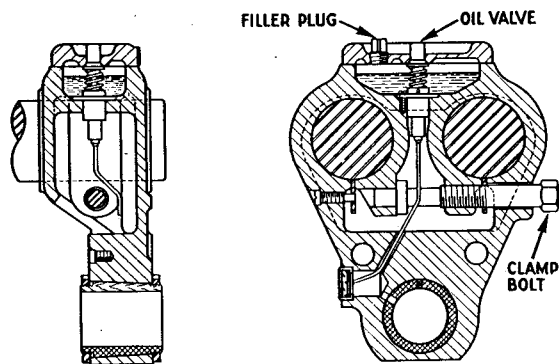


Fig. 11. Sections through arbor yoke show valve and reservoir for oiling adjustable arbor bushing, and illustrate method of securing equalized clamping to overarms.

Arbor Yokes. Two arbor yokes are furnished—one inner yoke and one outer. The inner yoke takes arbor sleeves $1\frac{7}{8}$ " diameter, and the outer yoke supports the outer end of arbors having a $2\frac{3}{32}$ "-diameter pilot. The arm braces (described below) 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. 10 and 11).

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

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. 11). Pushing the plunger all the way down and immediately releasing it will deliver a drop of oil to the bushing. The sight gage in the left 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 overarms and bring 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 serve 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. 12 and 13. 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 one of the arm braces 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

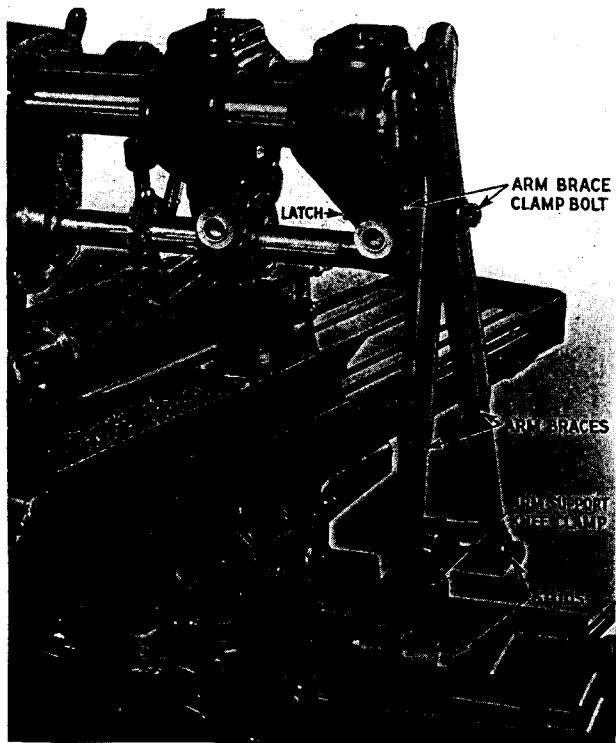


Fig. 12. A typical set-up showing arm braces in use with outer arbor yoke. The set-up illustrated gives maximum rigidity of cutter support, because (1) cutter is near spindle nose; (2) inner arbor yoke is used, and is located close to cutter; and (3) outer arbor yoke and arm braces rigidly tie overarms to knee, keeping vibration and deflection to a minimum.

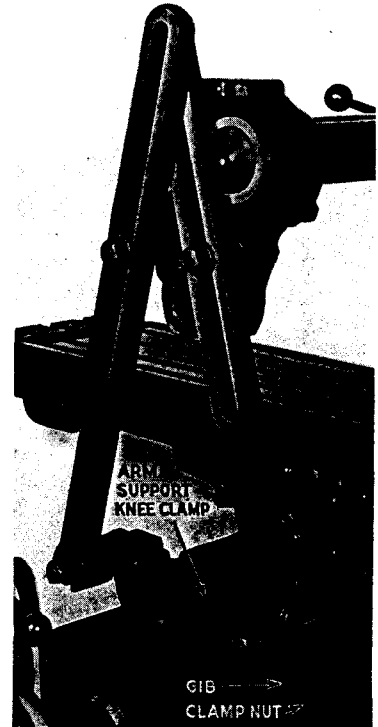


Fig. 13. Arrangement of arm braces when used with inner arbor yoke in outer position. This set-up is used when conditions such as shape of work or arrangement of cutters prevent using both arbor yokes.

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. 13), and complete the set-up by tightening the nuts against the arm braces.

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.

On the Universal and Plain machines, the rear end of the draw-in bolt is covered by a hinged guard (see Fig. 14).

Universal Spiral Index Centers

The Universal Spiral Index Centers and equipment illustrated in Fig. 15 (next page) are furnished as standard equipment with the Universal machine, and are available at extra cost for use with Plain and Vertical machines. These centers swing work to 10" diameter and take 28" length.

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. 16 (page 17). Set-up

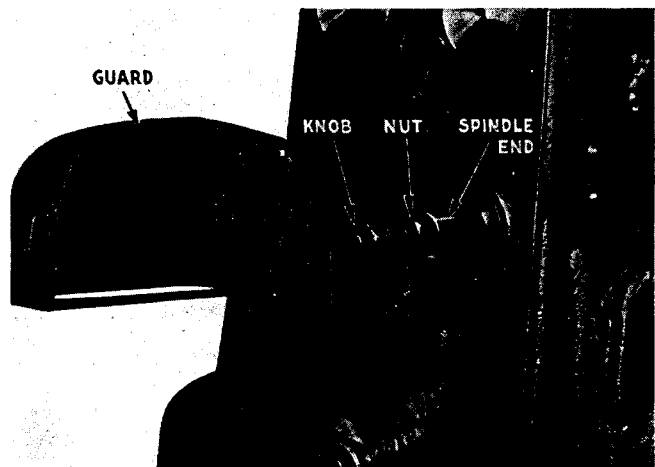
data for all available divisions to 382 are listed in the index table furnished.

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.

Fig. 14. Draw-in bolt and hinged guard on Universal and Plain machines.



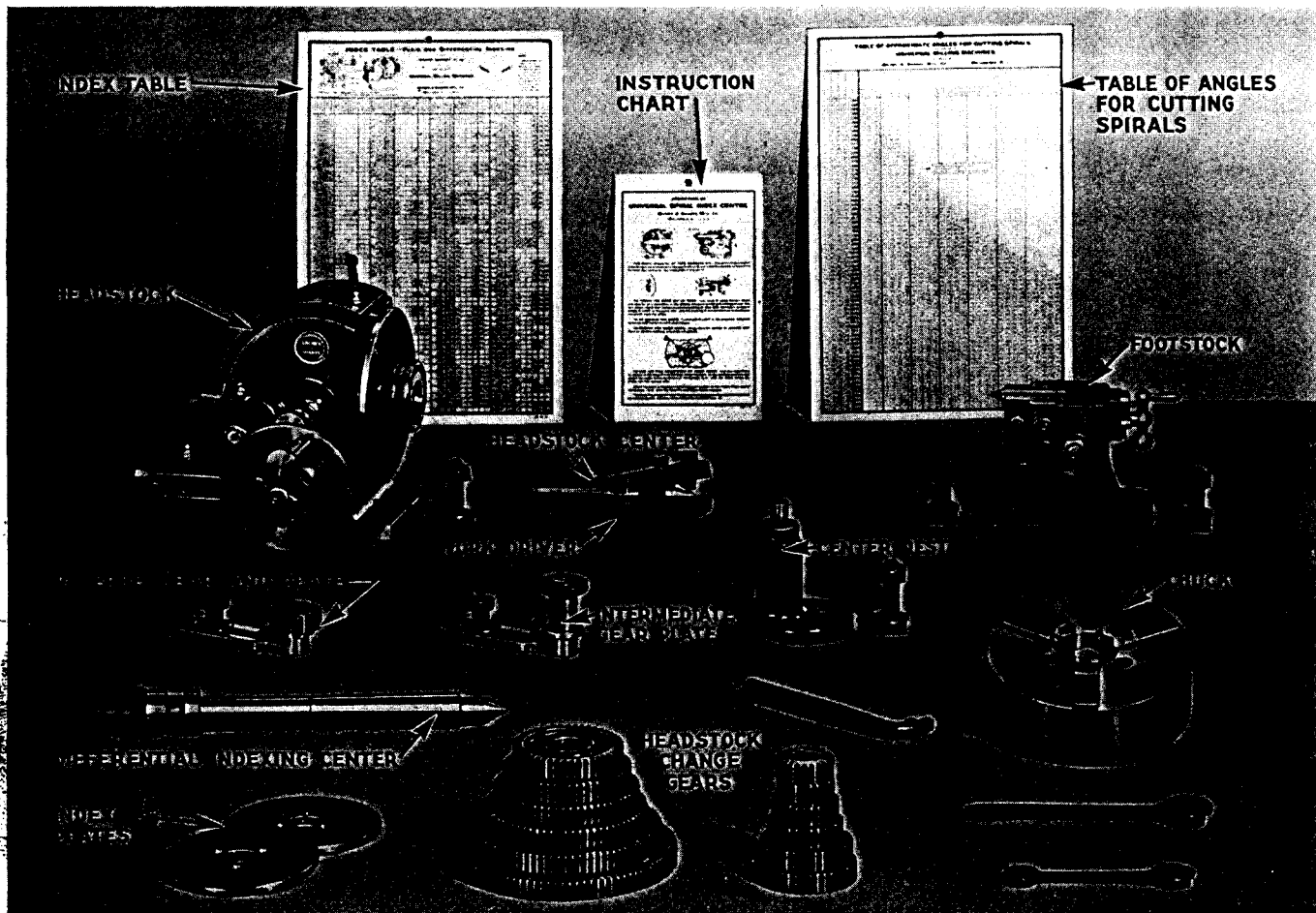


Fig. 15. Universal Spiral Index Centers and equipment.

To set the sector arms to the graduation listed 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 to be turned by hand, the headstock worm is disengaged as follows:

Referring to Fig. 17, turn the inner knob E about one-quarter of a revolution in the direction *opposite* to the direction indicated by the arrow stamped on the knob, using the pin wrench furnished. Then, continuing in the same direction, turn both knobs E and F together by hand until the mechanism comes against a positive stop.

To engage the worm, turn both E and F together in the direction indicated by the arrow until a positive stop is reached, then securely tighten knob E. To avoid damage to the worm and wheel,

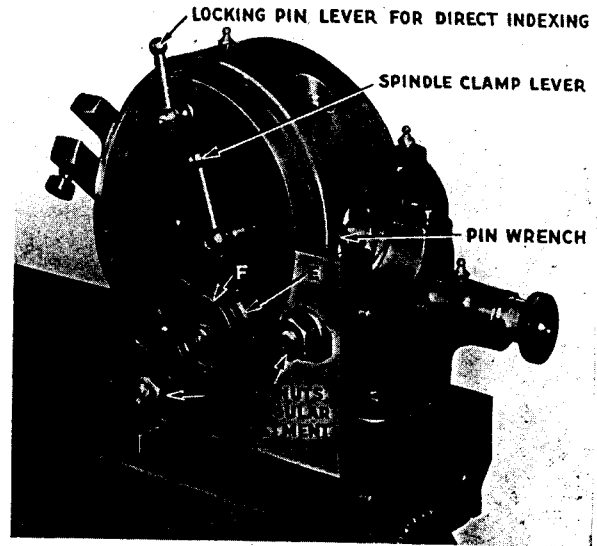
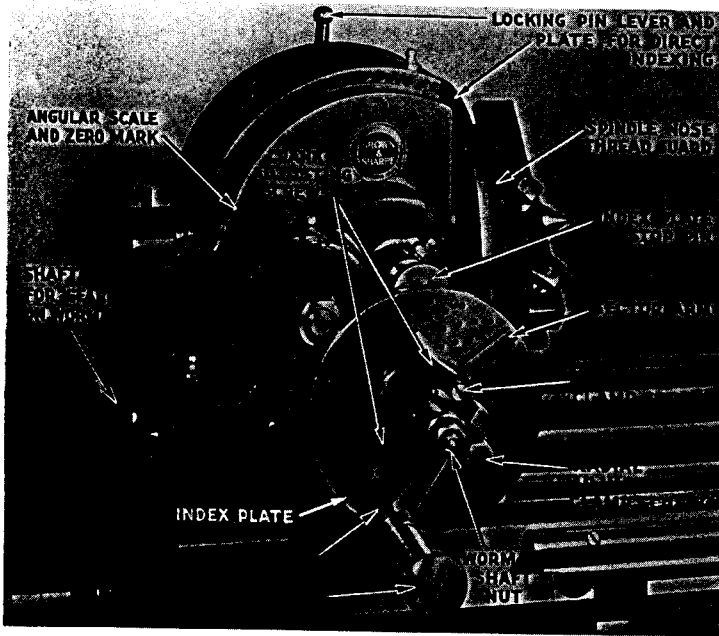


Fig. 16 (left) and Fig. 17 (above). Details of the Universal Spiral Index Centers headstock.

always make sure that the worm is either fully engaged or completely disengaged.

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 (see Fig. 16); 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; a sharp pull will remove it. Then remove the screw from the sleeve formerly adjacent to the crank (see Fig. 18) and slip off the sleeve and ball crank clutch as a unit. Take off the nut at the end of the table screw (Fig. 19), 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 right-hand clutch member (the part replaced next to the collar—see Fig. 19) 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

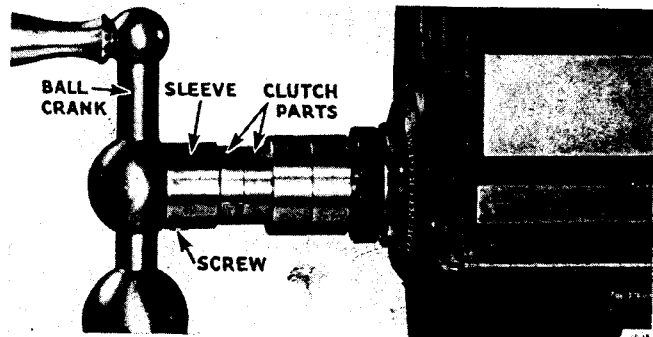
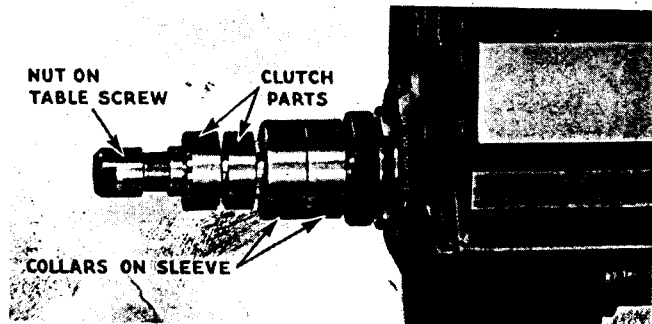


Fig. 18 (above) and Fig. 19 (below). Parts to be removed for installing "Gear on Screw". In lower illustration the ball crank, ball crank clutch, and sleeve have been removed and the nut on table screw loosened.



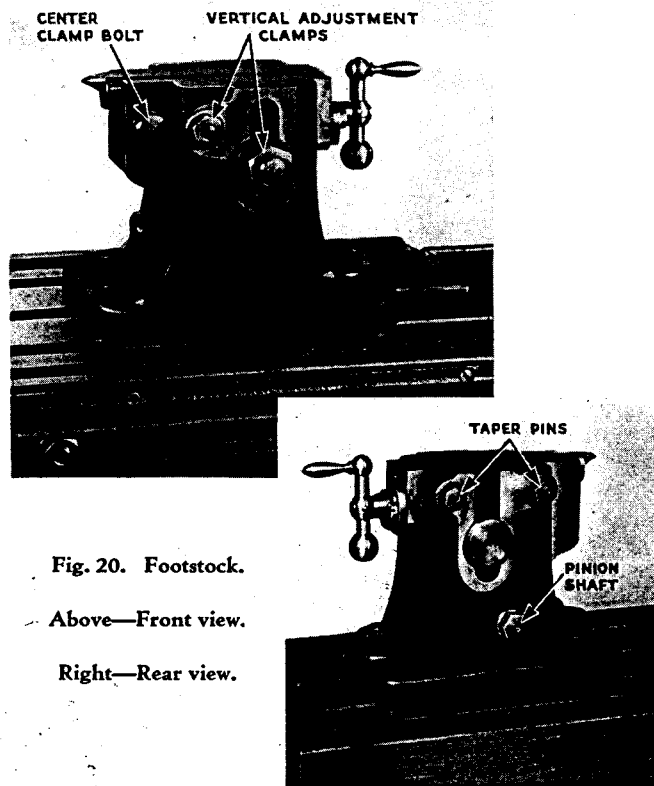


Fig. 20. Footstock.

Above—Front view.

Right—Rear view.

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.

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 (see above) but disengage power drive to the table screw, as follows:

Install the "Gear on Screw" as described above, but in reassembling the parts on the table screw turn the right-hand clutch member around so that its two teeth will face to the *left* 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 $\frac{1}{2}^\circ$. The angular setting is clamped by the two nuts at the rear, shown in Fig. 17.

Footstock Adjustments. The footstock adjustments and clamps are shown and identified in Fig. 20.

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

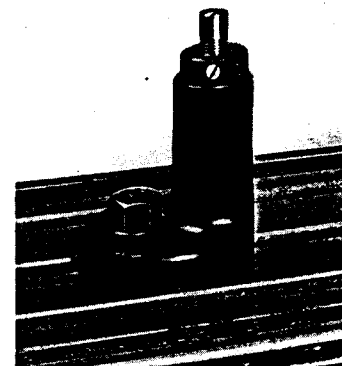
Releasing the two vertical adjustment clamps allows the center to be set at an angle in the vertical plane, and to be adjusted vertically above or below center height by turning the pinion shaft at the rear.

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. 21) 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. 21.
Adjustable center rest.



CHAPTER II

Typical Operations

The operations shown in this chapter are representative of the wide variety of work performed on these machines. 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 in the

space available in a book of this nature.

Note that in many instances the work shown on one machine could be performed equally well on another. For example, the cutting of spirals, which is usually thought of as a job for the Universal machine, can often be done on a Plain or Vertical equipped with Universal Spiral Index Centers.

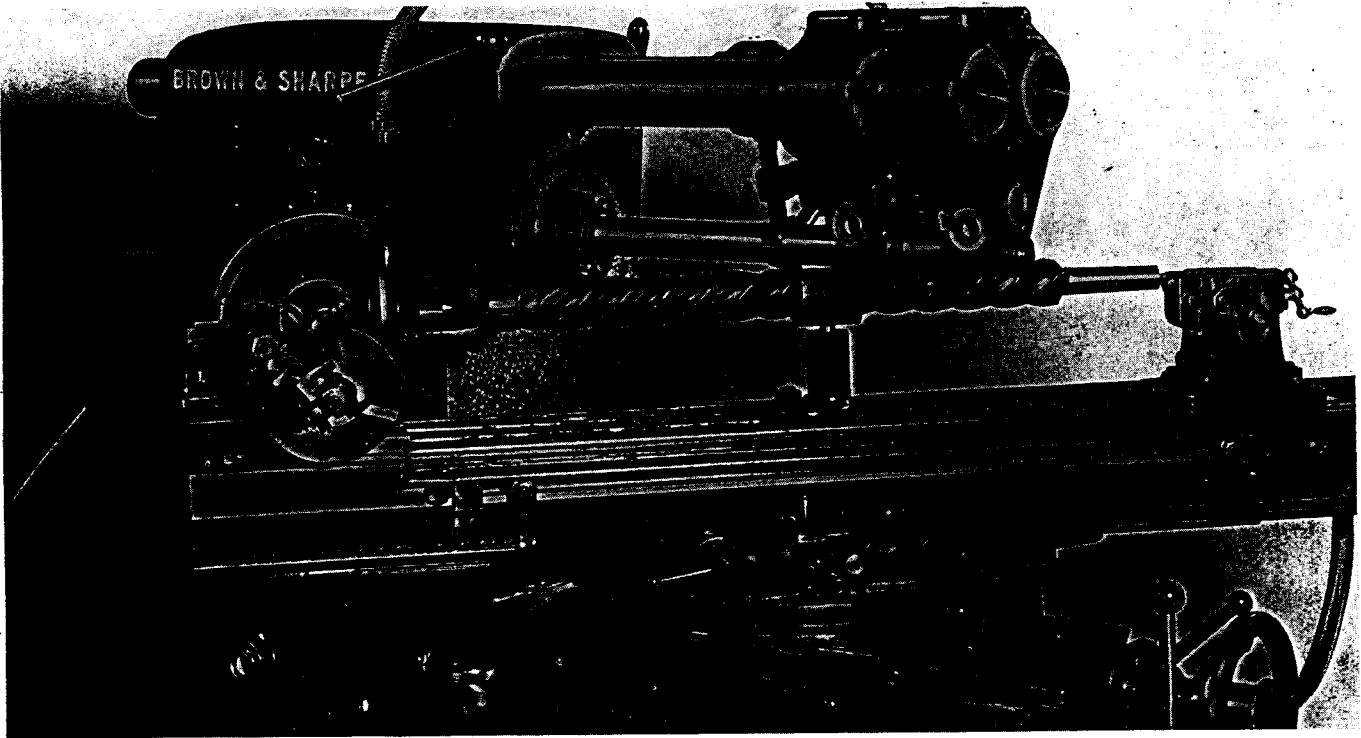


Fig. 22 (above). Taking a finishing cut on a 4-tooth arbor-type helical milling cutter. A Universal machine is used; and the arrangement of headstock gearing (here enclosed by Change Gear Guard) and angle at which to set swivel table are taken from a chart furnished. On completion of a cut, the work 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, and is supported in the middle by a special sleeve mounted on the center rest. Use of both arbor yokes assures adequate rigidity of cutter support.

Fig. 23. Cutting a straight-sided spiral on a Plain machine using an end mill held by an adapter in the machine spindle. This type of job can also be done on a Universal or Vertical machine using an equivalent set-up. Since in this instance the work, when finished, will be a helical cutter, the center lines of the work and end mill are offset enough to give the required undercut to the face of the teeth on the work.



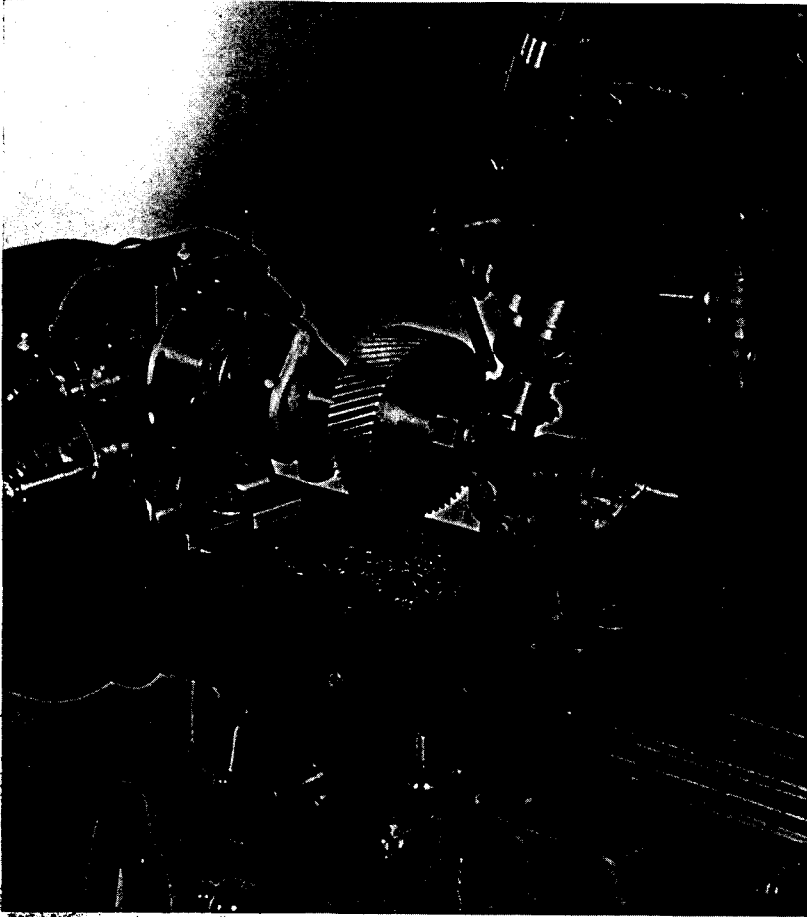


Fig. 24. This gear-cutting job is typical of the spiral work that can be done on the Vertical machine using Universal Spiral Index Centers. The spindle head of the machine is swiveled to the angle of spiral, and the table is adjusted vertically to bring the work centers in line with the center of the cutter.

Using a similar set-up, work of this sort can also be done on a Universal or Plain machine equipped with a Vertical or Universal Milling Attachment. On a Universal machine, however, the work would probably be done using a set-up similar to the one shown in Fig. 22 (preceding page) unless the angle of spiral exceeds the maximum swing of the table.

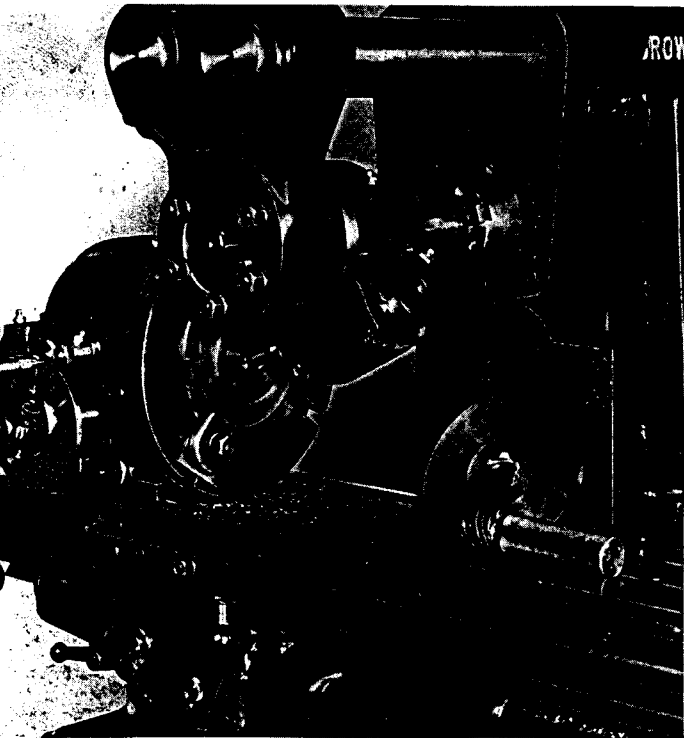


Fig. 25. Milling an internal thread, using a No. 0 High Speed Vertical Milling Attachment which is reversed on the overarms to bring the spindle to the desired position. With the table of the Universal machine set at zero, the Attachment spindle is set at the angle of spiral and the cut is taken at the front of the hole. The work is held on a special face plate mounted on the threaded nose of the headstock spindle.

Fig. 26. Milling teeth in a special cutter. The headstock is clamped with the spindle vertical, and the work is held in a chuck mounted on the threaded spindle nose. The work is indexed for each cut by plain indexing, and the table is fed to the right by power until stopped by a trip dog.

Rotary milling operations can often be performed on work held in the same way, using a vertically-mounted end mill. The work is rotated by turning the index crank or by power as described on page 18.

For jobs of these types beyond the capacity of this equipment, a Rotary Attachment can be used.

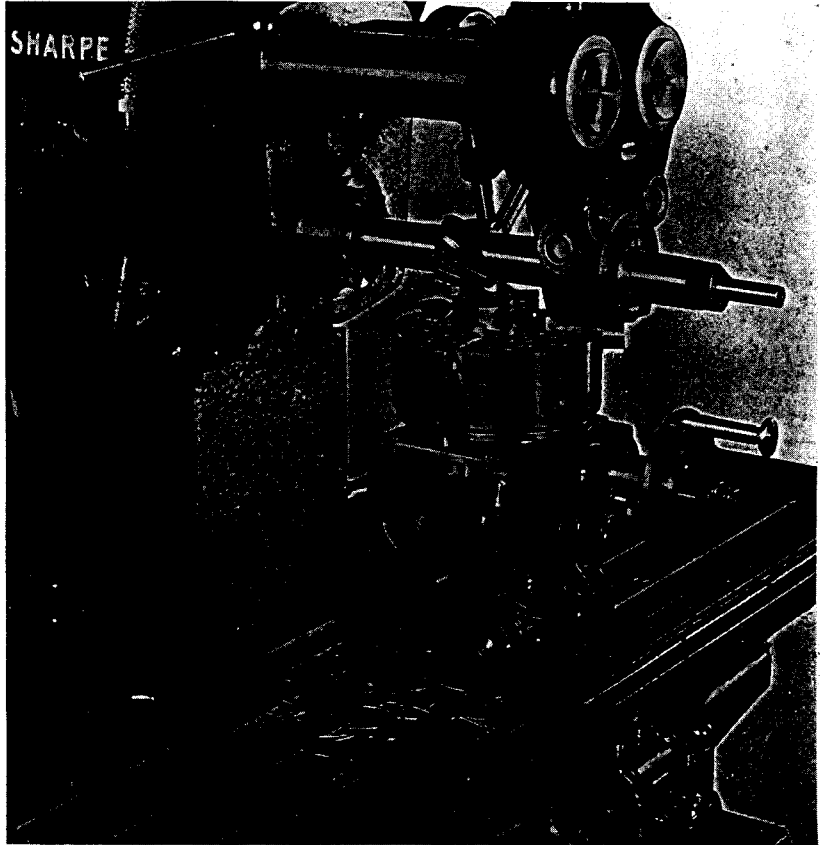


Fig. 27. A typical rotary milling job using a No. 0 Universal Milling Attachment and 18" Rotary Attachment. The work is located radially by a special stud in the center of the Rotary Attachment table and is held by the vise as illustrated.

In addition to milling circular slots and segments, Rotary Attachments are often used for indexing operations such as locating angularly-spaced holes or slots.



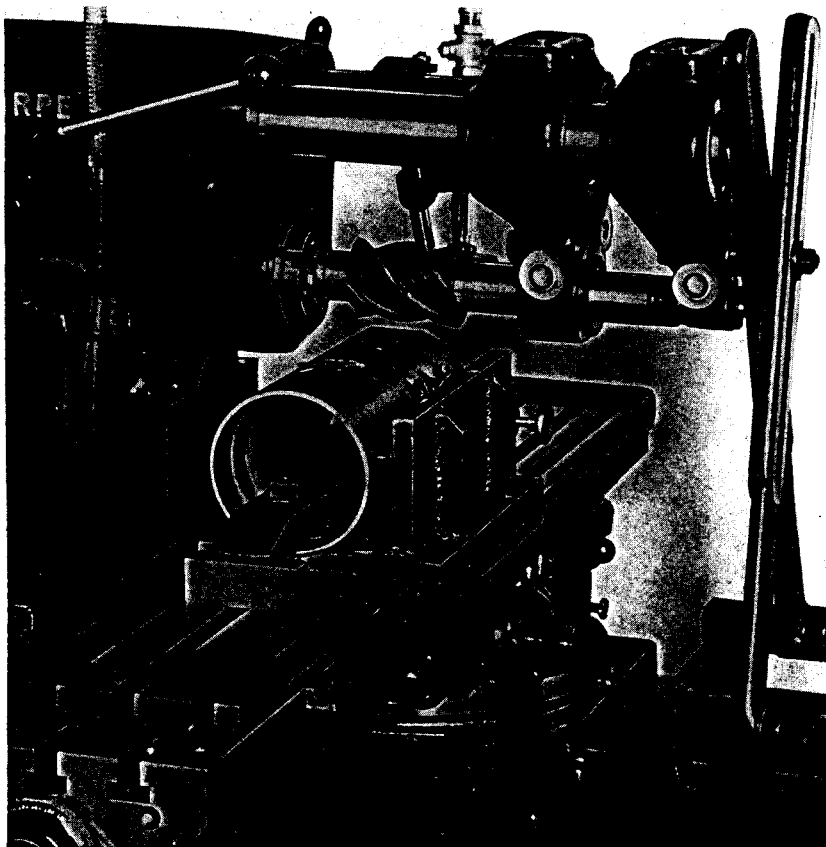


Fig. 28. This cylindrical part is securely clamped in the fixture at both ends before milling the flat shown. Since accuracy and good finish are called for in this job, rigid cutter support is essential; and this is obtained as follows:

The table is adjusted transversely to permit locating the cutter close to the spindle nose. The arbor bushings in the two arbor yokes are adjusted if necessary to give a good running fit with the arbor. The inner arbor yoke is mounted as close as possible to the cutter; and the outer yoke and arm braces rigidly anchor the overarms to the knee.

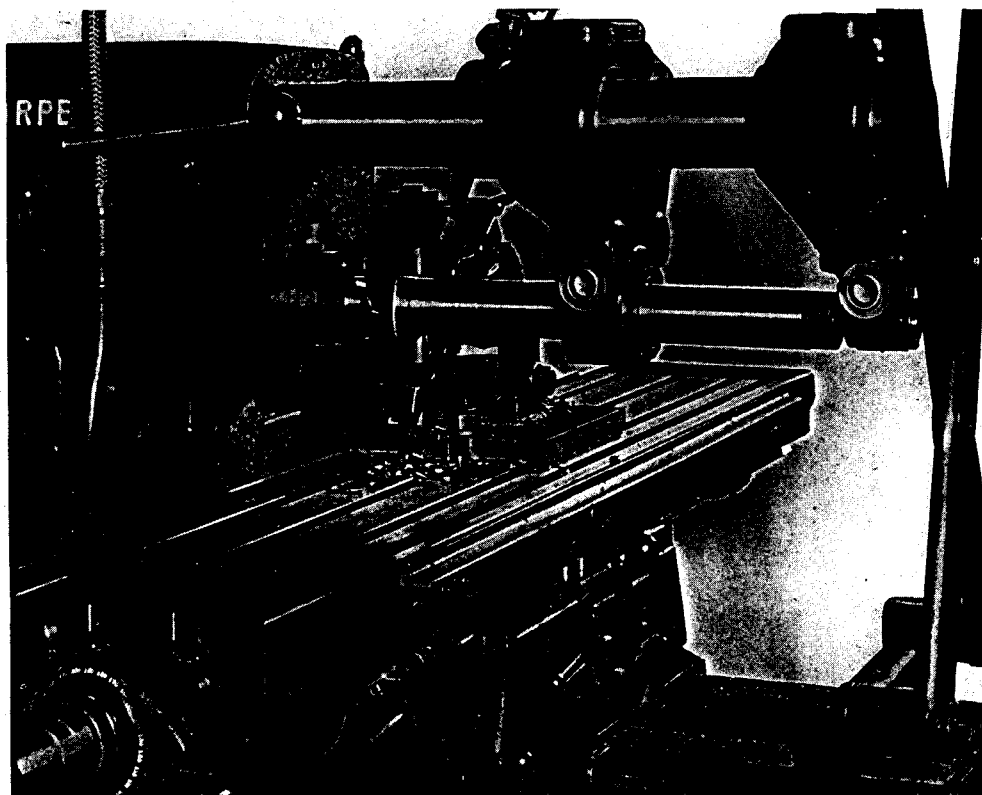


Fig. 29. Milling a blind slot in a part held in a fixture. The table is fed to the left, and is stopped by a trip dog at the desired depth of cut. For highest accuracy the cut would be completed by hand feed, using the positive table stop (see page 13) to locate the end of the cut.

Fig. 30. The clearance provided by the set-back face of the machine column allows this hard-to-reach surface to be machined without the use of special equipment. The work is securely strapped to the table, and the end mill is mounted in a Cam Lock cutter adapter held in the machine spindle by the draw-in bolt.

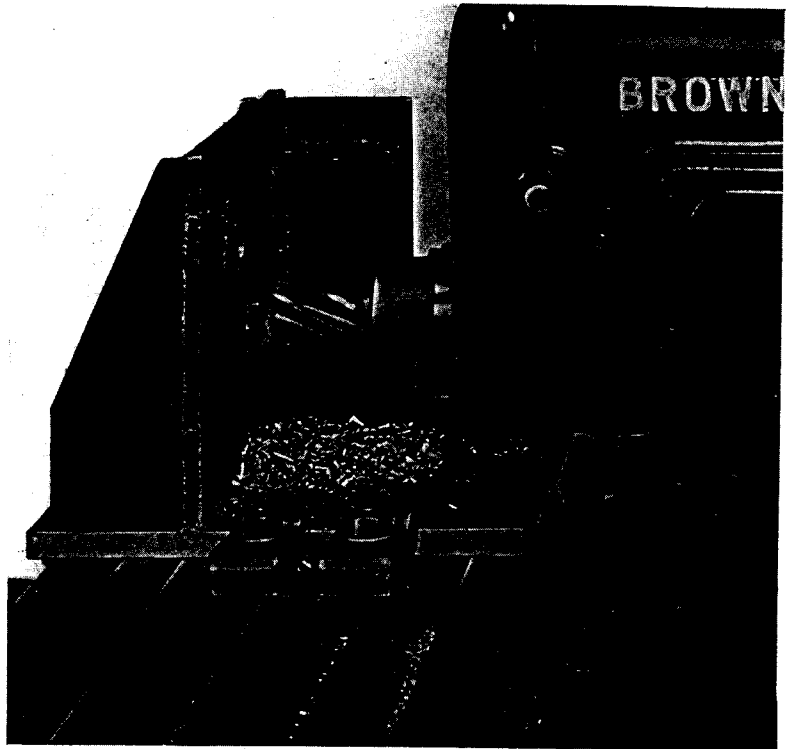
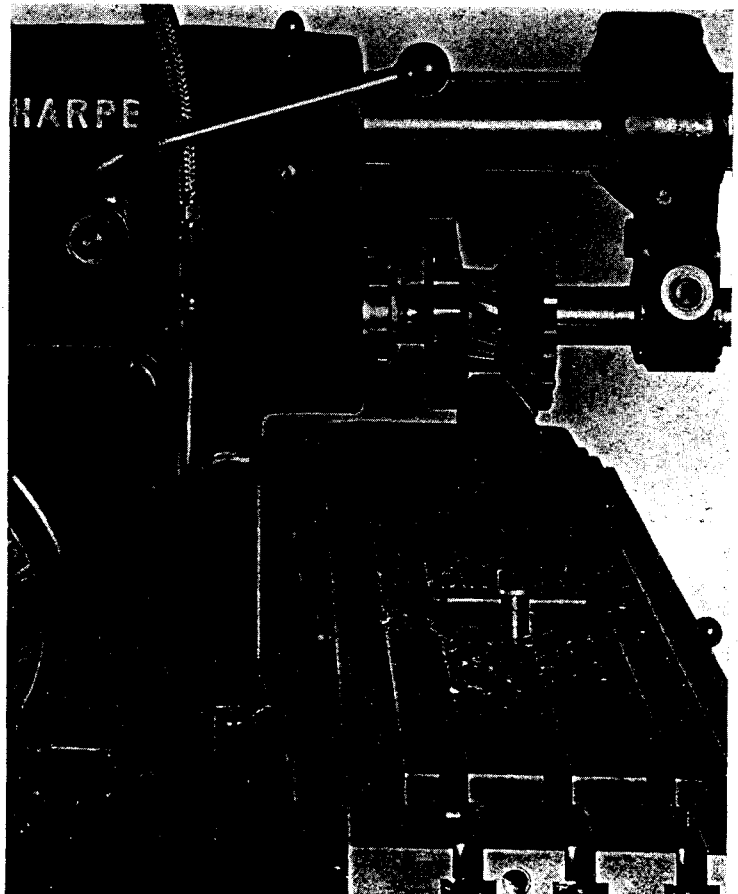


Fig. 31. Milling a form using a gang of three interlocking cutters. Note how the set-back face of the machine column allows the cutters to be mounted close to the spindle nose of the machine. Since arbor deflection (caused by the pressure of the cutters on the work) decreases rapidly as the cutters are brought closer to the spindle nose, the cutters should always be located as close to the spindle as possible in order to secure maximum cutter rigidity.



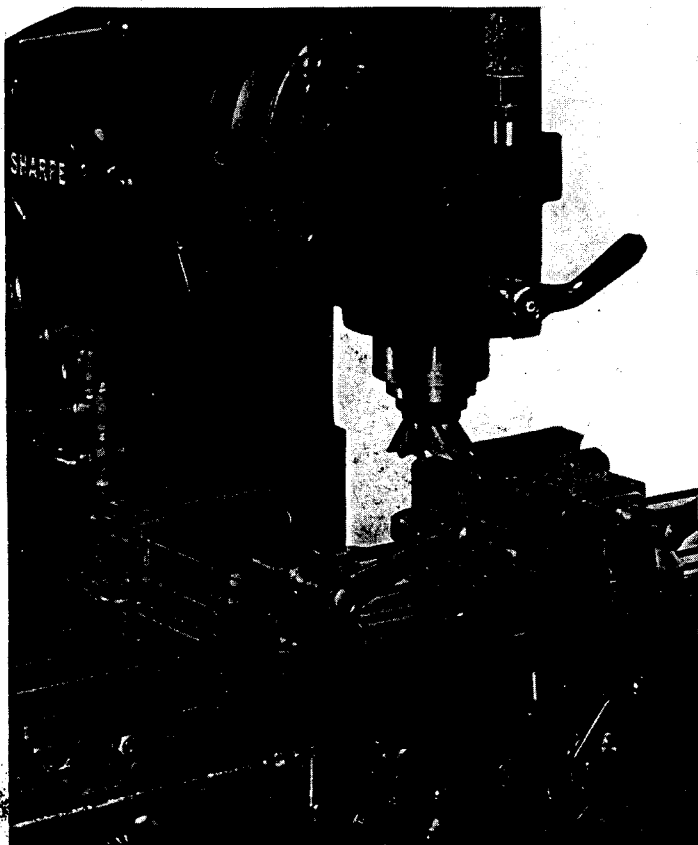
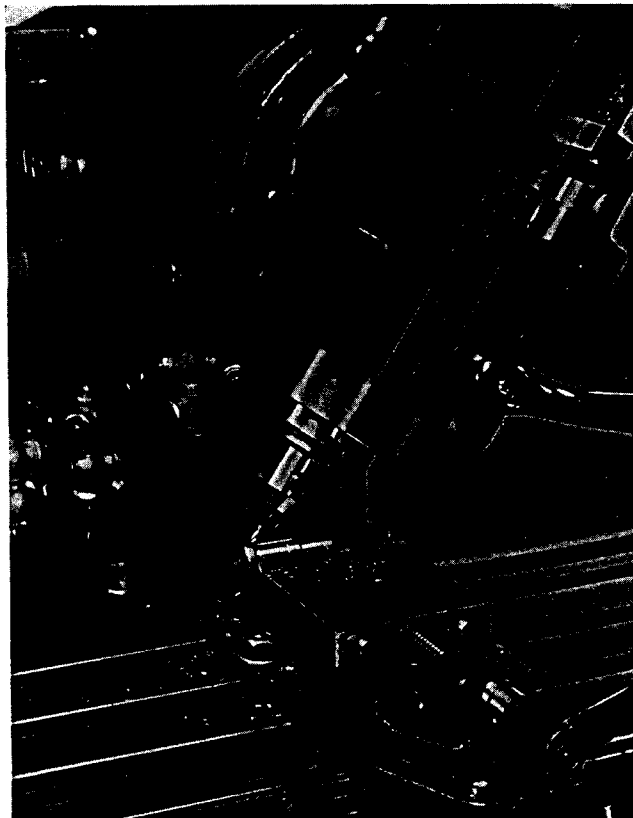
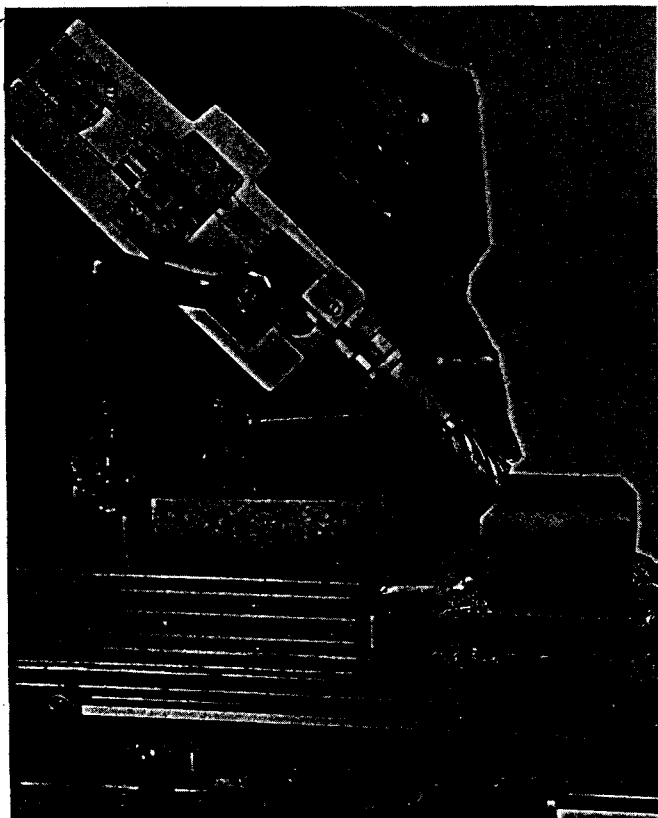


Fig. 32 (left). A production set-up on a Vertical machine. Steel parallels bring the cuts above the top of the vises. With the spindle stops in contact, the two front dovetails are milled; then the table is adjusted transversely and the two rear dovetails are machined. Using a gage block between the spindle stops, the height of the spindle is then adjusted and the top surfaces are milled as illustrated. For each pair of cuts, power fast travel is used to jump the gap between the two pieces.

Fig. 33 (lower left). A typical angular cut on a Vertical machine, using transverse feed with the spindle head set to give the required angle. By resetting the spindle head, cuts can often be taken at several different angles without relocating the work on the machine table.

Fig. 34 (lower right). Cutting a longitudinal oil groove with a Vertical machine, using a small end mill which is held in the spindle by means of an adapter bushing and cutter adapter. The spindle is set at an angle to allow the cut to run slightly into the vertical face of the work piece.



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. Unless otherwise noted, the equipment listed can be furnished for Universal, Plain and Vertical machines.

Coolant System

The Coolant System consists of a motor-driven centrifugal pump, 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 usually installed at our factory, 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.

With the Universal and Plain machines, a flexible supply pipe is furnished together with a distributor and adjustable bracket assembly of the type shown in Fig. 36. This unit can be quickly transferred to an overarm at the rear of the machine for storage. With the Vertical machine, a swivel-jointed distributor pipe is furnished instead; see illustrations on preceding page.

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 lower end of the flexible return pipe is usually connected to a hole in the top of the base near the column of the machine. On the Universal machine, when the table is swung to extreme

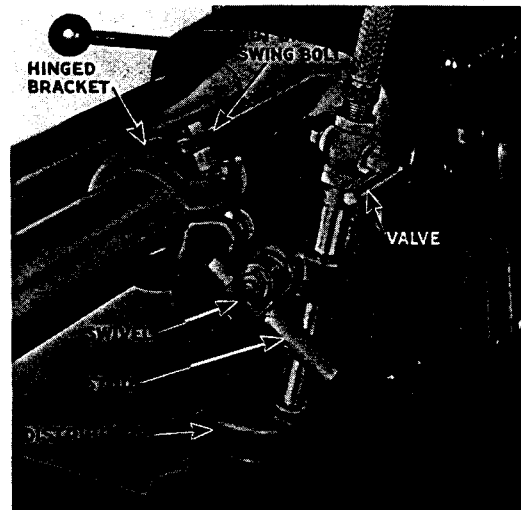


Fig. 36. Coolant distributor and bracket assembly for Universal and Plain machines.

angles the return pipe can be screwed into a hole near the front of the base if necessary.

The check valve is located just above the point where the delivery pipe comes out 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.

No. 0 Universal Milling Attachment

For Universal and Plain Machines

The two graduated swivels of this Attachment allow the spindle to be set accurately by half-degrees to any desired angle in any plane. Consequently this Attachment can be used for milling

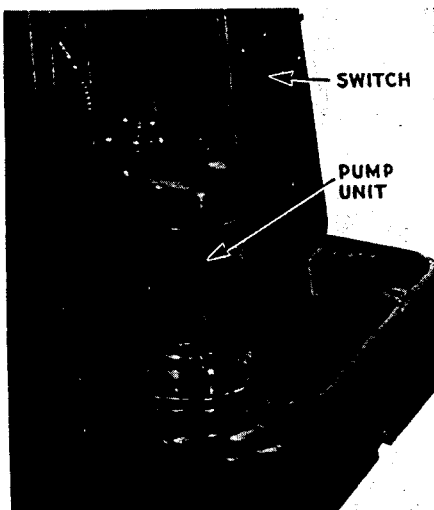


Fig. 35. Coolant pump and switch.

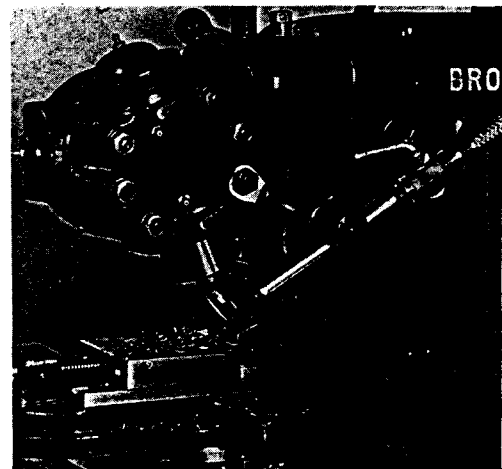


Fig. 37. No. 0 Universal Milling Attachment.

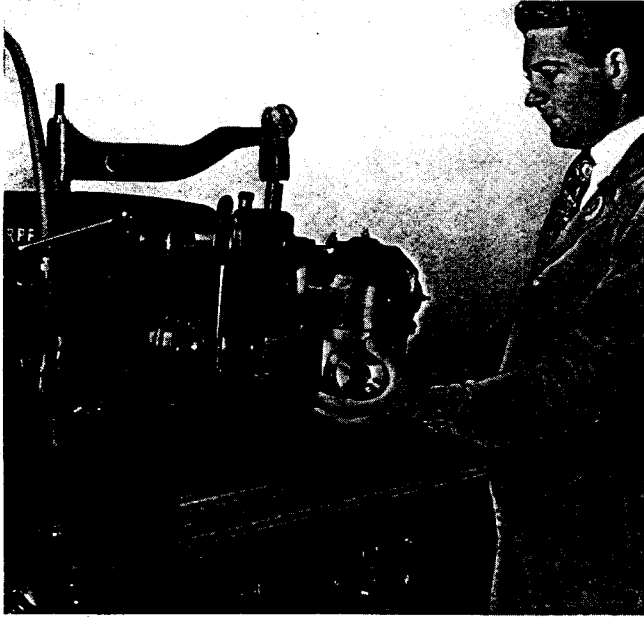


Fig. 38. Bringing Universal Milling Attachment into working position using Attachment Crane (furnished as an extra).

horizontal, vertical or angular slots and surfaces the same as with a vertical or compound vertical milling attachment; and in addition, the full universal adjustment facilitates such jobs as thread milling, rack milling and others requiring compound angular settings.

To install the Attachment on the machine, first set both overarms (but do not clamp them) so they project about three inches from the face of the column as shown in Fig. 38. Then line up the slots in the Attachment driving gear with the spindle keys of the machine. (One convenient method is to start with the spindle keys either vertical or horizontal.) Fit the Attachment onto the overarms and spindle and push it snug against

the face of the column. Tighten the two clamp bolts which fasten the Attachment to the column face, clamp the overarms, and tighten the vertical bolt at the top of the Attachment body to clamp the Attachment to the overarms.

The Attachment spindle regularly has a No. 30 Milling Machine Standard taper hole and the Brown & Sharpe Cam Lock construction. The Attachment can also be furnished with a spindle having a No. 9 B & S taper hole. Speed ratio of Attachment spindle to machine spindle is 2:1, the Attachment being suitable for speeds to 2700 r.p.m.

When the Attachment is used on a machine equipped with a Coolant System, the coolant nozzle is clamped in position as illustrated in Fig. 37 using the bracket furnished.

When the Attachment Crane is provided, the Universal Milling Attachment can be swung into (or away from) operating position with the minimum of time and effort and when not in use can be bolted to a finished pad provided on the side of the machine (see Fig. 39). The crane arm pivots on a stud which fits a tapped hole provided in the machine, and carries the Attachment by means of a traveler and adjustable stud.

No. 0 High Speed Vertical Milling Attachment

For Universal and Plain Machines

The high speeds available— $2\frac{1}{2}$ times the machine spindle speeds to a maximum of 3300 r.p.m.—suit this Attachment particularly to high-speed end mill and T-slot operations, drilling and boring.

The Attachment spindle can be set at any angle from vertical to horizontal in a plane at right angles to the machine spindle, clamp bolts at the rear maintaining the setting. Considerable transverse adjustment is also provided, the Attachment

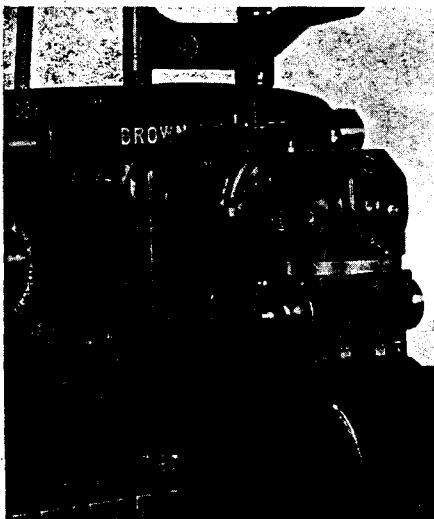
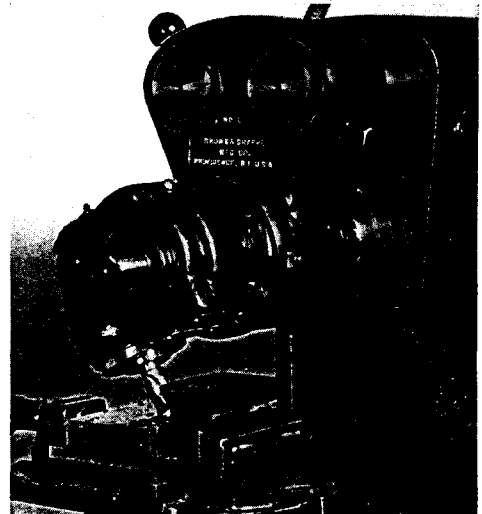


Fig. 39. Universal Milling Attachment in storage position.

Fig. 40. No. 0 High Speed Vertical Milling Attachment.



being reversed on the overarms to bring the spindle closest to the column of the machine.

To install the Attachment on the machine, first insert the driving arbor in the Attachment; then put the Attachment in position on the overarms, clamp the overarms and tighten the clamp bolt at the upper right side of the Attachment body. Finally, fasten the driving arbor in the machine spindle nose with the draw-in bolt of the machine.

The Attachment spindle has a No. 7 B & S taper hole; and a draw-in bolt is furnished, together with an "R" collet having a No. 5 B & S taper hole.

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

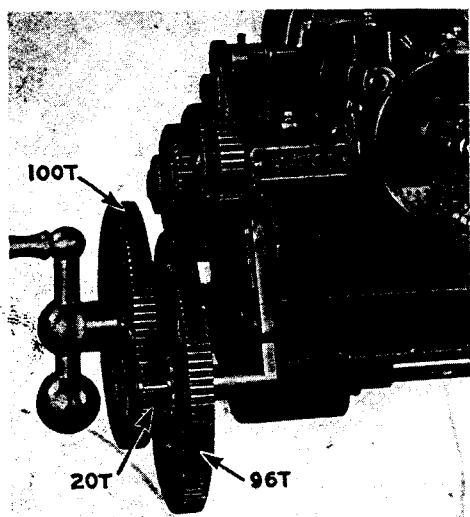


Fig. 41. No. 0 Short Lead and Feed Reducing Attachment.

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 in succession 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.

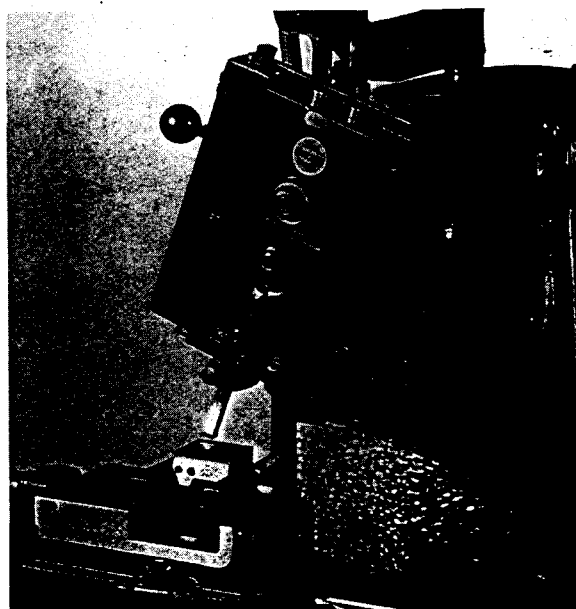
No. 0 Slotting Attachment

For Universal and Plain Machines

The Slotting Attachment 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

Fig. 42. No. 0 Slotting Attachment (shown with Attachment Crane).



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 2" may be selected; and the tool slide can be set at any angle to 90° either side of zero.

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 the Vertical machine, or on Universal and Plain machines equipped with a Universal or 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.

The Light Type machines take the 10" and 18" Rotary Attachments (Hand Feed) as well as the 18" Rotary Attachment (Power Feed) illustrated in Fig. 43. In many respects the two Hand Feed Attachments and the table unit of the Power Feed Attachment 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 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

Fig. 43 (below). 18" Rotary Attachment (Power Feed).

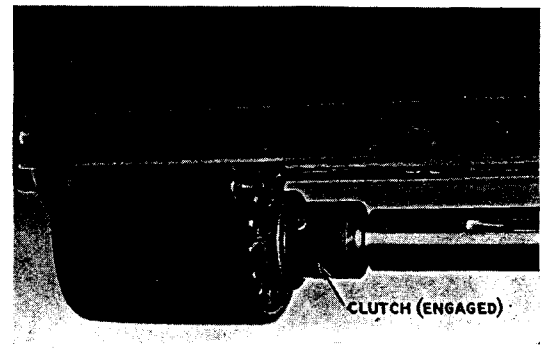
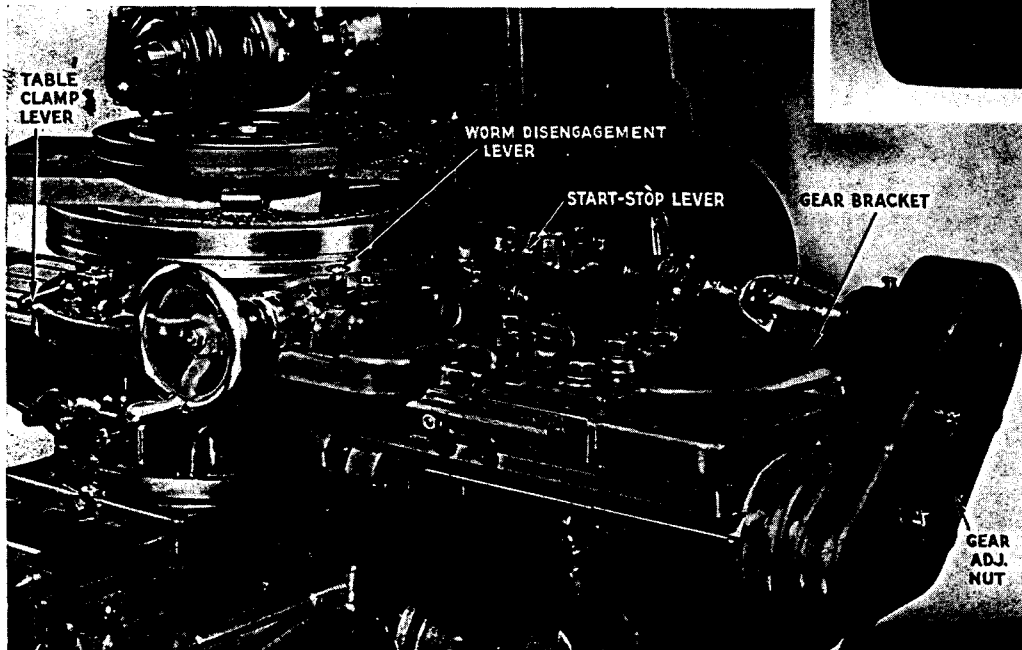


Fig. 44 (above).

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

of the machine table as illustrated in Fig. 43. 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. 44. 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 five or six 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

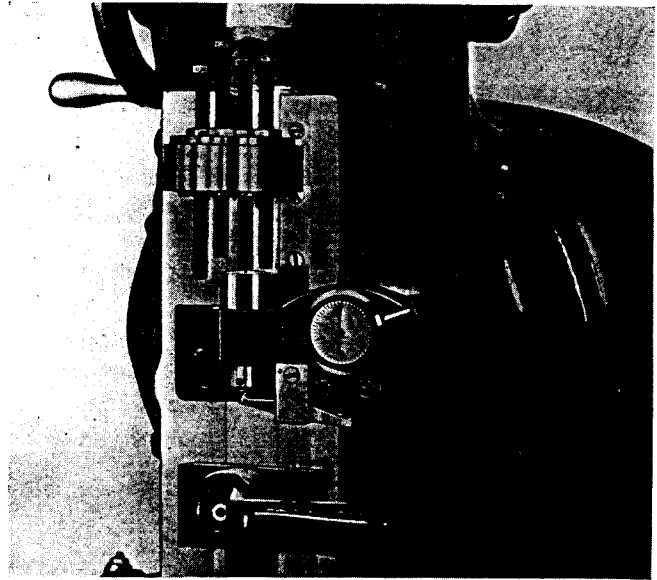


Fig. 45. Turret Type Spindle Stop with Dial Test Indicator.

divisions to 372. The index crank and sector are like those used on our Index Centers.

Turret Type Spindle Stop with Dial Test Indicator For Vertical Machines

A real time-saver on production work, this equipment provides a simple means of securing accurate duplication in machining parts to one, two, three or four depths. The turret mechanism permits quick indexing, while the dial indicator assures precision in setting the spindle for depth of cut.

As illustrated in Fig. 45, the arrangement takes the place of the two spindle stops regularly furnished and includes a turret, mounting bracket, four hardened stop screws with lock nuts, and a dial indicator and bracket.

One convenient method of setting the stop screws is to start with the spindle withdrawn, the knee clamped and the end of the cutter just touching a finished reference point or surface which is higher than the cuts to be taken. On the cylindrical anvil beneath the screw being set, place a measuring block the thickness of which equals the required advance of the cutter. Adjust the stop screw until it is in contact with the block, and lock it there. Then set the dial indicator to zero, withdraw the gage block and index the next stop screw into position. In adjusting the other stops it will not be necessary to set the dial indicator to zero,

for it will read zero automatically when the other measuring blocks are placed on the anvil.

In using this Arrangement, positive indication of the correct depth of cut is given when the proper stop screw is in contact with the pin in the anvil and the dial indicator reads zero.

No. 0 Micrometer Table Setting Attachment

This Attachment (not illustrated) 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.

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 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.

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:

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. The essential characteristics of this equipment are outlined below.

Universal Spiral Index Centers. Furnished as standard equipment with the Universal machine, these centers are available as extras for both the Plain and Vertical machines. Indexing can be performed and spirals cut with the headstock spindle either horizontal or at an angle in the vertical plane. The Universal Spiral Index Centers are described in detail on pages 15 to 18 of this book.

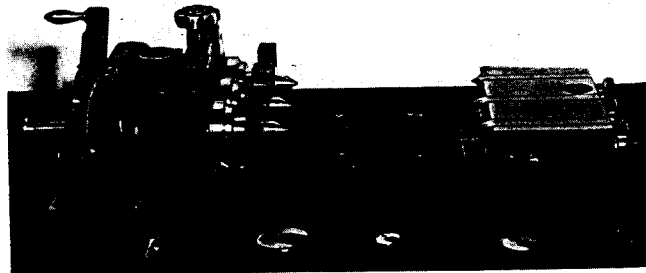
A hinged sheet steel **Change Gear Guard** completely enclosing the headstock gearing is available as an extra.

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. Four sizes available swing work to 6", 10", 12" and 14" diameter.

Plain Index Centers. Two sizes of Plain Index Centers take work to 10¼" and 16" diameter respectively, the larger centers being intended primarily for cutting parts which are too large and heavy for the usual milling machine indexing equipment. The Plain Index Centers accommodate horizontal work only.

No. 2½ Triple Index Centers. These centers (Fig. 46) 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. 46. No. 2½ Triple Index Centers.



CHAPTER IV Maintenance

Installing or Relocating the Machine

In lifting or moving the Universal or Plain machines, pass the hoisting rope under the two overarms next to the column at both front and rear. With the Vertical machine, pass one rope under the throat of the column and an auxiliary rope under the spindle motor guard at the rear. All three machines will be approximately in balance when the hoisting hook is located over a point slightly behind the knee-supporting face of the column, and adjustment for balance can be made by moving the saddle in or out. The Universal, Plain and Vertical machines weigh approximately 3750, 3550 and 3750 pounds respectively including Coolant System.

The machine should be located on a level and rigid floor which is free from heavy vibration. With the machine in position, screw down the lag screws until nearly tight, 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. After tightening the lag screws, test the level of the table surface again in both directions and readjust if necessary.

The subject of connecting to the power supply is covered on page 36.

Lubrication

All driving mechanisms throughout the column, knee and table, and all ways as well, 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.

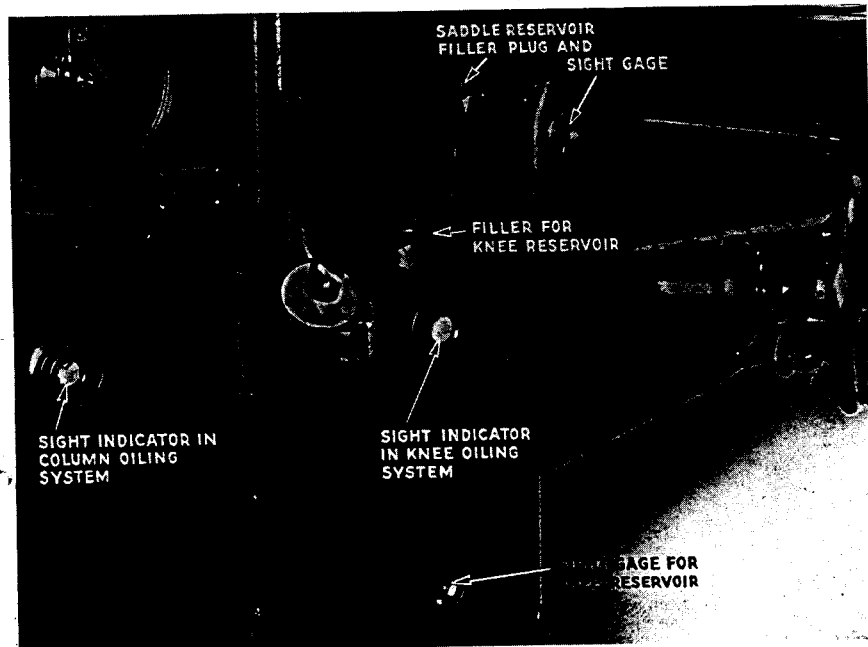
The fact that automatic oiling is provided should by no means lead the operator or maintenance man to forget the matter of lubrication. Check the level of the oil reservoirs weekly and refill as necessary (see Fig. 47). Also, look at the oil sight indicators occasionally during operation to make sure 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 few days.

Use a good grade of mineral oil of 300 seconds S.U.V. at 100° or S.A.E. 20 throughout.

The gears and bearings within the column are oiled by a plunger pump immersed in a reservoir in the column. The pump runs continuously whenever the spindle motor is running. The filler for the reservoir is on the side of the machine and has an overflow hole at the maximum oil level.

Fig. 47. Oil gages etc. for automatic lubrication systems. Combined filler and gage for column reservoir is on right side* of machine as shown in Fig. 48 (next page).



*On some machines this unit is on left side of column near sight indicator.

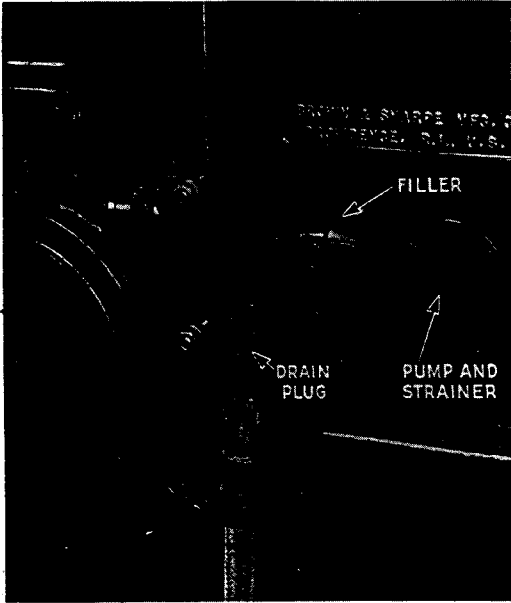


Fig. 48. Pump and strainer unit, drain plug and filler for column oiling system. (On some machines, filler is on other side of column near sight indicator.)

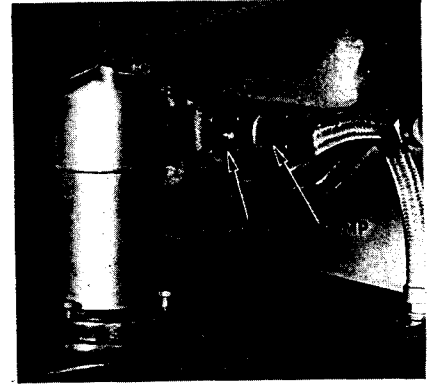


Fig. 49. Pump and strainer for knee oiling system. Drain plug is in bottom of knee behind elevating screw.

The pump and strainer unit is located in the right side of the column as illustrated in Fig. 48. 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.

All knee mechanisms and the vertical ways as well are oiled by a plunger pump immersed in a reservoir in the bottom of the knee (see Fig. 49). This pump runs continuously whenever the table motor is running and delivers oil to the automatic feed valve (Fig. 50).

The automatic feed valve has a spring-loaded hollow piston. When the machine is started, the oil pressure quickly moves the piston toward the front of the machine until a hole in the piston comes opposite to a port at the top of the valve body. Oil then flows through the pipe A (Fig. 50) to provide continuous oiling of the feed case gear-

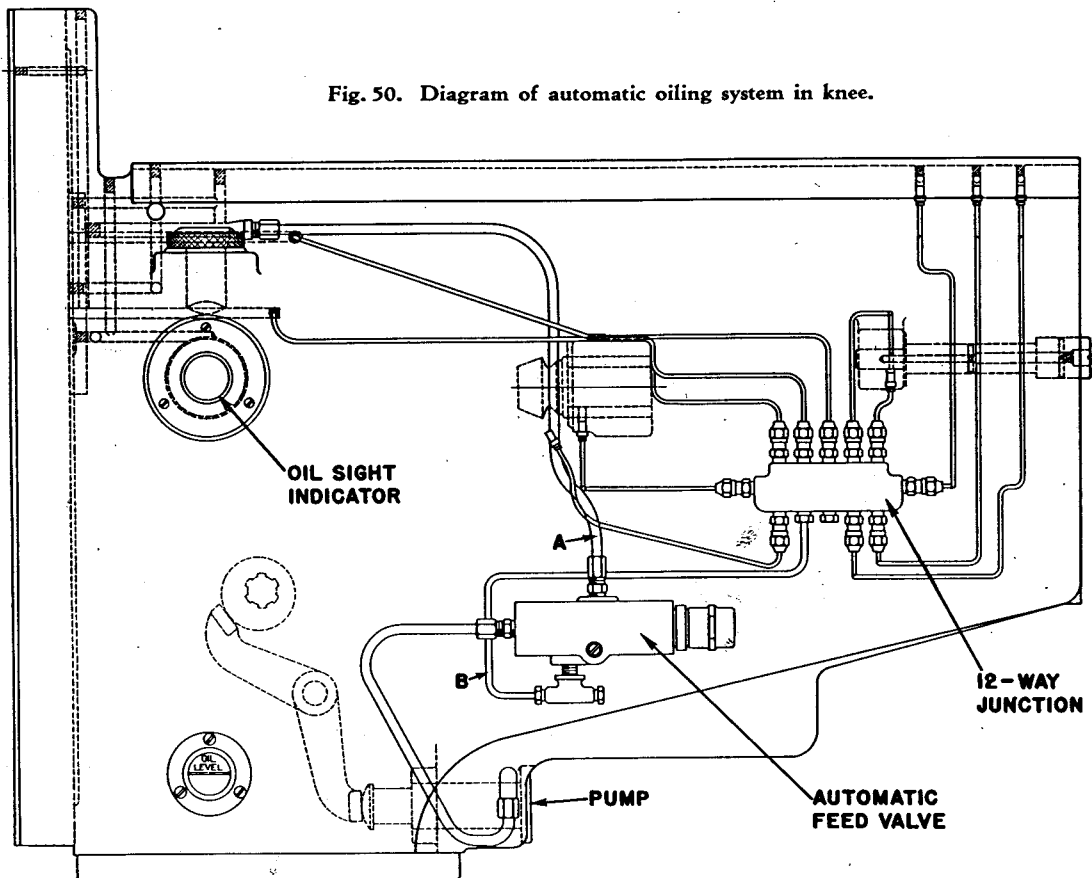


Fig. 50. Diagram of automatic oiling system in knee.

ing. 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 a port at the bottom. Oil then flows through pipe B to the 12-way junction (Fig. 50). 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 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. This unit is set at our factory and should require no attention.

The oil pump and the strainer can be removed individually. The pump is behind a circular cap (Fig. 49) and is held by a set screw in the bottom of the knee just behind the cap. A $\frac{1}{8}$ " pipe thread tapped in the end of the pump body permits easy removal. The strainer is held in by the four screws shown in Fig. 49 and has a tapped hole ($\frac{3}{8}$ "-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, the table ways and the bearing surfaces at the top of the knee are oiled from a reservoir in the back of the saddle by a pump 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.

The spindle head of the Vertical machine is grease-lubricated through a fitting at each end of the spindle feed handwheel shaft, one in the center of the spindle sleeve clamp lever hub and four on the left side of the head. Grease annually with a good grade of non-fibrous high-temperature bearing grease.

Arbor yokes are oiled manually by means of the push valve at the top of each yoke as described on page 14.

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.

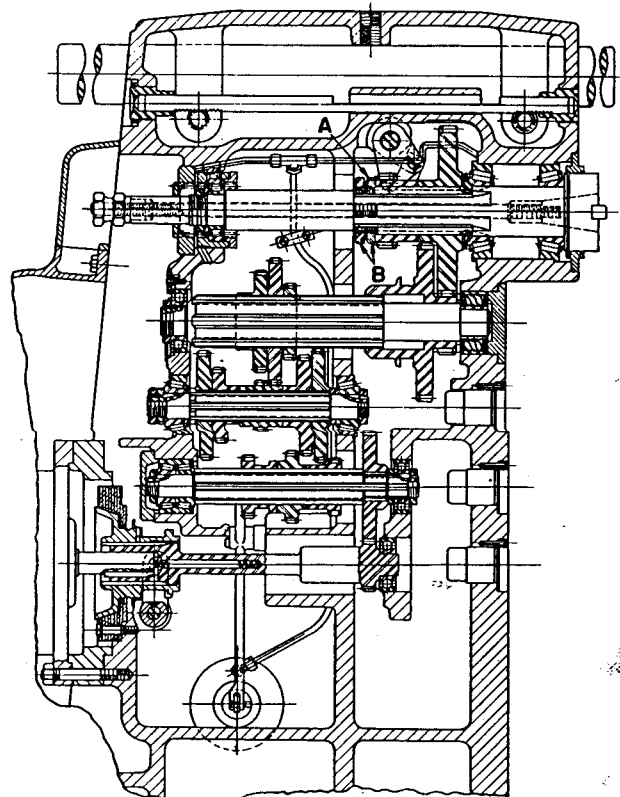
Section drawings (Figs. 51, 52 and 55) will be of assistance in diagnosing and curing any troubles in the spindle and table driving mechanisms, and the illustrations in the Repair Parts section will be found of considerable help in disassembling and reassembling all parts of the machine.

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.

Spindle Bearings

Universal and Plain Machines. To adjust the front spindle bearings, first remove the cover plate 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. Straighten the lock washer A (Fig. 51), tighten the two nuts B one notch at a

Fig. 51. Developed section through spindle drive of Universal and Plain machines. Vertical machine has similar mechanism except spindle shown is replaced by driving shaft.



time until play is removed (one or two notches will usually be enough) and bend the washer to lock the nuts.

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

Vertical Machine. To adjust the lower spindle bearings, remove plug A (Fig. 52), straighten the lock washer C and tighten nuts D. Lock the adjustment with the washer.

To adjust the spindle gear bearing, remove plug B (Fig. 52), straighten lock washer E and proceed as above.

To remove the spindle, take out the clamp lever F and its stud (Fig. 52), remove the screw and washer H at the top, unscrew cap G, take off the nuts at the top of the spindle and slide the spindle out of the head.

Fast Travel Clutch

This friction clutch is at the right of the spiral gear at the top of the feed case (see Fig. 54, next page) and is controlled by the fast travel lever. Takeup for wear is made as follows:

Referring to Fig. 53, 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 enough to clear plug F inside the knee, turning the cross feed handwheel to allow the shaft to pass between the spokes. Re-

move plug F; then turn the clutch body until the loop on the end of flat spring G can be reached. Lift spring G with a stiff bent wire, hold the right-hand member stationary and turn the knurled collar H one tooth toward the rear of the machine.

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. 54 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

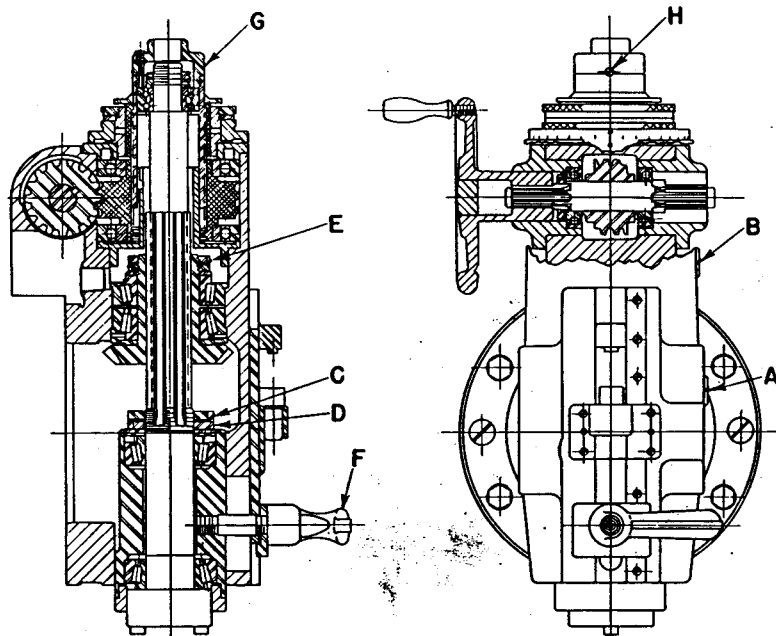


Fig. 52. Spindle head of Vertical machine.

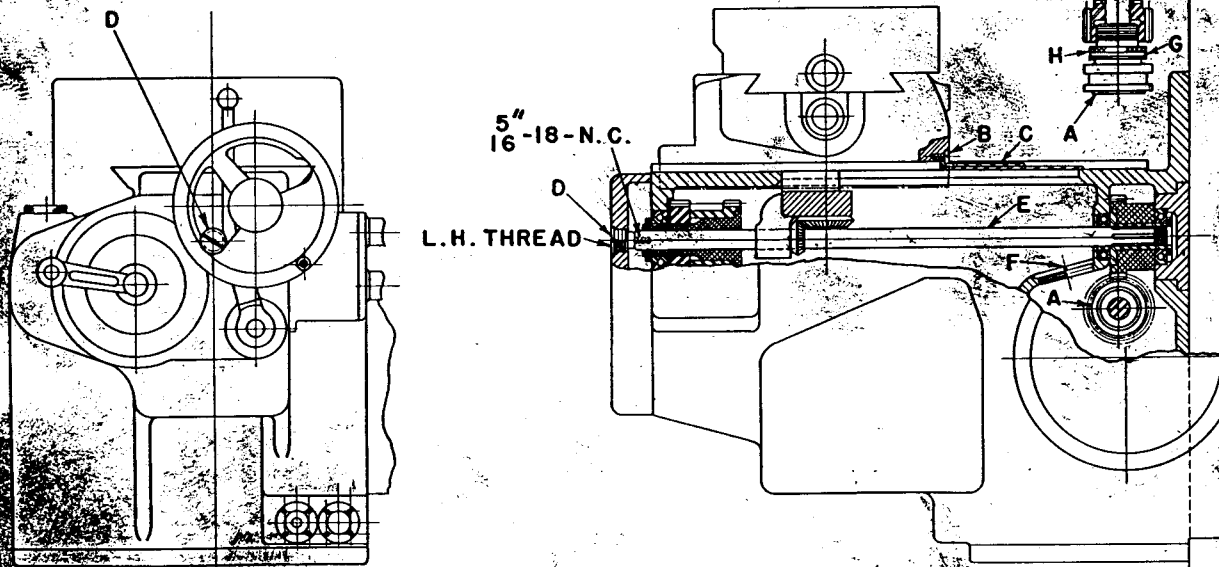


Fig. 53. Adjustment of fast travel clutch.

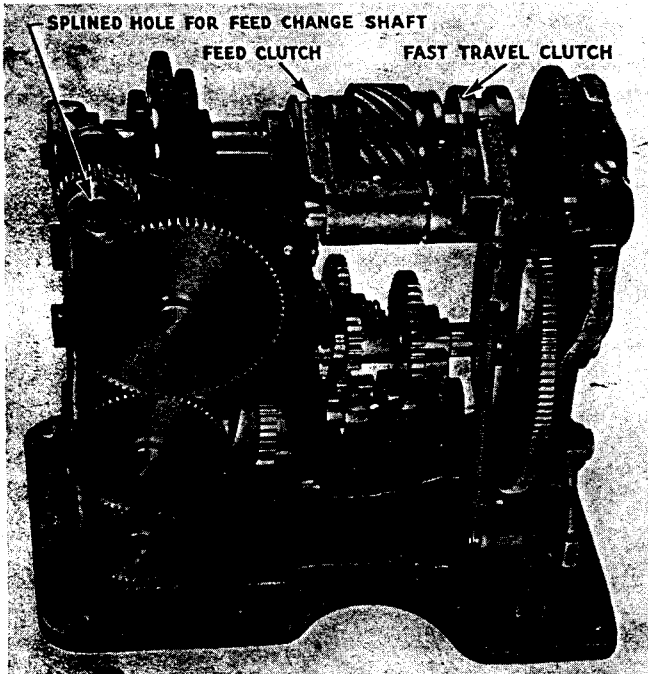


Fig. 54. Feed case.

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. If, on some machines, the shaft does not come far enough forward, remove the pin from the fast travel lever hub and loosen the seven screws in the case or bracket at the front of the knee enough to permit this unit to be pulled forward a slight amount to free the shaft.

Next remove the table motor. First disconnect the wires at the motor, pull them through into the case on the side of the knee and remove the lock nut inside the case to free the conduit (see Fig. 57, next page). (On later-design machines having rigid conduit, unscrew the conduit bushing in the motor junction box after disconnecting the wires, and swing the conduit downward to clear the motor.) Then take out the motor mounting screws and the motor will come right off.

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.

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.

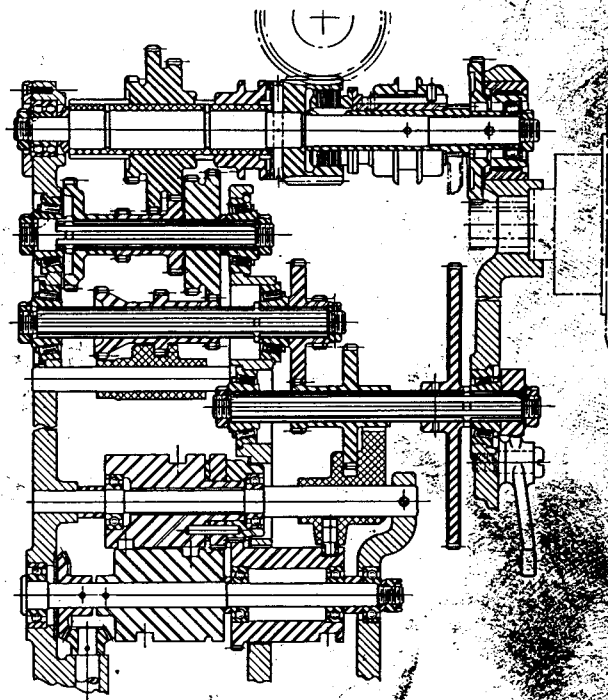
In replacing the feed case, first make sure that the gasket is in good condition. If difficulty is encountered in getting the feed case all the way into the knee, remove plug F (Fig. 53, page 34) as described under "Fast Travel Clutch" and work through the hole to fit the dog into the slot in the brass fast travel clutch shoe.

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.

Fig. 55. Developed section through feed case mechanism.



Electrical Controls

Connecting to Power Supply. The machine should be connected to the power line through a disconnect switch and should be properly grounded. The power wires are led into the machine through a hole in the lower right side of the column (see Fig. 58, next page). They may be connected to the line wires furnished on the machine, but are preferably run directly to the terminals to which the line wires are connected.

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. 6, page 12) 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.

Start-Stop Switch Unit. The machine start-stop switch assembly is located in a covered compartment in the right-hand side of the column (Fig. 56). The mechanical adjustments are for assembly purposes only and should not be tampered with.

Clutch Solenoid. The clutch solenoid in the right-hand side of the knee (Fig. 57) operates a

Fig. 56. Start-stop switch unit and operating mechanism. (Universal or Plain machine illustrated.)

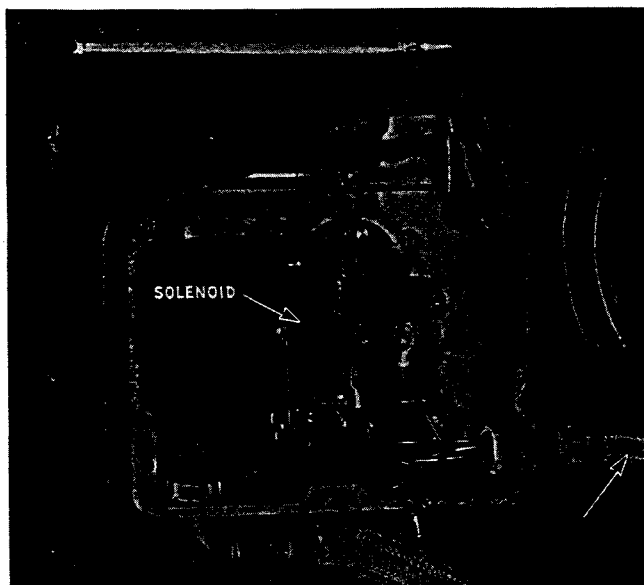
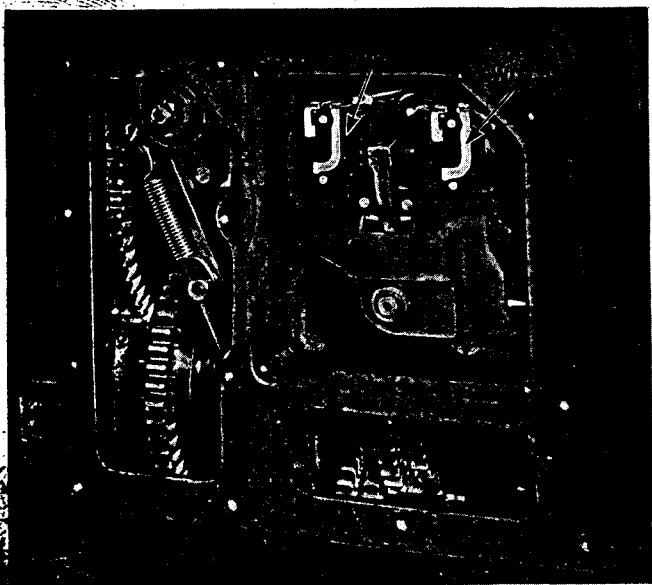


Fig. 57. Solenoid in knee compartment (cover removed). Solenoid is energized while table motor is running. When motor is stopped, spring in feed case brings linkage to position shown.

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. 58.

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. 58) 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 at the top. The transformer has sufficient extra capacity to supply power for a 100-watt light.

Magnetic Switches and Overload Relays. These units, illustrated and identified in Figs. 58 and 59, are mounted on panels behind hinged covers in compartments in the right side and rear of the machine column.

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 the trouble, as follows:

First change each of the overload relays identified in Figs. 58 and 59 from automatic to hand

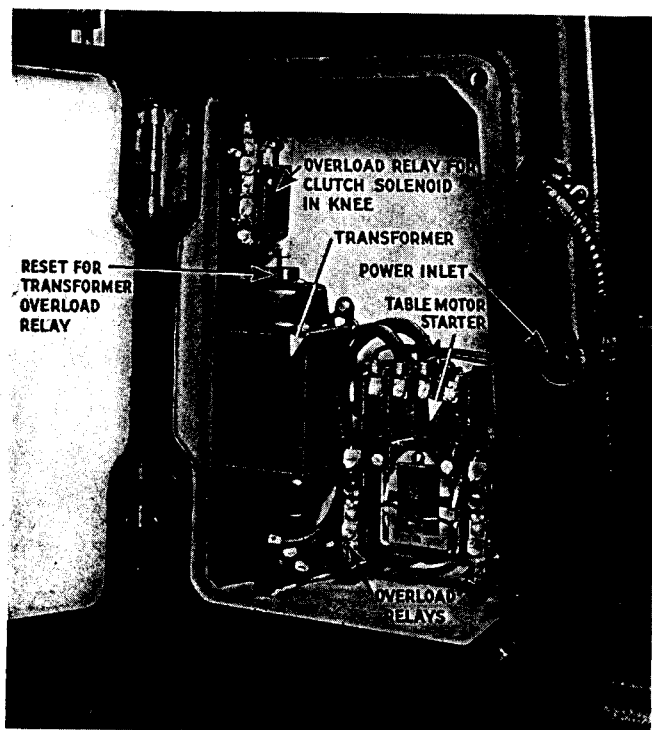


Fig. 58. Electrical controls in compartment in right-hand side of column.

reset by moving the wire loop of each relay to the position indicated on the relay itself. Then start the machine and run it until it is stopped by a relay tripping out. After the relay has had time to cool, push each reset plunger in succession 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. (The sample diagrams on page 38 are for 3-phase 60-cycle installations.) 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 sandpaper 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

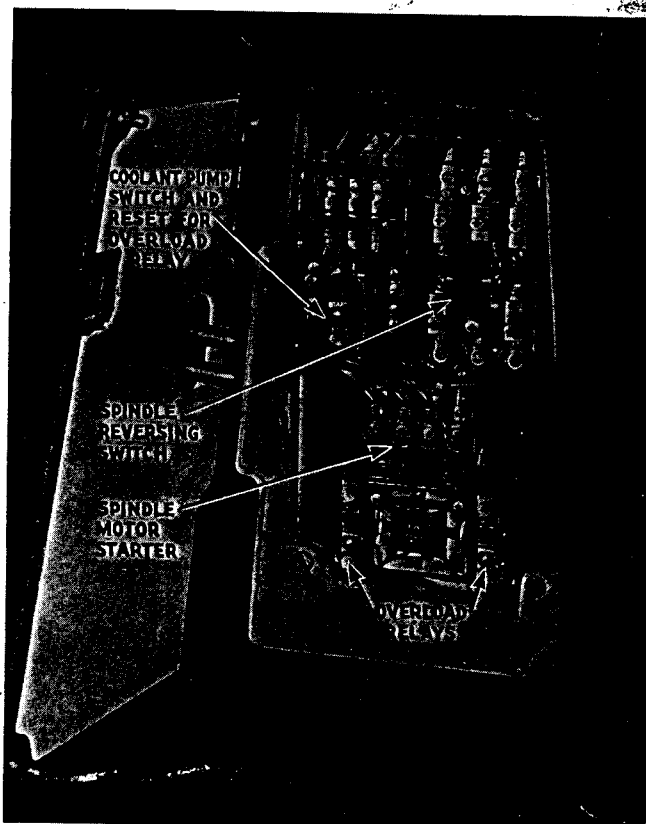
Much maintenance work can be avoided by keeping the machine clean and in good condition. Furthermore, on a machine which is given proper care the operator will produce accurate work with much less trouble and effort than on a machine which has been neglected.

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 and dirt into the

Fig. 59. Electrical controls in compartment in rear of column.



PART II
REPAIR PARTS
 for
No. 2 UNIVERSAL, No. 2 PLAIN and
No. 2 VERTICAL MILLING MACHINES
LIGHT TYPE

REPLACEMENT parts are listed and illustrated in this section of the book. To facilitate the identification of parts as well as stripping and assembling, the parts are shown separated and are arranged so far as possible in the same relative position as in the machines.

In some cases when a part is ordered, not only that part but one or more supplementary parts also may be sent. This is done when, from our experience, it is known to be advisable for a more satisfactory repair job.

When ordering repair parts it is essential that the size, style and serial number of the machine be stated in addition to the part number and name given in the following pages.

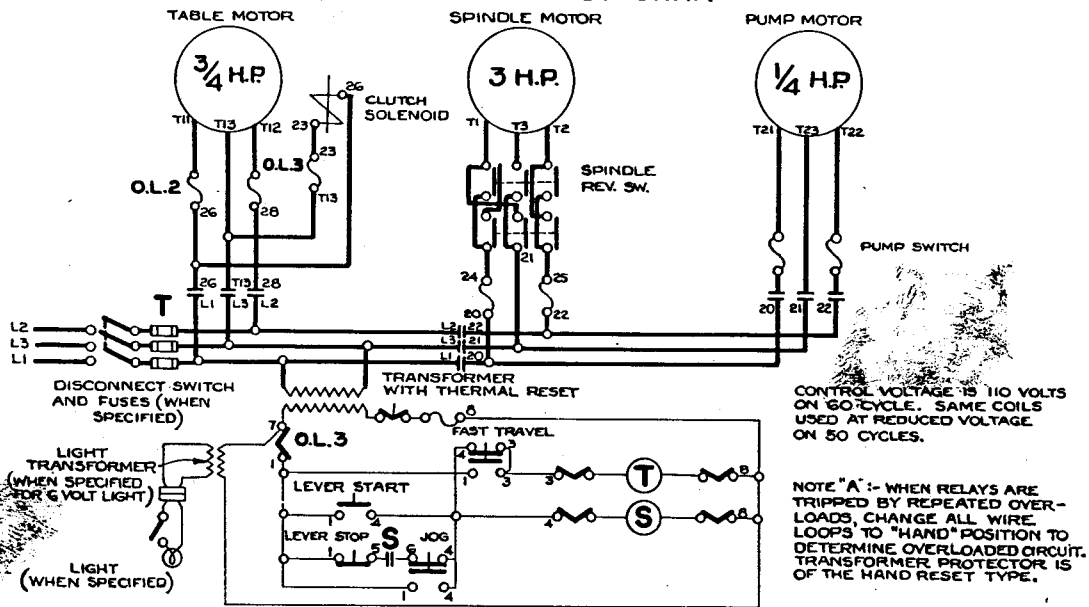
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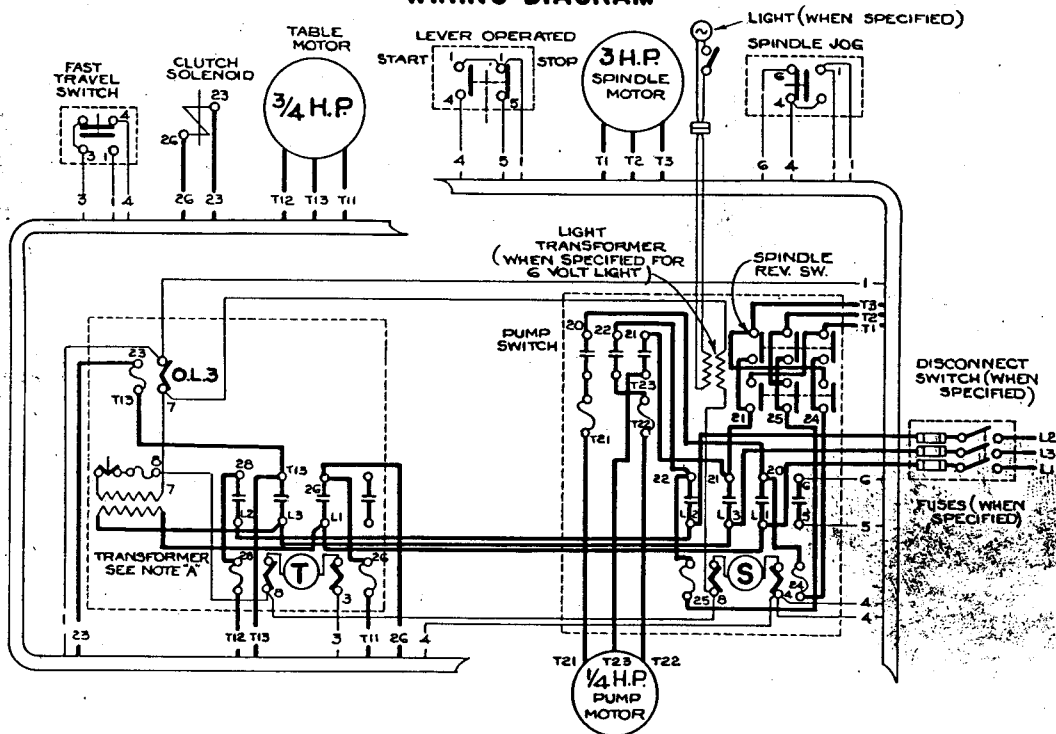
IMPORTANT

Parts illustrated in this book are *finished* parts and are shown for identification purposes only. In some cases repair parts as furnished will require fitting and therefore may need to have holes drilled, shoulders squared or other machining in order to make them fit properly.

ELEMENTARY DIAGRAM



WIRING DIAGRAM



Elementary and wiring diagrams for 3-phase 60-cycle installations.

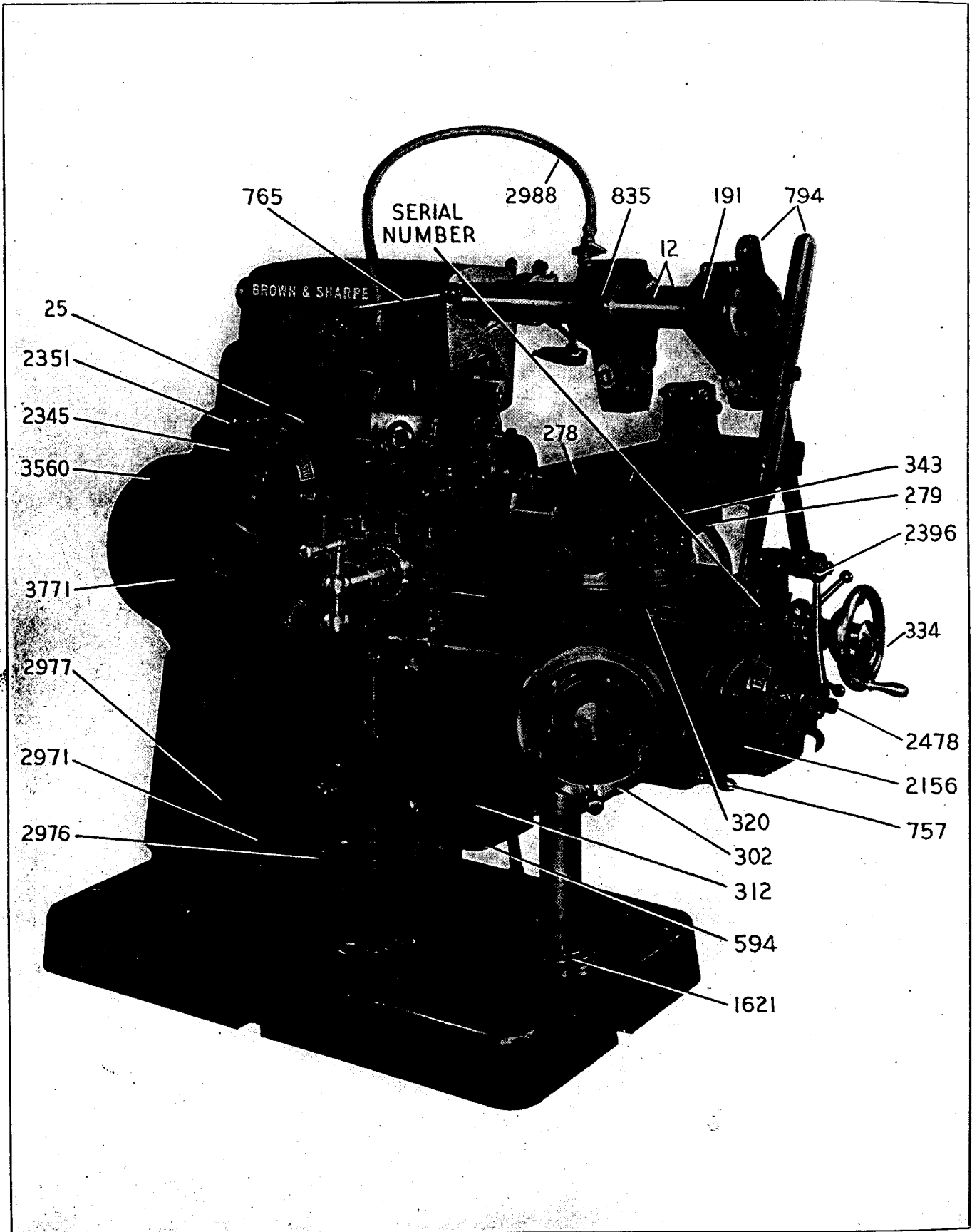
machine or into other machines nearby. In general, it is much better to flush with coolant or, if necessary, to clean with a brush.

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

Cutters, tools and work should never be dropped

onto the top of the table. Place them there gently if at all, to avoid bruising the table surface. Wrenches should be kept in the wrench racks provided on the knee.

Remember to clean out the coolant occasionally. Large openings in the top make this an easy task.



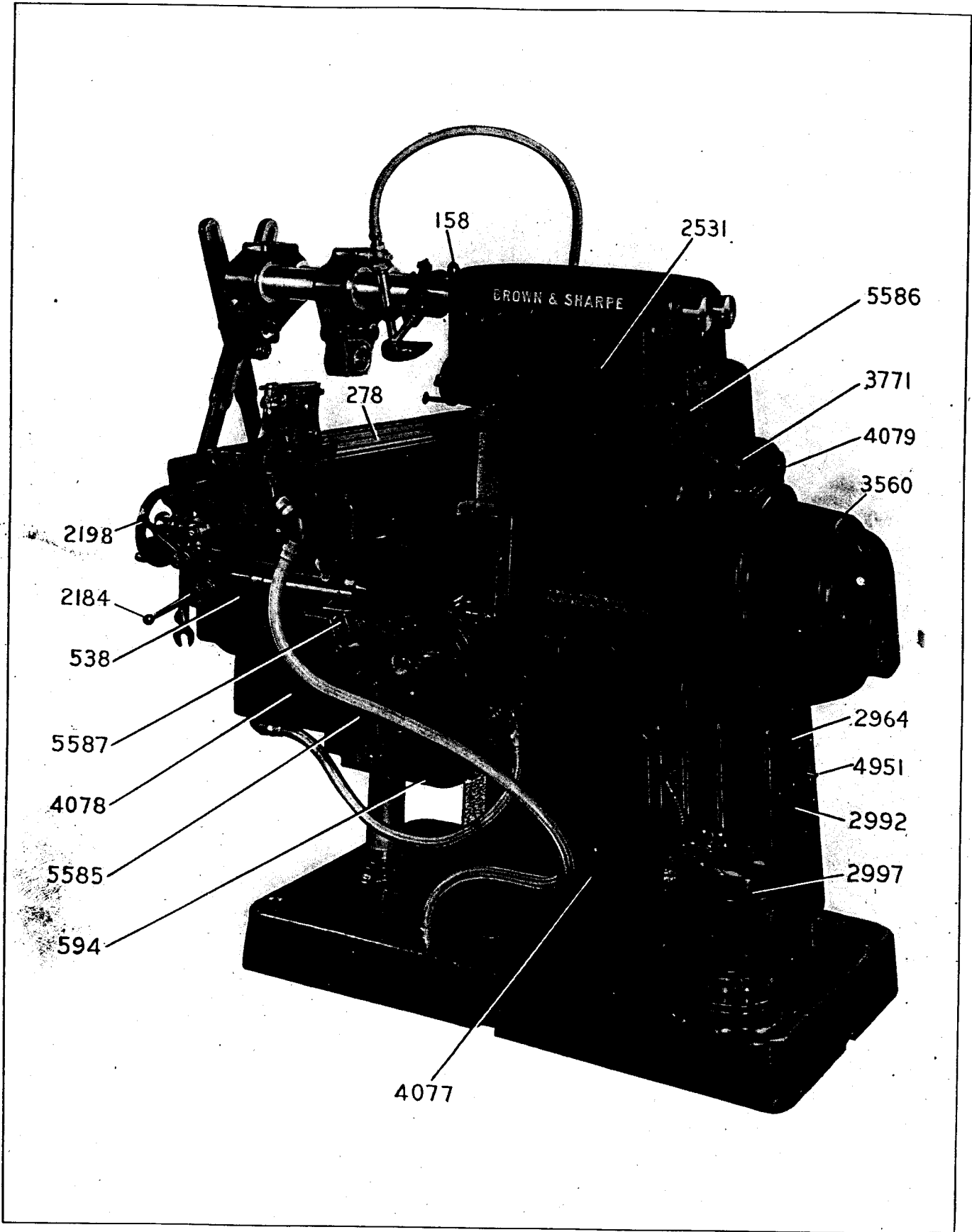
Front View
 Universal and Plain Machines
 (Universal Machine Shown)

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Front View

**Universal and Plain Machines
(Universal Machine Shown)**

12	Overarm
25	Speed Control Bracket
191	Arbor Yoke, Outer
278	Table
279	Saddle
302	Knee Elevating Shaft Handwheel
312	Knee
320	Clamp Bed
334	Cross Feed Handwheel
343	Table Feed Trip Lever
594	Feed Case
757	Knee Clamp Crank
765	Starting Lever
794	Arm Support
835	Arbor Yoke, Inner
1621	Knee Screw Horn
2156	Cross Feed Screw Dial Bracket
2345	Speed Change Dial
2351	Speed Change Lever
2396	Fast Travel Handle Complete
2478	Feed Change Lever
2971	Change Gear Box Cover
2976	Change Gear Box Cover Latch
2977	Change Gear Box Cover Hinge
2988	Distributor Flexible Tube
3560	Motor Guard
3771	Stand Cover, Rear



Rear View
 Universal and Plain Machines
 (Universal Machine Shown)

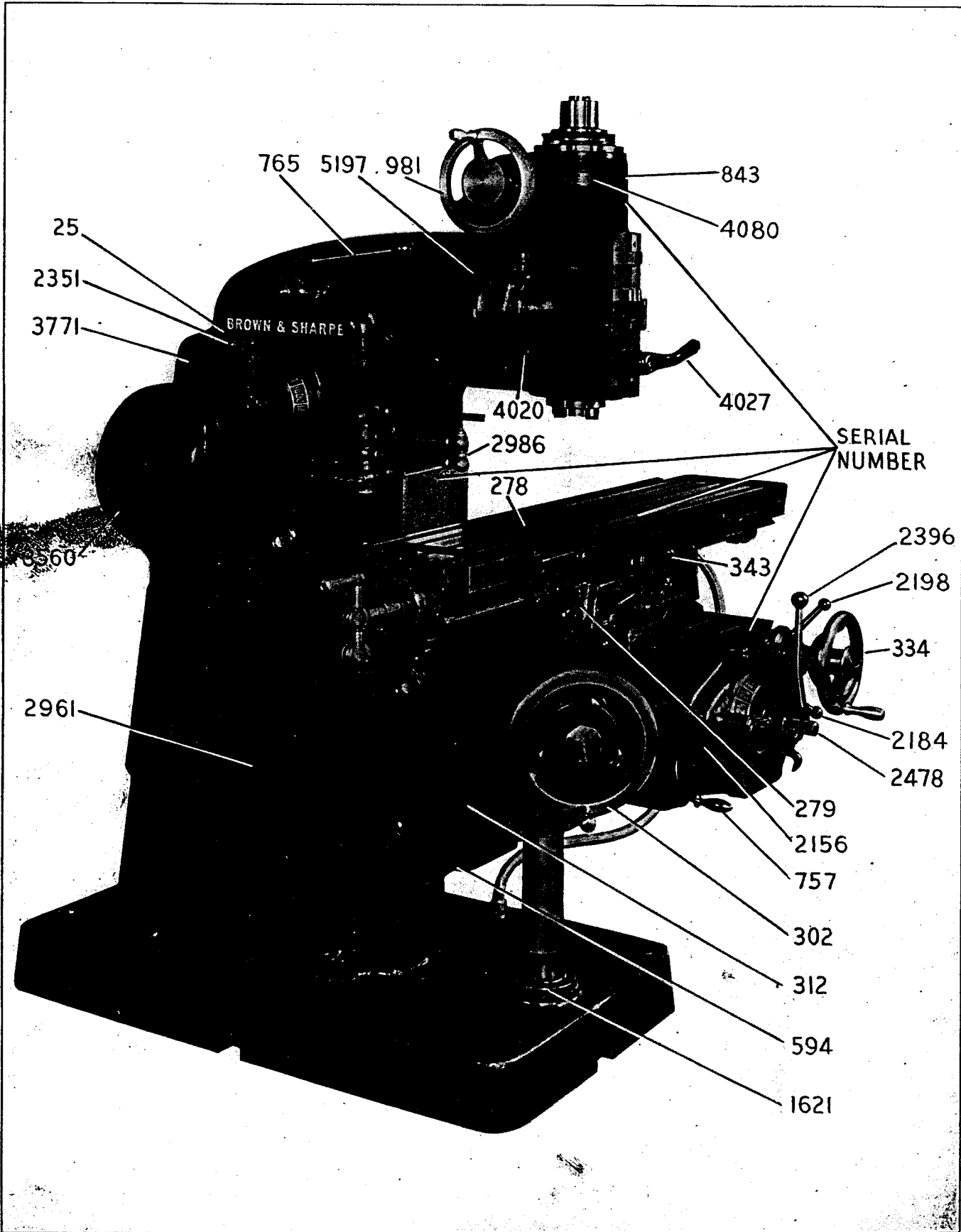
When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Rear View
Universal and Plain Machines
(Universal Machine Shown)

158	Arm Clamp Lever
278	Table
538	Cross & Vertical Feed Trip Bracket
594	Feed Case
2184	Vertical Feed Control Lever
2198	Cross Feed Control Lever
2531	Stand Opening Cover
2964	Electrical Compartment Door, Rear
2992	Coolant Switch
*2997	Motor Driven Centrifugal Pump
3560	Motor Guard
3771	Stand Cover, Rear
4077	Electrical Compartment Door, Side
4078	Solenoid Compartment Cover
4079	Spindle Jog Switch
4951	Spindle Reversing Switch
†5585	Table Motor
5586	Stand Cover Rear Hinge, Complete
5587	Solenoid Compartment

*See also "Repair Parts for Brown & Sharpe Pumps"

†State make and serial number

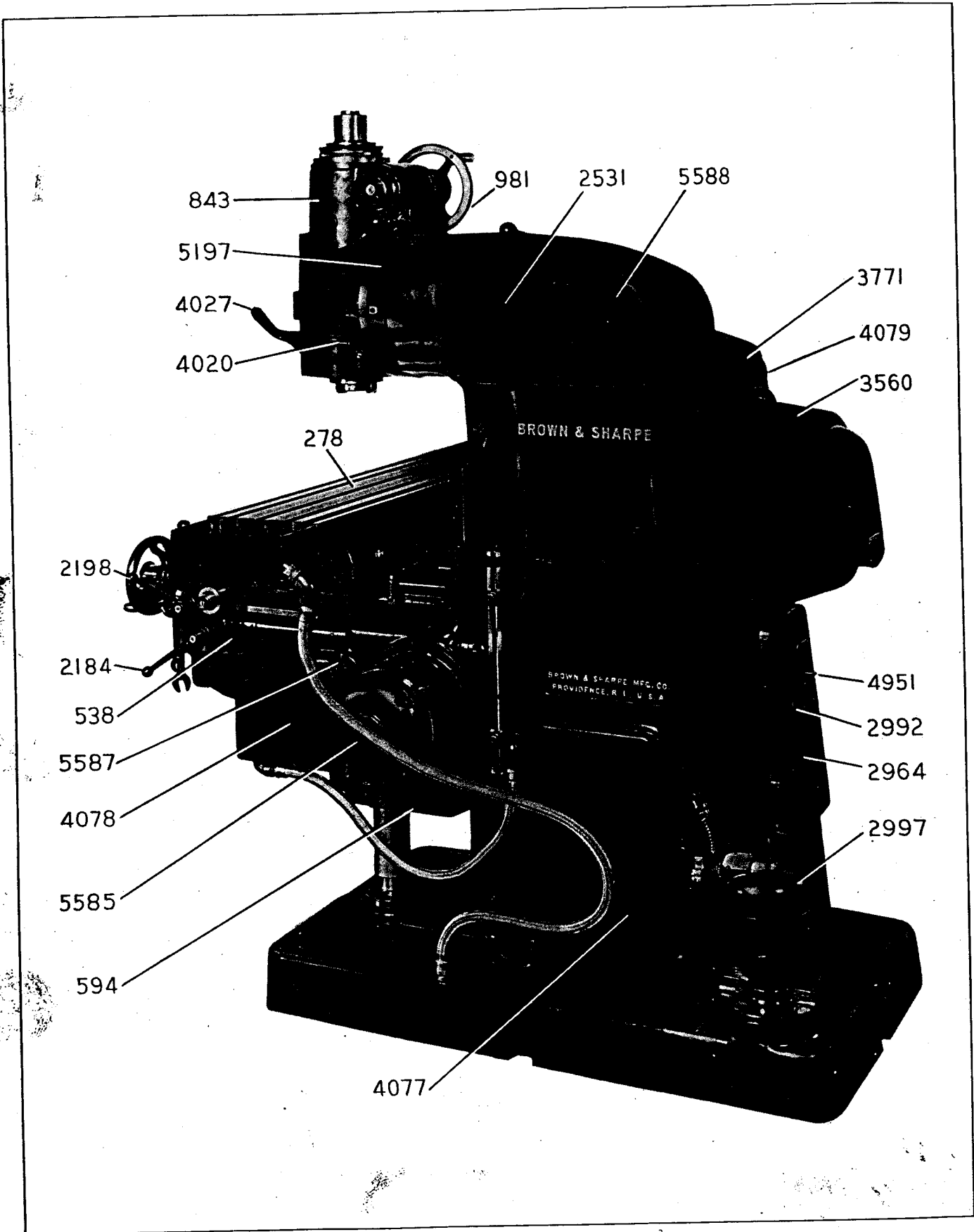


Front View
Vertical Machine

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Front View
Vertical Machine

25	Speed Control Bracket
278	Table
279	Saddle
302	Knee Elevating Shaft Handwheel
312	Knee
334	Cross Feed Handwheel
343	Table Feed Trip Lever
594	Feed Case
757	Knee Clamp Crank
765	Starting Lever
843	Spindle Head
981	Spindle Elevating Handwheel
1621	Knee Screw Horn
2156	Cross Feed Screw Dial Bracket
2184	Vertical Feed Control Lever
2198	Cross Feed Control Lever
2351	Speed Change Lever
2396	Fast Travel Handle Complete
2478	Feed Change Lever
2961	Stand Opening Cover, Lower
2986	Coolant Piping
3560	Motor Guard
3771	Stand Cover, Rear
4020	Spindle Head Clamp Bolt
4027	Spindle Clamp Lever
4080	Grease Notice Plate
5197	Spindle Head Adapter



- 843
- 5197
- 4027
- 4020
- 278
- 2198
- 2184
- 538
- 5587
- 4078
- 5585
- 594
- 981
- 2531
- 5588
- 3771
- 4079
- 3560
- 4951
- 2992
- 2964
- 2997
- 4077

Rear View
Vertical Machine

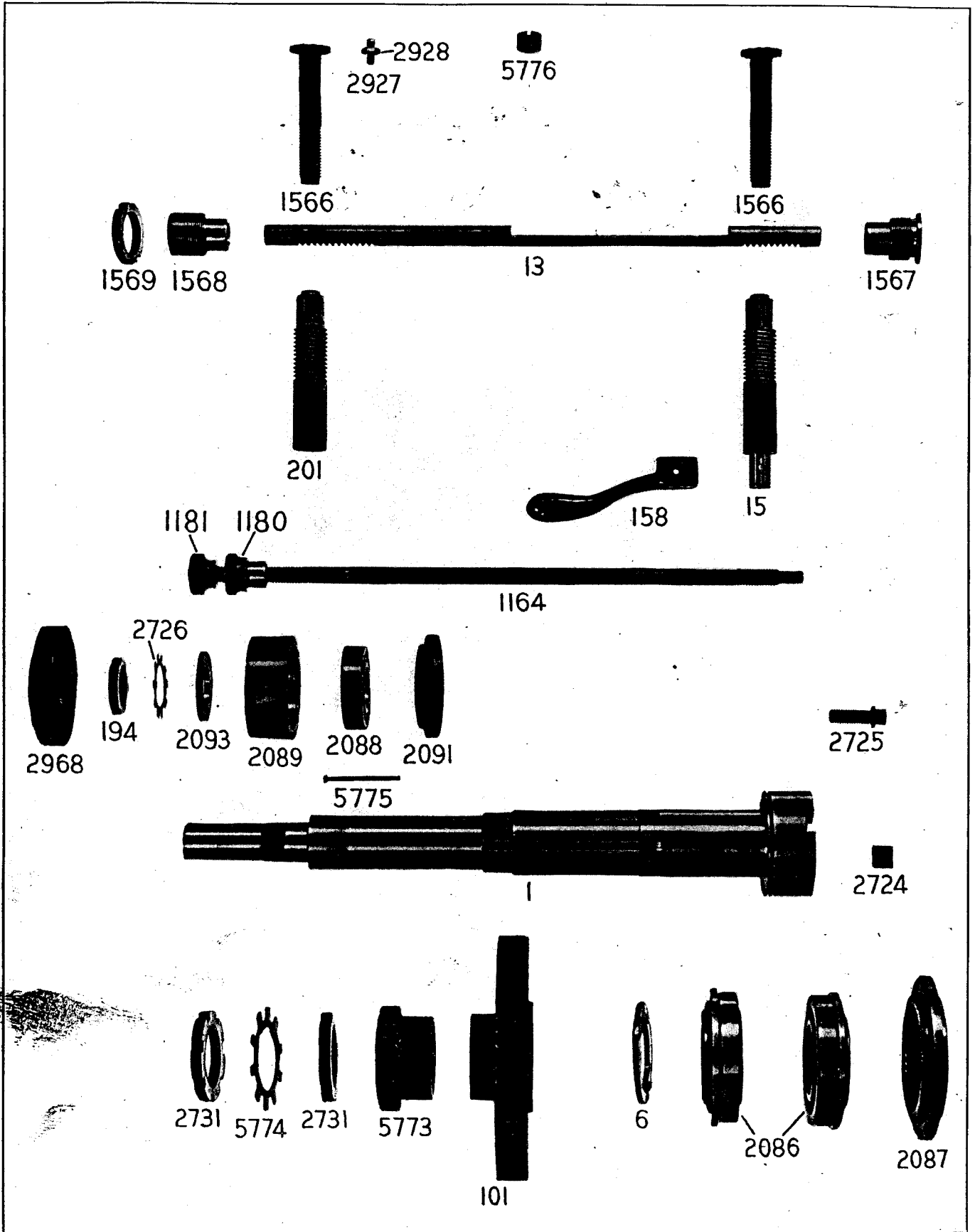
When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

**Rear View
Vertical Machine**

278	Table
538	Cross & Vertical Feed Trip Bracket
594	Feed Case
843	Spindle Head
981	Spindle Elevating Handwheel
2184	Vertical Feed Control Lever
2198	Cross Feed Control Lever
2531	Stand Opening Cover
2964	Electrical Compartment Door, Rear
2992	Coolant Switch
*2997	Motor Driven Centrifugal Pump
3560	Motor Guard
3771	Stand Cover, Rear
4020	Spindle Head Clamp Bolt
4027	Spindle Clamp Lever
4077	Electrical Compartment Door, Side
4078	Solenoid Compartment Cover
4079	Spindle Jog Switch
4951	Spindle Reversing Switch
5197	Spindle Head Adapter
†5585	Table Motor
5587	Solenoid Compartment
5588	Starting Switch Cover

*See also "Repair Parts for Brown & Sharpe Pumps"

†State make and serial number



Spindle Parts and Arm Clamp
 Universal and Plain Machines

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

**Spindle Parts and Arm Clamp
Universal and Plain Machines**

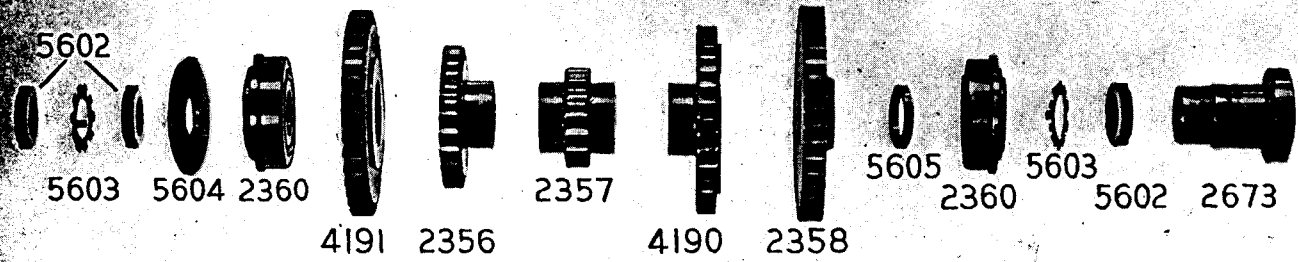
1	Spindle
6	Spindle Gear Thrust Washer
13	Arm Clamp Rack
15	Arm Clamp Screw, Front
101	Spindle Gear, Large
158	Arm Clamp Lever
194	Spindle End Nut
201	Arm Clamp Screw, Rear
1164	Draw-in Bolt
1180	Draw-in Bolt Nut
1181	Draw-in Bolt Knob
1566	Arm Clamp Adjusting Screw
1567	Arm Clamp Rack (Front) Bearing
1568	Arm Clamp Rack (Rear) Bearing
1569	Clamp Rack (Rear) Bearing Nut
2086	Spindle Roller Bearing, Front
2087	Spindle Bearing (Front) Dust Guard
2088	Spindle Roller Bearing, Rear
2089	Spindle Bearing (Rear) Holder
2091	Spindle Bearing (Rear) Retainer
2093	Spindle Bearing (Rear) Nut Washer
2724	Spindle Nose Key
2725	Holding Screw
2726	Spindle End Nut Lockwasher
2731	Spindle Nut
2927	Arm Clamp Locking Screw
2928	Arm Clamp Locking Screw Nut
2968	Spindle Bearing (Rear) Dust Guard
5773	Spindle Gear, Small
5774	Spindle Nut Lockwasher
5775	Spindle Bearing (Rear) Dust Guard Screw
5776	Crane Arm Stud Plug



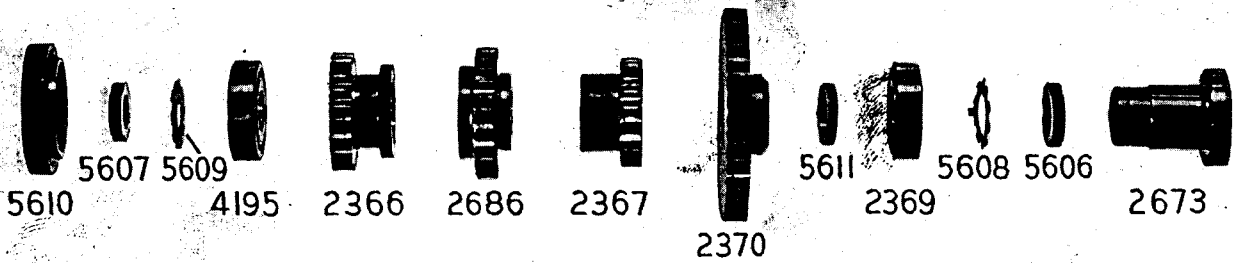
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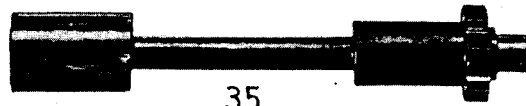
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2365



5589



35



37



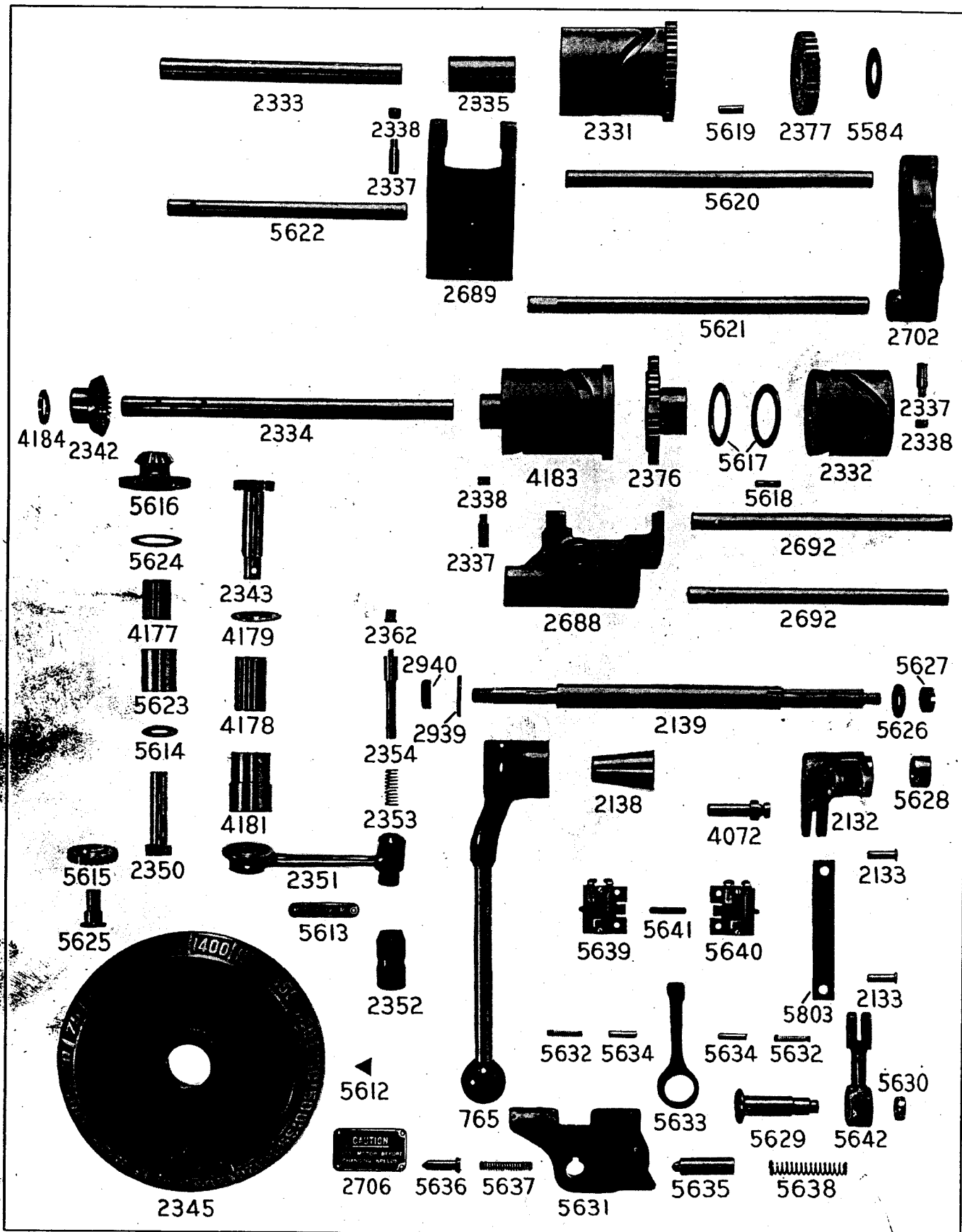
2673

Speed Change Gears

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Speed Change Gears

35	Driving Shaft
37	Driving Shaft Bearing
104	Stand Plug, Upper
2355	Speed Change Gear Shaft
2356	Speed Change Gear No. 4
2357	Speed Change Gear No. 3
2358	Speed Change Gear No. 1
2360	Speed Change Gear Shaft Bearing
2365	Speed Sliding Gear Shaft
2366	Speed Sliding Gear No. 3
2367	Speed Sliding Gear No. 1
2369	Speed Sliding Gear Shaft Bearing, Front
2370	Speed Driving Gear
2673	Stand Plug
2686	Speed Sliding Gear No. 2
4190	Speed Change Gear No. 2
4191	Speed Change Gear No. 5
4195	Speed Sliding Gear Shaft Bearing, Rear
5589	Driving Shaft Spring
5591	Spindle Intermediate Gear Shaft
5592	Spindle Intermediate Gear Shaft Lockwasher
5593	Spindle Intermediate Gear Shaft Nut
5594	Spindle Intermediate Gear, Large
5595	Spindle Intermediate Shaft Bearing Retainer
5596	Spindle Intermediate Shaft Bearing, Front
5597	Spindle Intermediate Shaft Bearing, Rear
5598	Intermediate Gear Shaft Bearing Seal
5599	Intermediate Sliding Gear No. 1
5600	Intermediate Sliding Gear No. 2
5601	Intermediate Sliding Gear No. 3
5602	Speed Change Gear Shaft Nut
5603	Speed Change Gear Shaft Lockwasher
5604	Change Gear Shaft Bearing Seal
5605	Speed Change Gear Shaft Spacer
5606	Speed Sliding Gear Shaft Nut
5607	Speed Sliding Gear Shaft Nut, Rear
5608	Speed Sliding Gear Shaft Lockwasher
5609	Speed Sliding Gear Shaft Lockwasher, Rear
5610	Sliding Gear Shaft Bearing Retainer
5611	Speed Driving Gear Spacer



Speed Change and Starting Lever Mechanisms

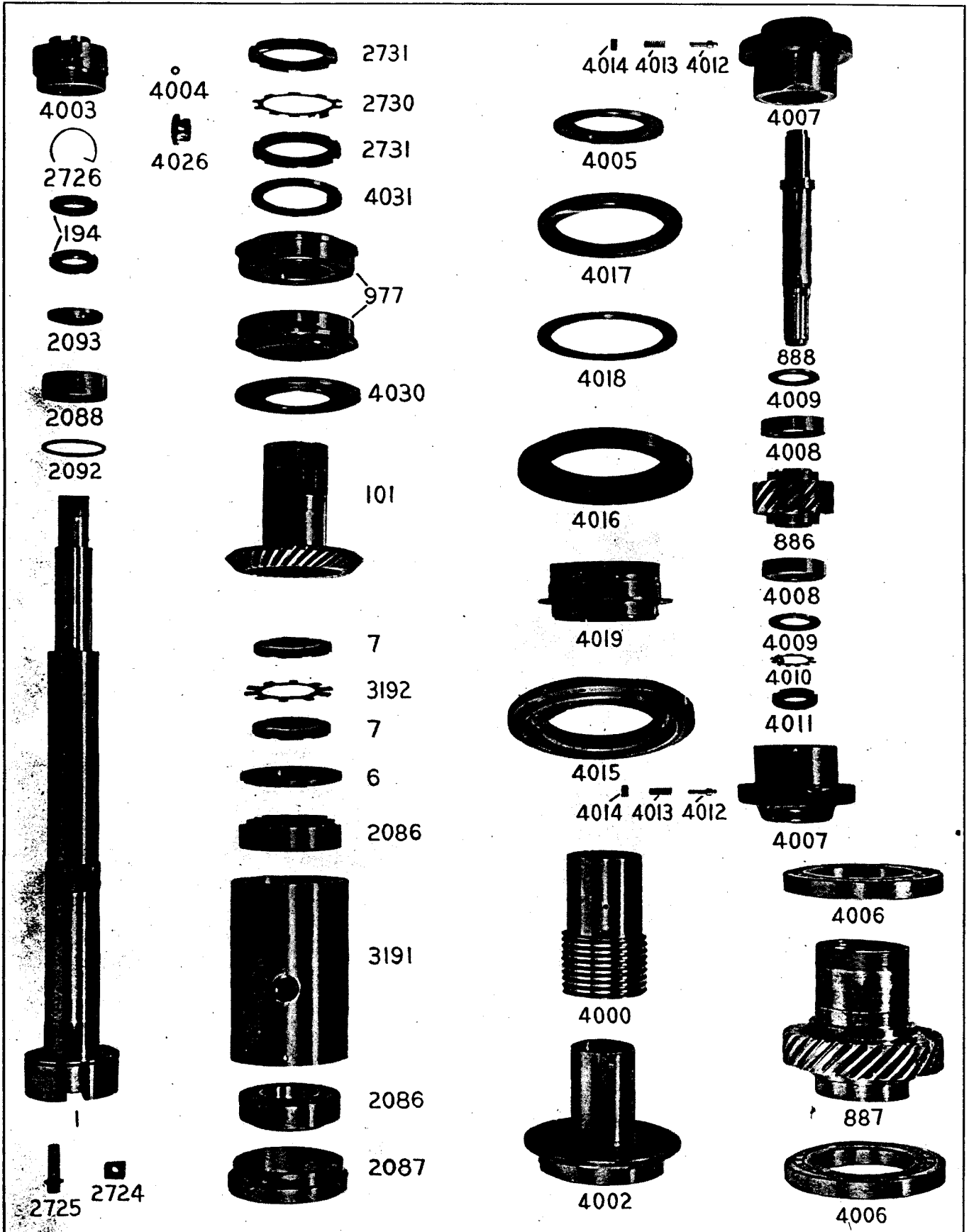
When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Speed Change and Starting Lever Mechanisms

765	Starting Lever	5584	Speed Control Cam Shaft (Upper) Washer
2132	Brake Operating Lever	5612	Dial Pointer
2133	Switch Operating Link Stud	5613	Speed Change Lever Plate
2138	Starting Lever Bushing	5614	Speed Change Dial Pinion Washer
2139	Starting Lever Shaft	5615	Speed Change Dial Intermediate Gear
2331	Speed Control Cam No. 2	5616	Speed Change Dial Operating Gear
2332	Speed Control Cam No. 3	5617	Speed Intermittent Gear (Driven) Washer
2333	Speed Control Cam Shaft, Upper	5618	Speed Intermittent Gear (Driven) Pin
2334	Speed Control Cam Shaft, Lower	5619	Speed Intermittent Gear (Driver) Pin
2335	Speed Control Cam Shaft Collar	5620	Spindle Intermediate Gear Shoe Shaft, Upper
2337	Cam Shoe Stud	5621	Spindle Intermediate Gear Shoe Shaft, Lower
2338	Speed Cam Roll	5622	Intermediate Sliding Gear Shoe Shaft
2342	Speed Bevel Gear	5623	Dial Pinion Bearing Sleeve
2343	Speed Change Operating Pinion	5624	Dial Pinion Bearing Sleeve Washer
2345	Speed Dial	5625	Dial Intermediate Gear Stud
2350	Speed Change Dial Pinion	5626	Starting Lever Shaft Washer, Right
2351	Speed Change Lever	5627	Starting Lever Shaft Nut, Right
2352	Speed Change Lever Handle	5628	Starting Lever Shaft Sleeve
2353	Speed Change Lever Handle Spring	5629	Starting Switch Lever Shaft
2354	Speed Change Lever Plunger	5630	Starting Switch Lever Shaft Washer
2362	Plunger Stop Bushing	5631	Starting Switch Operating Lever Carrier
2376	Speed Intermittent Gear, Driven	5632	Starting Switch Operating Lever Carrier Spring
2377	Speed Intermittent Gear, Driver	5633	Starting Switch Operating Lever
2688	Speed Sliding Gear Shoe	5634	Switch Operating Lever Plunger
2689	Intermediate Sliding Gear Shoe	*5635	Operating Lever Carrier Plunger
2692	Speed Sliding Gear Shoe Shaft	†5636	Operating Lever Carrier Plunger
2702	Intermediate Gear Shoe	†5637	Operating Lever Carrier Plunger Spring
2706	Speed Change Caution Plate	*5638	Operating Lever Carrier Plunger Spring
2939	Starting Lever Shaft Washer, Left	5639	Lever Start Switch
2940	Starting Lever Shaft Nut, Left	5640	Lever Stop Switch
4072	Brake Operating Link Stud	5641	Switch Operating Screw
4177	Speed Change Dial Pinion Bearing	5642	Starting Switch Lever
4178	Speed Change Operating Pinion Bearing	5803	Switch Operating Link
4179	Speed Change Operating Pinion Washer		
4181	Speed Change Dial Sleeve		
4183	Speed Control Cam No. 1		
4184	Speed Bevel Gear Washer		

*Vertical Machine

†Universal and Plain Machines

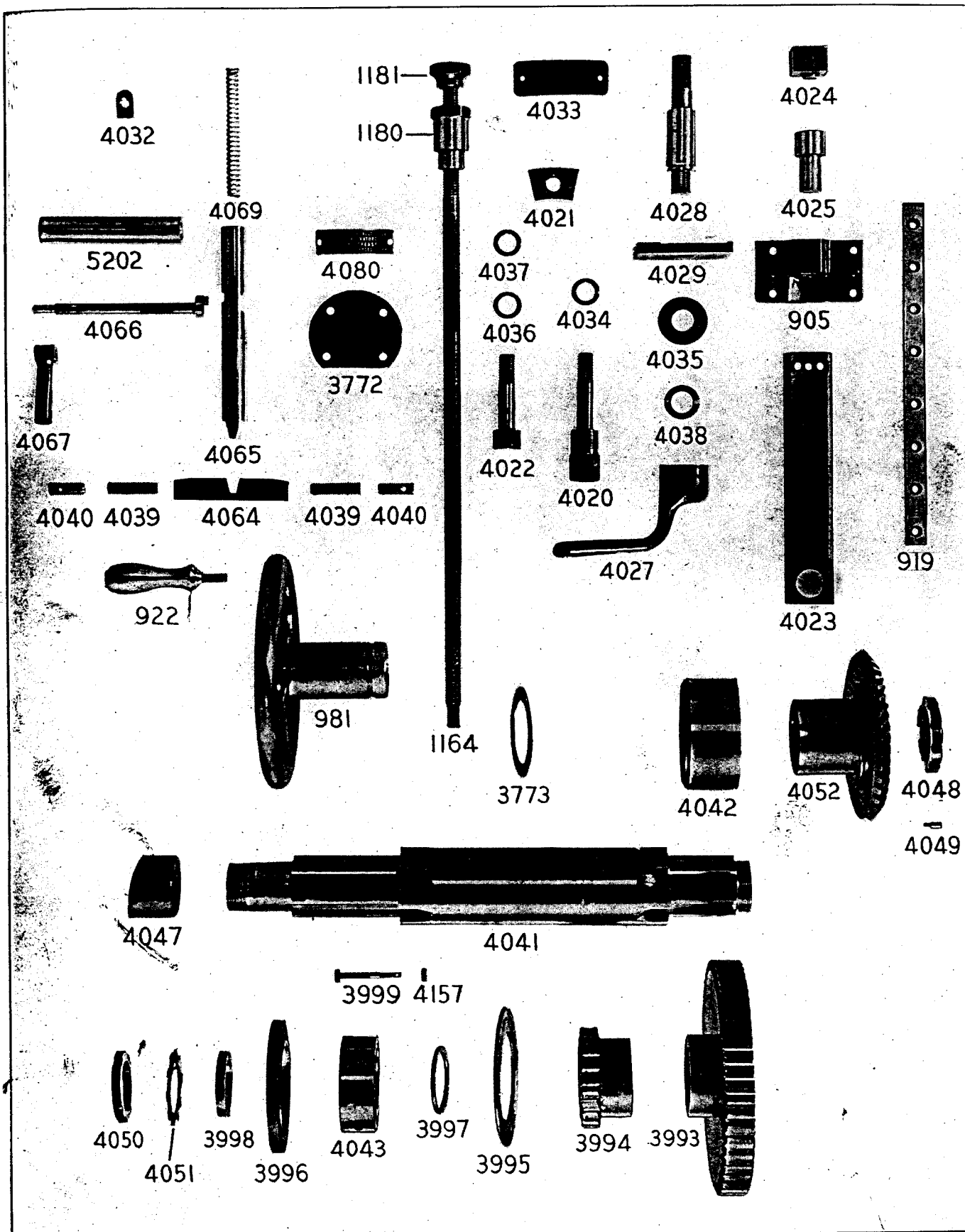


Spindle Head
Vertical Machine

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

**Spindle Head
Vertical Machine**

1	Spindle	4002	Spindle Elevating Screw Sleeve
6	Spindle Bearing Thrust Washer	4003	Spindle Elevating Screw Cap
7	Spindle Nut, Lower	4004	Spindle Elevating Screw Cap Key
101	Spindle Gear	4005	Elevating Screw Dust Guard
194	Spindle Nut, Upper	4006	Spindle Elevating Nut Ball Bearing
886	Spindle Elevating Gear	4007	Spindle Elevating Gear Shaft Cap
887	Spindle Elevating Nut	4008	Spindle Elevating Gear Shaft Ball Bearing
888	Spindle Elevating Gear Shaft		
977	Spindle Gear Roller Bearing (State Whether With Keyway)	4009	Elevating Gear Shaft Spacer
		4010	Elevating Gear Shaft Lockwasher
2086	Spindle Roller Bearing (State Whether With Keyway)	4011	Spindle Elevating Gear Shaft Nut
		4012	Elevating Handwheel Detent
2087	Spindle Dust Guard	4013	Elevating Handwheel Detent Spring
2088	Spindle Ball Bearing	4014	Elevating Handwheel Detent Bushing Screw
2092	Spindle Elevating Screw Bearing Washer		
2093	Spindle Bearing (Upper) Clamp Washer	4015	Spindle Head Cap
2724	Spindle Nose Key	4016	Spindle Head Dial
2725	Holding Screw	4017	Spindle Head Dial Nut
2726	Spindle Nut Lock Spring	4018	Spindle Head Dial Nut Washer
2730	Spindle Gear Lockwasher	4019	Spindle Head Dial Sleeve
2731	Spindle Gear Nut	4026	Spindle Head Plug
3191	Spindle Sleeve	4030	Spindle Gear Washer
3192	Spindle Nut Lockwasher	4031	Spindle Gear Thrust Washer
4000	Spindle Elevating Screw		

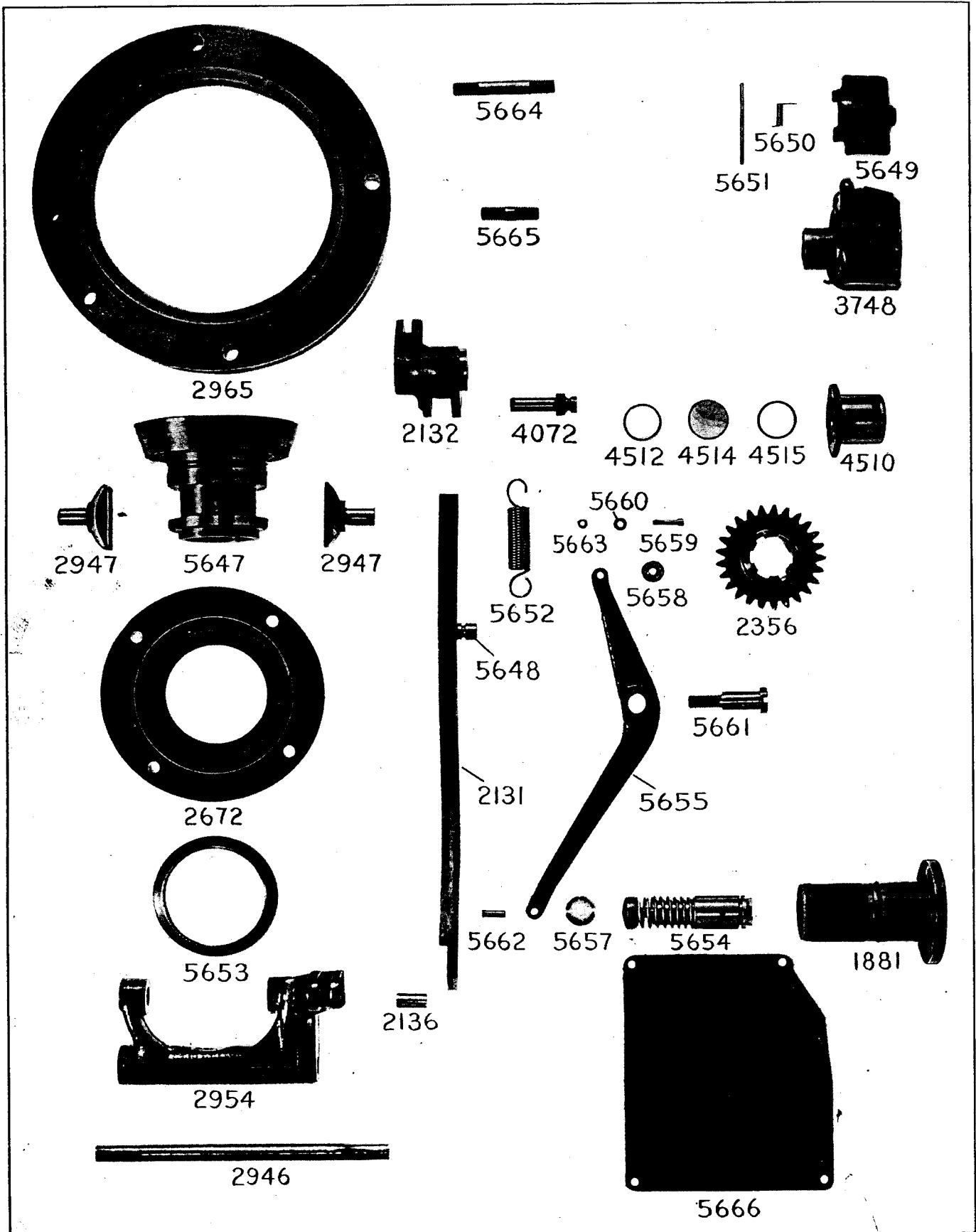


Spindle Head Drive, Lock and Clamp
Vertical Machine

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

**Spindle Head Drive, Lock and Clamp
Vertical Machine**

905	Spindle Head Stop Bracket	4032	Index Finger
919	Spindle Head Adjusting Slide Gib	4033	Clamp Bolt Nut Hole Cover
922	Spindle Elevating Handwheel Handle	4034	Spindle Head Clamp Bolt Washer
981	Spindle Elevating Shaft Handwheel	4035	Spindle Clamp Lever Spring
1164	Draw-in Bolt, Complete	4036	Spindle Head Friction Bolt Spring Washer
1180	Draw-in Bolt Nut		
1181	Draw-in Bolt Knob	4037	Spindle Head Friction Bolt Washer
3772	Spindle Head Cap, Rear	4038	Spindle Clamp Lever Washer
3773	Spindle Driving Gear Washer	4039	Locking Plunger Set Screw
3993	Spindle Gear, Large	4040	Locking Plunger Lock Screw
3994	Spindle Gear, Small	4041	Spindle Driving Shaft
3995	Spindle Driving Shaft Bearing Retainer, Outer	4042	Spindle Driving Shaft Bearing, Front
		4043	Spindle Driving Shaft Bearing, Rear
3996	Spindle Driving Shaft Bearing Retainer, Inner	4047	Spindle Driving Shaft Bearing Cap
		4048	Spindle Driving Shaft Nut, Front
3997	Spindle Driving Shaft Bearing Washer	4049	Spindle Driving Shaft Nut Lock
3998	Spindle Driving Shaft Washer	4050	Spindle Driving Shaft Nut, Rear
3999	Driving Shaft Bearing Retainer Screw	4051	Spindle Driving Shaft Lockwasher
4020	Spindle Head Clamp Bolt	4052	Spindle Driving Gear
4021	Spindle Head Clamp Nut	4064	Spindle Head Locking Plunger Seat
4022	Spindle Head Friction Bolt	4065	Spindle Head Locking Plunger
4023	Spindle Head Adjusting Slide	4066	Spindle Head Locking Plunger Eccentric
4024	Spindle Head Stop, Upper	4067	Locking Plunger Eccentric Handle
4025	Spindle Head Stop, Lower	4069	Locking Plunger Spring
4027	Spindle Clamp Lever	4080	Grease Notice Plate
4028	Spindle Clamp Stud	4157	Bearing Retainer Screw Nut
4029	Spindle Clamp Lever Plate	5202	Locking Plunger Eccentric Bushing

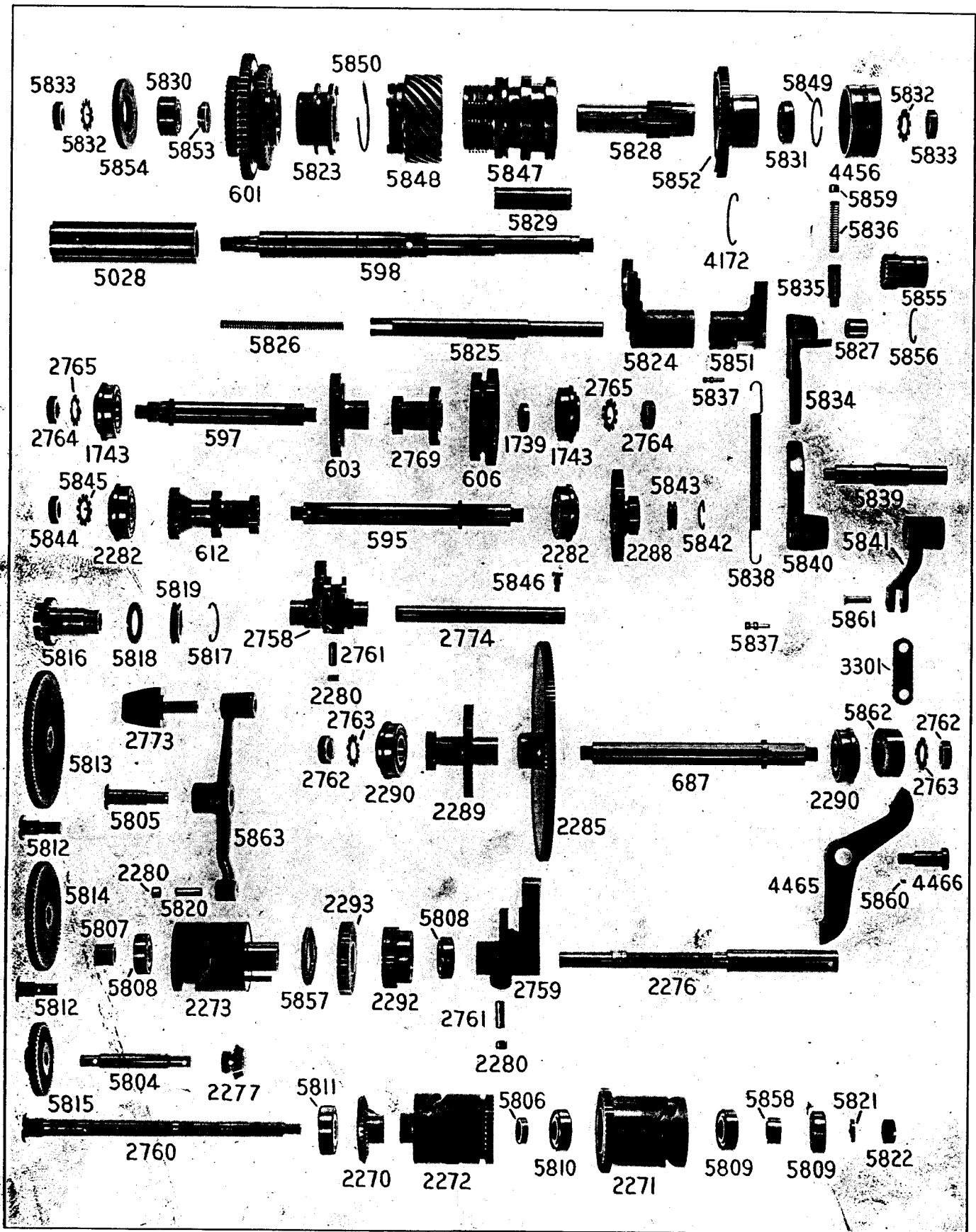


Brake and Column Lubricating Parts

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Brake and Column Lubricating Parts

1881	Lubricating Pump Housing
2131	Brake Operating Lever Link
2132	Brake Operating Lever
2136	Brake Operating Yoke Pin
2356	Speed Change Gear No. 4
2672	Driving Shaft Brake Ring
2946	Brake Operating Yoke Shaft
2947	Brake Operating Yoke Shoe
2954	Brake Operating Yoke
2965	Motor Bracket
3748	Oil Filler
4072	Brake Operating Link Stud
4510	Oil Sight Gage
4512	Oil Sight Gage Ring
4514	Oil Sight Gage Window
4515	Oil Sight Gage Gasket
5647	Driving Shaft Brake Body
5648	Brake Operating Lever Spring Pin
5649	Oil Filler Cover
5650	Oil Filler Cover Spring
5651	Oil Filler Cover Hinge Pin
5652	Brake Operating Link Spring
5653	Driving Shaft Oil Slinger
5654	Lubricating Pump Complete
5655	Pump Operating Lever
5657	Pump Operating Lever Roll
5658	Pump Operating Lever Cam Roll
5659	Pump Operating Lever Roll Stud
5660	Pump Operating Lever Spacer
5661	Pump Operating Lever Stud
5662	Pump Operating Lever Pin
5663	Roll Stud Nut
5664	Motor Stud, Long
5665	Motor Stud, Short
5666	Starting Switch Cover

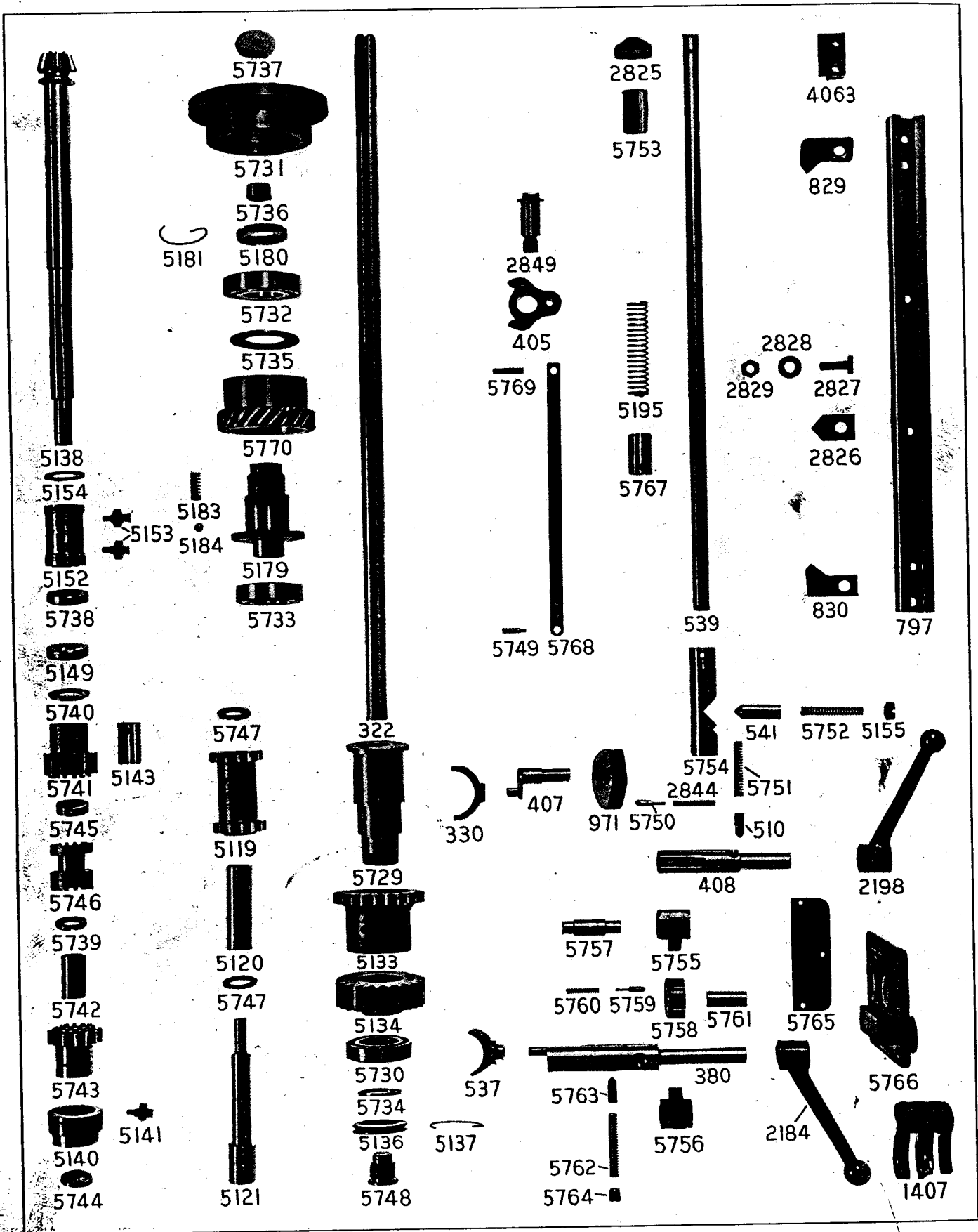


Feed Case

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Feed Case

595	Feed Sliding Gear Shaft	5815	Feed Control Gear, Driven
597	Feed Change Gear Shaft	5816	Feed Control Gear, Driver
598	Feed Fast Travel Clutch Shaft	5817	Feed Control Gear (Driver) Lock Spring
601	Feed Gear	5818	Feed Control Gear (Driver) Washer
603	Feed Change Gear No. 1	5819	Feed Control Gear (Driver) Nut
606	Feed Change Gear No. 3	5820	Feed Cam Lever Roll Stud
612	Feed Sliding Gear	5821	Feed Cam Shaft (Lower) Washer
687	Feed Driving Shaft	5822	Feed Cam Shaft (Lower) Nut
1739	Feed Change Gear Shaft Washer	5823	Feed Clutch
1743	Feed Change Gear Shaft Roller Bearing	5824	Feed Clutch Shoe
2270	Feed Case Bevel Gear	5825	Feed Clutch Shoe Shaft
2271	Feed Case Cam No. 3	5826	Feed Clutch Shoe Shaft Spring
2272	Feed Case Cam No. 1	5827	Feed Clutch Shoe Shaft Spacer
2273	Feed Case Cam No. 2	5828	Feed Driving Pinion
2276	Feed Cam Shaft, Upper	5829	Feed Driving Pinion Bushing
2277	Feed Case Bevel Pinion	5830	Feed Fast Travel Clutch Shaft Bearing, Left
2280	Feed Cam Roll	5831	Feed Fast Travel Clutch Shaft Bearing, Right
2282	Feed Sliding Gear Shaft Roller Bearing	5832	Feed Fast Travel Clutch Shaft Lockwasher
2285	Feed Driving Shaft Gear	5833	Feed Fast Travel Clutch Shaft Nut
2288	Sliding Gear Shaft Driving Gear	5834	Feed Throwout Lever
2289	Feed Driving Shaft Sliding Gear	5835	Feed Throwout Lever Locking Pin
2290	Feed Driving Shaft Roller Bearing	5836	Feed Throwout Lever Locking Pin Spring
2292	Feed Intermittent Gear, Driver	5837	Feed Throwout Lever Spring Pin
2293	Feed Intermittent Gear, Driven	5838	Feed Throwout Lever Shaft Spring
2758	Feed Sliding Gear Shoe	5839	Feed Throwout Operating Lever Shaft
2759	Feed Case Cam Shoe, Lower	5840	Feed Throwout Operating Lever
2760	Feed Cam Shaft, Lower	5841	Feed Throwout Solenoid Lever
2761	Feed Cam Shoe Stud	5842	Feed Sliding Gear Shaft Nut Lock Spring
2762	Feed Driving Shaft Nut	5843	Feed Sliding Gear Shaft Nut, Right
2763	Feed Driving Shaft Lockwasher	5844	Feed Sliding Gear Shaft Nut, Left
2764	Feed Change Gear Shaft Nut	5845	Feed Sliding Gear Shaft Lockwasher
2765	Feed Change Gear Shaft Lockwasher	5846	Feed Sliding Gear Shoe Shaft Screw
2769	Feed Change Gear No. 2	5847	Fast Travel Clutch
2773	Feed Case Cam Shoe, Upper	5848	Fast Travel Clutch Gear
2774	Feed Sliding Gear Shoe Shaft	5849	Fast Travel Driving Gear Bearing Retainer
3301	Solenoid Lever Link	5850	Fast Travel Clutch Gear Lock Spring
4172	Fast Travel Driving Gear Lock Spring	5851	Fast Travel Clutch Shoe
4456	Fast Travel Driving Gear Bearing	5852	Fast Travel Driving Gear
4465	Pump Operating Lever	5853	Clutch Sleeve Spacer
4466	Pump Operating Lever Stud	5854	Clutch Shaft Bearing Retainer
5028	Feed Clutch Sleeve	5855	Table Motor Pinion
5804	Feed Case Bevel Pinion Shaft	5856	Table Motor Pinion Lock Spring
5805	Feed Case Cam Lever Stud	5857	Intermittent Gear Washer
5806	Feed Case Cam (No. 1 & No. 3) Spacer	5858	Cam Shaft (Lower) Bearing Spacer
5807	Feed Case Cam (No. 2) Spacer	5859	Locking Pin Spring Collar
5808	Feed Case Cam (No. 2) Bearing	5860	Pump Operating Lever Pin
5809	Feed Case Cam (No. 3) Bearing	5861	Solenoid Link Pin (Upper)
5810	Feed Case Shaft (Lower) Bearing, Right	5862	Pump Cam
5811	Feed Case Shaft (Lower) Bearing, Left	5863	Feed Case Cam Lever
5812	Feed Control Intermediate Gear Stud		
5813	Feed Control Intermediate Gear, Large		
5814	Feed Control Intermediate Gear, Small		

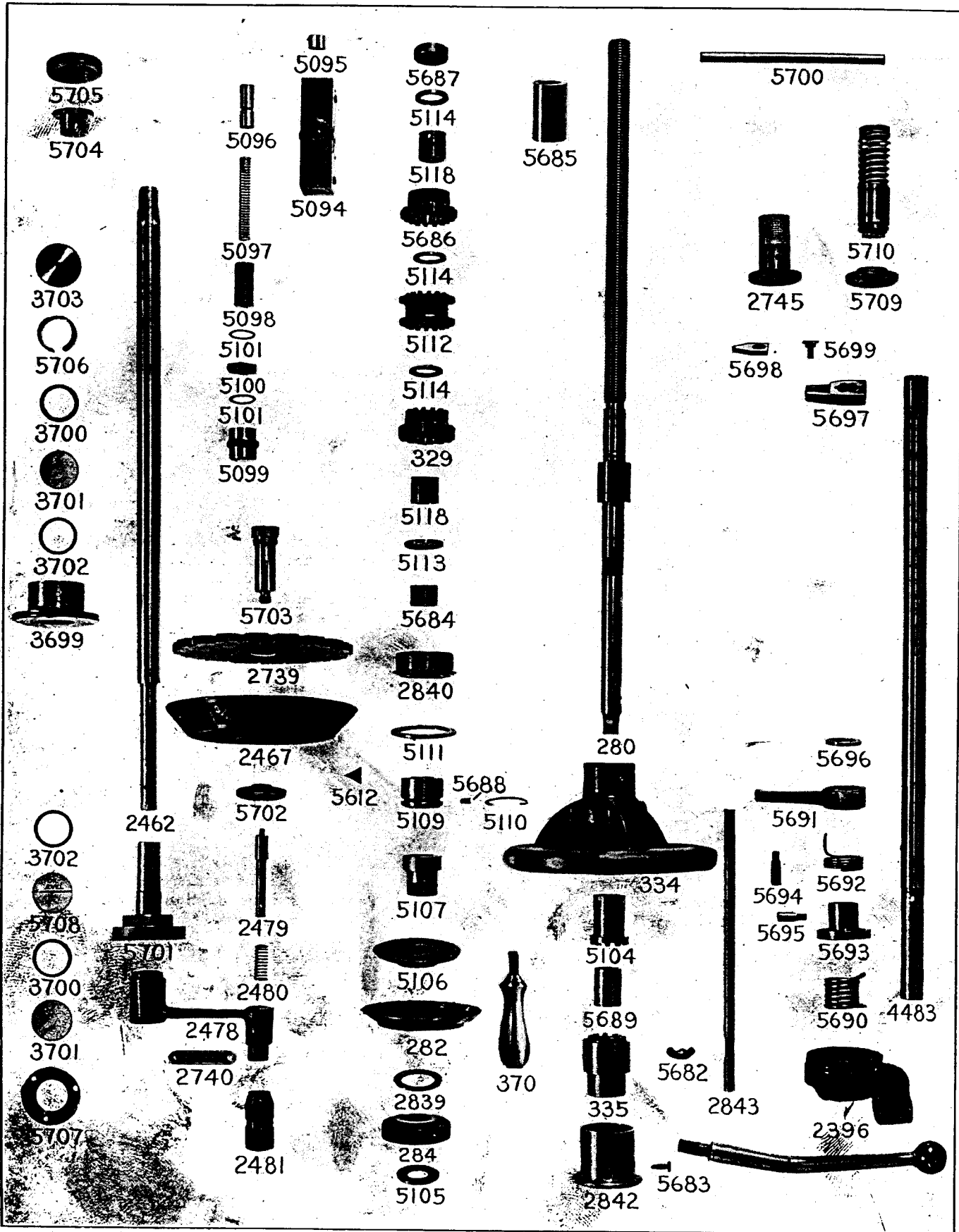


Transverse and Vertical Feed Control Parts

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Transverse and Vertical Feed Control Parts

322	Feed Shaft	5184	Feed Safety Clutch Steel Ball
330	Cross Feed Clutch Gear Shoe	5195	Vertical Feed Trip Rod Spring
380	Vertical Feed Clutch Eccentric Shaft	5729	Feed Shaft Gear Sleeve
405	Cross Feed Trip Lever	5730	Feed Shaft Gear Sleeve Bearing
407	Cross Feed Clutch Eccentric Shaft	5731	Feed Shaft Rear Bearing Holder
408	Cross Feed Trip Pinion	5732	Feed Shaft Rear Bearing
510	Cross Feed Trip Pinion Detent	5733	Feed Shaft Bearing
537	Power Shaft Clutch Shoe	5734	Feed Shaft Sleeve Bearing Washer
539	Vertical Feed Trip Rod	5735	Feed Safety Clutch Washer
541	Vertical Feed Trip Rod Detent	5736	Feed Safety Clutch Plug
797	Vertical Feed Trip Dog Bracket	5737	Feed Shaft Rear Bearing Holder Plug
829	Vertical Feed Safety Stop, Upper	5738	Power Knee Shaft Collar, Rear
830	Vertical Feed Safety Stop, Lower	5739	Power Shaft Clutch Gear Washer
971	Cross Feed Trip Segment	5740	Power Shaft Clutch Gear (Rear) Washer
1407	Wrench Rack, Small	5741	Power Knee Shaft Clutch Gear, Rear
2184	Vertical Feed Control Lever	5742	Power Knee Shaft Clutch Gear Bushing
2198	Cross Feed Control Lever	5743	Power Knee Shaft Clutch Gear, Front
2825	Vertical Feed Trip Rod Collar	5744	Power Knee Shaft End Washer
2826	Vertical Feed Trip Dog	5745	Power Knee Shaft Gear Collar
2827	Vertical Feed Trip Dog Bolt	5746	Power Knee Shaft Reverse Clutch
2828	Vertical Feed Trip Dog Washer	5747	Feed Reverse Gear Shaft Washer
2829	Vertical Feed Trip Dog Nut	5748	Feed Shaft Thrust Screw
2844	Cross Feed Trip Segment Detent Spring	5749	Cross Feed Trip Segment Screw
2849	Cross Feed Trip Lever Stud	5750	Cross Feed Trip Segment Detent
4063	Knee Stop	5751	Trip Pinion Detent Spring
5119	Feed Reverse Gear	5752	Trip Rod Detent Spring
5120	Feed Reverse Gear Bushing	5753	Vertical Feed Trip Rod Bushing
5121	Feed Reverse Gear Shaft	5754	Vertical Feed Trip Rod End
5133	Feed Shaft Driving Gear	5755	Vertical Feed Control Segment, Upper
5134	Feed Shaft Gear, Front	5756	Vertical Feed Control Segment, Lower
5136	Feed Shaft Gear Sleeve Nut	5757	Vertical Feed Control Segment Stud
5137	Feed Shaft Gear Sleeve Nut Lock Spring	5758	Vertical Feed Control Gear
5138	Power Knee Shaft	5759	Vertical Feed Control Gear Detent
5140	Power Shaft Clutch Gear Bearing	5760	Vertical Feed Control Gear Detent Spring
5141	Power Shaft Clutch Gear Bearing Screw	5761	Vertical Feed Control Gear Stud
5143	Power Shaft Clutch Gear (Rear) Bushing	5762	Vertical Feed Clutch Shaft Detent Spring
5149	Power Knee Shaft Collar	5763	Vertical Feed Clutch Shaft Detent
5152	Power Knee Shaft Bushing	5764	Vertical Feed Clutch Shaft Detent Plug
5153	Power Knee Shaft Bushing Screw	5765	Trip Bracket Cover
5154	Power Knee Shaft Washer	5766	Trip Bracket Cap
5155	Trip Rod Detent Plug	5767	Trip Rod Spring Collar
5179	Feed Safety Clutch Hub	5768	Cross Feed Trip Lever Link
5180	Feed Safety Clutch Nut	5769	Cross Feed Trip Lever Link Stud
5181	Feed Safety Clutch Nut Lock Spring	5770	Feed Safety Clutch Gear
5183	Feed Safety Clutch Spring		

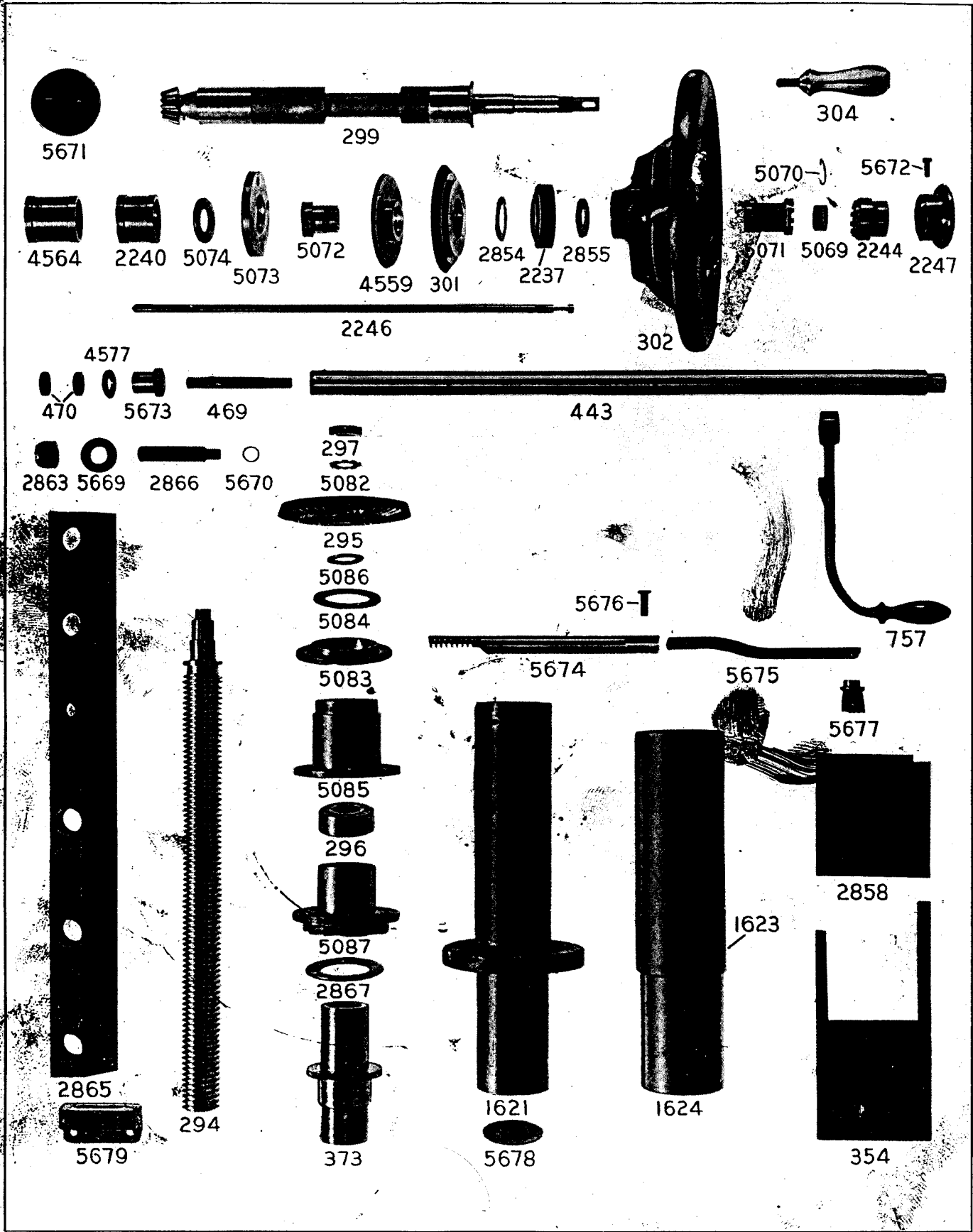


Miscellaneous Knee Parts

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Miscellaneous Knee Parts

280	Cross Feed Screw	5107	Cross Feed Screw Dial Sleeve
282	Cross Feed Screw Dial	5109	Cross Feed Screw Bearing Nut
284	Cross Feed Screw Dial Nut	5110	Cross Feed Screw Bearing Nut Lock Spring
329	Cross Feed Clutch Gear, Front	5111	Cross Feed Screw Fitting Washer, Front
334	Cross Feed Handwheel	5112	Cross Feed Reverse Clutch
335	Cross Feed Handwheel Clutch	5113	Cross Feed Screw Fitting Washer, Rear
370	Cross Feed Handwheel Handle	5114	Clutch Gear Washer
2396	Fast Travel Handle Complete	5118	Cross Feed Clutch Gear Bushing
2462	Feed Change Control Shaft	5612	Dial Pointer
2467	Feed Dial	5682	Cross Feed Handwheel Clutch Lever
2478	Feed Change Lever	5683	Cross Feed Handwheel Clutch Knob Screw
2479	Feed Change Lever Plunger	5684	Cross Feed Screw Bearing Sleeve
2480	Feed Change Lever Handle Spring	5685	Cross Feed Stop Collar
2481	Feed Change Lever Handle	5686	Cross Feed Clutch Gear, Rear
2739	Feed Change Dial Disk	5687	Cross Feed Screw Collar
2740	Feed Change Lever Plate	5688	Cross Feed Screw Bearing Nut Screw
2745	Round Strainer	5689	Cross Feed Handwheel Clutch Sleeve
2839	Cross Feed Screw Dial Washer	5690	Fast Travel Handle Spring
2840	Cross Feed Screw Bearing	5691	Fast Travel Switch Lever
2842	Cross Feed Handwheel Clutch Knob	5692	Fast Travel Switch Lever Spring
2843	Cross Feed Screw Clutch Pin	5693	Switch Lever Spring Retainer
3699	Oil Sight Gage	5694	Control Shaft Stop Screw
3700	Washer, Cork	5695	Fast Travel Control Shaft Screw
3701	Oil Sight Gage Glass	5696	Fast Travel Control Shaft Washer
3702	Washer, Fiber	5697	Fast Travel Shoe Shifter Lever
3703	Oil Sight Gage Glass Retainer	5698	Fast Travel Shoe Shifter
4483	Fast Travel Control Shaft	5699	Shifter Stud
5094	Automatic Feed Valve Body	5700	Knee Oil Pipe
5095	Automatic Feed Valve Bushing	5701	Feed Change Dial Disk Driver
5096	Automatic Feed Valve Piston	5702	Feed Change Dial Stud Nut
5097	Automatic Feed Valve Spring	5703	Feed Change Dial Stud
5098	Automatic Feed Valve Adjustment Screw	5704	Oil Filler Insert
5099	Adjustment Screw Cap	5705	Oil Filler Cap
5100	Adjustment Screw Nut	5706	Oil Sight Gage Sleeve
5101	Feed Valve Adjustment Screw Washer	5707	Oil Level Indicator Glass Retainer
5104	Cross Feed Handwheel Sleeve	5708	Oil Level Indicator Plate
5105	Cross Feed Screw Washer	5709	Lubricating Pump Cap
5106	Cross Feed Screw Dial Back	5710	Lubricating Pump



Knee Elevating Mechanism

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Knee Elevating Mechanism

294	Knee Screw	2867	Knee Screw Horn Sleeve Stop
295	Knee Screw Gear	4559	Knee Elevating Shaft Dial Back
296	Knee Screw Bearing	4564	Knee Elevating Shaft Bushing, Rear
297	Knee Screw Gear Nut	4577	Knee Clamp Stud Washer
299	Knee Elevating Shaft	5069	Knee Elevating Handwheel Nut
301	Knee Elevating Shaft Dial	5070	Handwheel Nut Lock Spring
302	Knee Elevating Shaft Handwheel	5071	Knee Elevating Shaft Handwheel Sleeve
304	Knee Elevating Shaft Handwheel Handle	5072	Knee Elevating Shaft Dial Sleeve
354	Knee Dust Guard, Lower	5073	Knee Elevating Shaft Spacer
373	Knee Screw Nut	5074	Knee Elevating Shaft Thrust Washer
443	Knee Clamp Shaft	5082	Knee Screw Nut Lockwasher
469	Knee Clamp Stud	5083	Knee Power Feed Interlock
470	Knee Clamp Stud Nut	5084	Power Feed Interlock Cap
757	Knee Clamp Crank	5085	Knee Screw Bearing Holder
1621	Knee Screw Horn	5086	Knee Screw Washer
1623	Knee Screw Horn Sleeve, Outer	5087	Knee Screw Nut Sleeve
1624	Knee Screw Horn Sleeve, Inner	5669	Knee Gib Screw Washer
2237	Knee Elevating Shaft Dial Nut	5670	Knee Gib Screw Copper Gasket
2240	Knee Elevating Shaft Bushing, Front	5671	Feed Case Opening Plug
2244	Knee Elevating Shaft Handwheel Clutch	5672	Handwheel Clutch Knob Screw
2246	Knee Elevating Shaft Clutch Pin	5673	Knee Clamp Shaft Bushing
2247	Knee Elevating Handwheel Clutch Knob	5674	Power Feed Interlock Rack
2854	Knee Elevating Shaft Dial Washer	5675	Power Feed Interlock Link
2855	Knee Elevating Shaft Washer	5676	Power Feed Interlock Link Pin
2858	Knee Dust Guard, Upper	5677	Power Shaft Clutch Shoe
2863	Knee Gib Screw Nut	5678	Knee Elevating Screw Horn Plug
2865	Knee Gib	5679	Wrench Rack
2866	Knee Gib Screw		



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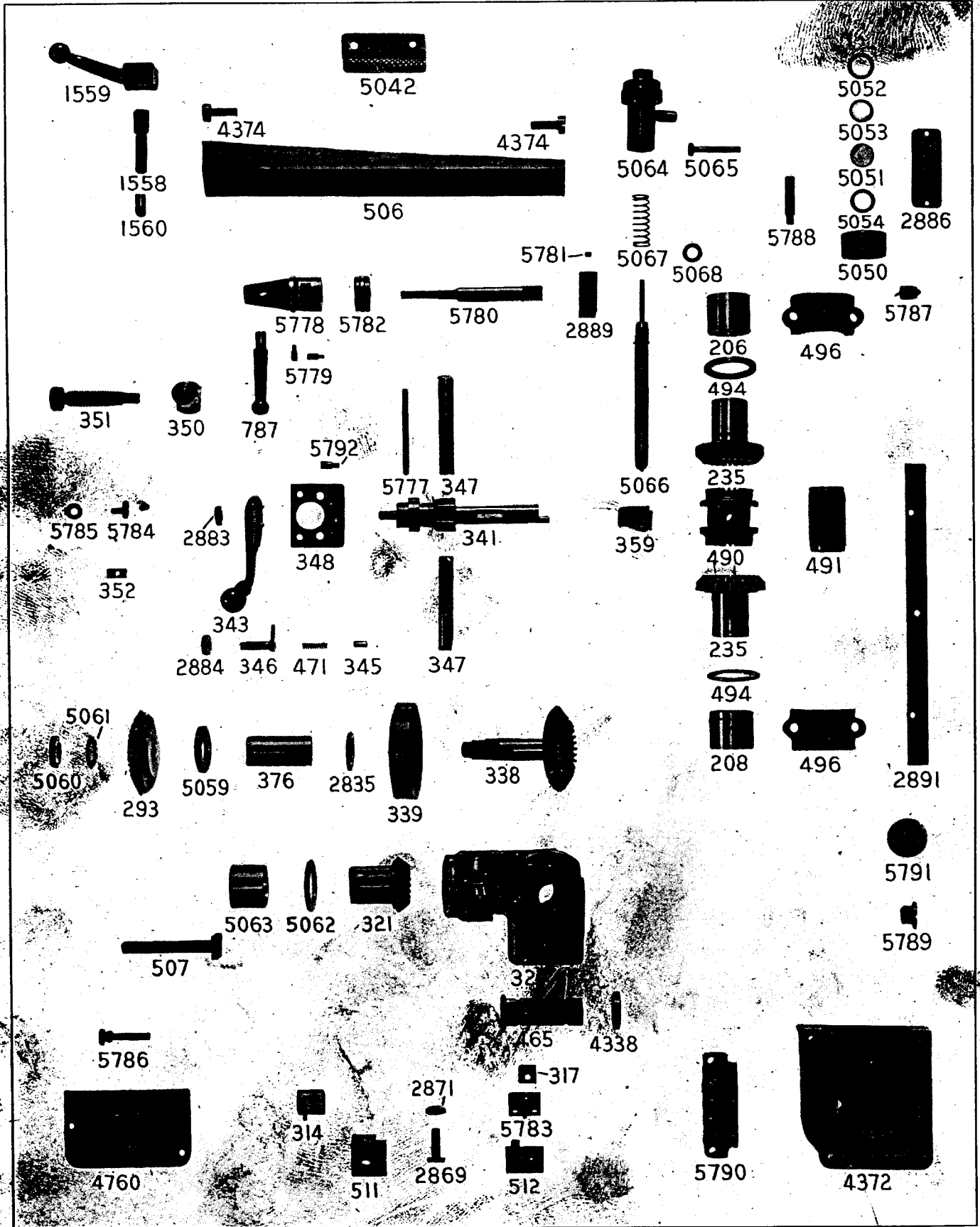
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When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Table Parts

165	Table Feed Shaft Bushing, Left	2878	Table Screw Dial Sleeve Washer
305	Table Gib	2880	Table Screw Dial Sleeve Bushing
306	Table Feed Trip Dog	2885	Table Oil Cock
307	Table Feed Trip Dog Bolt Nut	2888	Table Feed Trip Dog Bolt Washer
308	Table Feed Trip Dog Bolt	4323	Table Screw Dial Back
357	Table Thrust Bearing	4373	Table Gib Screw
358	Table Feed Shaft Gear Coupling	5045	Table Drain Plug
374	Table Screw Nut	5046	Table Oil Trough, Front
375	Table Screw Nut	5047	Table Oil Trough, Rear
476	Table Screw Gear	5711	Table Feed Shaft Thrust Collar
481	Table Screw Dial Bracket	5712	Table Screw Gear Thrust Washer
482	Table Screw Dial	5713	Table Screw Thrust Washer
483	Table Screw Dial Nut	5714	Table Feed Shaft Split Washer
486	Table Screw Ball Crank	5715	Table Screw Dial Sleeve
487	Table Screw Ball Crank Handle	5716	Table Screw Gear Clutch
489	Table Feed Shaft	5717	Ball Crank Knock-out Clutch
497	Table Feed Shaft Gear	5718	Ball Crank Knock-out Plunger
499	Table Screw Bearing	5719	Ball Crank Knock-out Plunger Spring
504	Table Feed Shaft Washer	5720	Ball Crank Knock-out Rod
576	Table Feed Shaft Collar, Right	5721	Ball Crank Knock-out Rod Pin
785	Table Feed Safety Stop, Right	5722	Ball Crank Clutch
786	Table Feed Safety Stop, Left	5723	Ball Crank Clutch Guard
805	Table Dog Guard	5724	Ball Crank Clutch Guard Screw
811	Table Screw Bearing Bushing, Large	5725	Table Screw Hand Clutch Nut
845	Table Screw Bearing Bushing, Small	5726	Table Screw Hand Clutch
872	Table Screw Thrust Bearing Nut	5727	Table Screw Drive Collar
875	Thrust Bearing Nut Lockwasher	5728	Tube Retainer Plate
877	Table Screw Gear Collar		

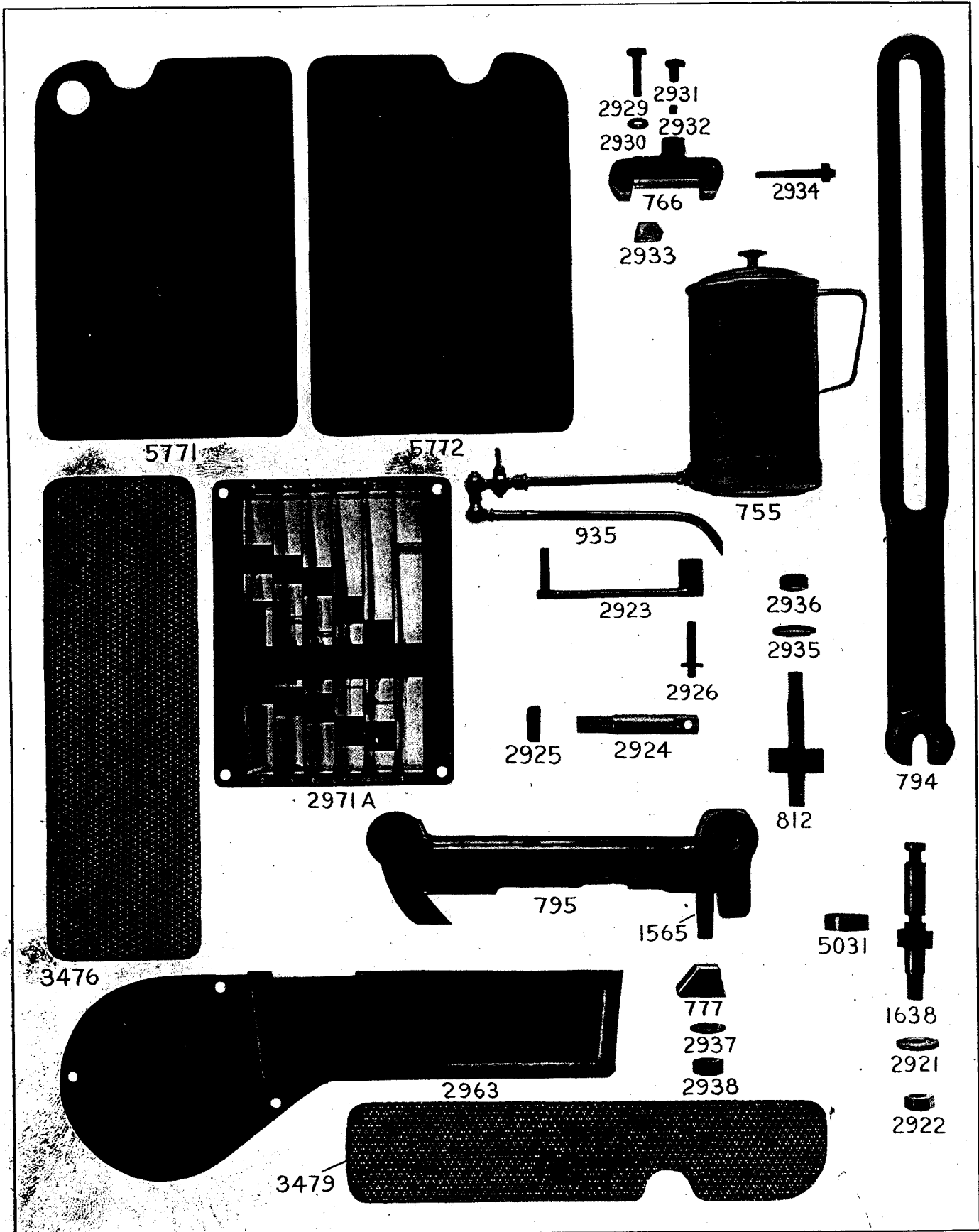


Saddle Parts

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Saddle Parts

206	Table Feed Clutch Gear Bushing, Left	2886	Table Oil Plate
208	Table Feed Clutch Gear Bushing, Right	2889	Table Clamp Lever Nut
235	Table Feed Clutch Gear	2891	Saddle T-Slot Cover
293	Lower Swivel Gear	4338	Cross Feed Screw Nut Lock Nut
314	Cross Feed Safety Stop, Front	4372	Oil Pump Header Cover
317	Cross Feed Safety Stop, Rear	4374	Saddle or Clamp Bed Gib Screw
321	Feed Shaft Pinion	4760	Switch Compartment Cover
327	Cross Feed Screw Bracket	5042	Saddle or Clamp Bed Gib Plate
338	Vertical Shaft Gear	5050	Saddle Oil Sight Plug
339	Cross Feed Screw Bracket Collar	5051	Saddle Gage Glass Disk
341	Table Feed Trip Lever Shaft	5052	Saddle Gage Glass Retainer
343	Table Feed Trip Lever	5053	Saddle Gage Cork Washer
345	Table Feed Trip Lever Stop Detent	5054	Saddle Gage Fiber Washer
346	Table Feed Trip Lever Stop	5059	Lower Swivel Gear Washer
347	Table Feed Trip Plunger	5060	Vertical Shaft Gear Nut
348	Table Feed Trip Lever Plate	5061	Vertical Shaft Lockwasher
350	Saddle Clamp Stud	5062	Feed Shaft Pinion Washer
351	Saddle Clamp Screw	5063	Cross Feed Screw Bracket Bushing
352	Saddle Index Finger	5064	Saddle Pump
359	Table Feed Clutch Shoe	5065	Oil Pump Locking Pin
376	Vertical Shaft Gear Bushing	5066	Saddle Pump Plunger
465	Cross Feed Screw Nut	5067	Saddle Pump Plunger Spring
474	Table Feed Trip Lever Stop Spring	5068	Saddle Pump Plunger Washer
490	Table Feed Clutch	5777	Table Clamp Lock Plunger
491	Table Feed Clutch Sleeve	5778	Table Clamp
494	Table Feed Clutch Gear Washer	5779	Table Clamp Screw Stop
496	Table Clutch Gear Bearing Cap	5780	Table Clamp Screw
506	Saddle or Clamp Bed Gib	5781	Table Clamp Lever Nut Shoe
507	Saddle Clamp Bolt	5782	Table Clamp Thrust Bearing
511	Cross Feed Trip Dog, Front	5783	Cross Feed Safety Stop Holder
512	Cross Feed Trip Dog, Rear	5784	Dust Guard Stop Screw
787	Table Clamp Lever Handle	5785	Dust Guard Stop Screw Washer
1558	Saddle or Clamp Bed Clamp Screw	5786	Switch Lever Hole Stud
1559	Saddle or Clamp Bed Clamp Screw Handle	5787	Saddle Air Vent Plug
1560	Saddle or Clamp Bed Gib Shoe	5788	Table Stop Screw
2835	Vertical Shaft Gear Washer	5789	Backlash Take-up Spring Plug
2869	Cross Feed Trip Dog Bolt	5790	Saddle Oil Distributor
2871	Cross Feed Trip Dog Nut	5791	Saddle Oil Reservoir Plug
2883	Table Feed Trip Lever Shaft Nut	5792	Table Feed Trip Lever Plate Screw
2884	Table Feed Trip Lever Stop Knob		

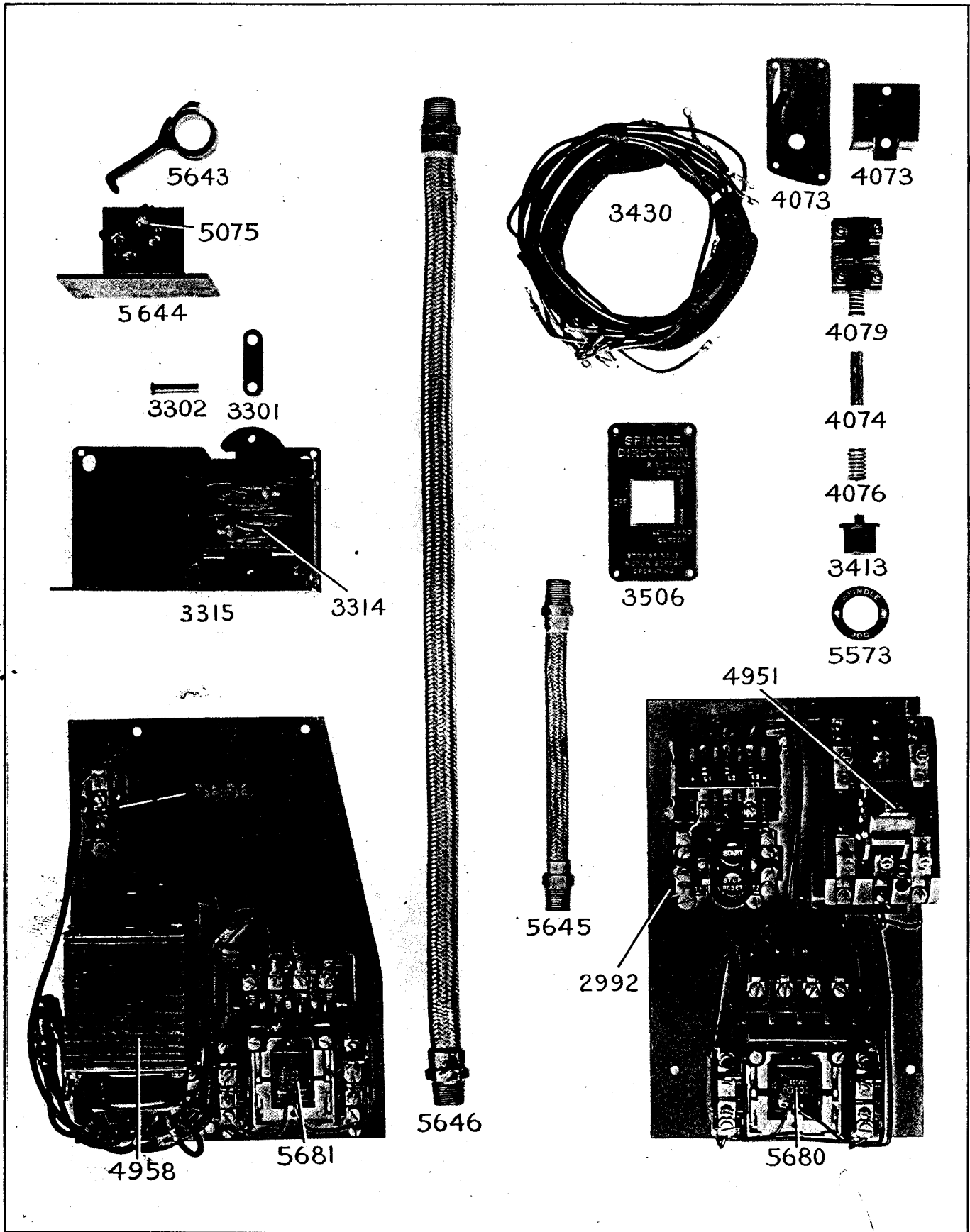


Miscellaneous Parts

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Miscellaneous Parts

755	Coolant Drip Can
766	Table Stop
777	Arm Support Knee Clamp Gib
794	Arm Support
795	Arm Support Knee Clamp
812	Arm Support Stud
935	Coolant Drip Can Spout
1565	Knee Clamp Gib Stud
1638	Arm Support Clamp Stud
2921	Arm Support Bolt Washer
2922	Arm Support Bolt Nut
2923	Coolant Drip Can Support
2924	Coolant Drip Can Support Stud
2925	Coolant Drip Can Support Stud Nut
2926	Coolant Drip Can Pivot
2929	Table Stop Gib Bolt
2930	Table Stop Gib Bolt Washer
2931	Adjusting Screw Clamp Bolt
2932	Adjusting Screw Clamp Shoe
2933	Table Stop Gib
2934	Table Stop Adjusting Screw
2935	Arm Support Stud Washer
2936	Arm Support Stud Nut
2937	Clamp Gib Stud Washer
2938	Clamp Gib Stud Nut
2963	Pump Opening Cover
2971A	Change Gear Box
3476	Stand Strainer, Side
3479	Stand Strainer, Rear
5031	Arm Support Clamp Stud Collar
5771	Base Tank Cover, Front Right
5772	Base Tank Cover, Front Left



Electrical Controls

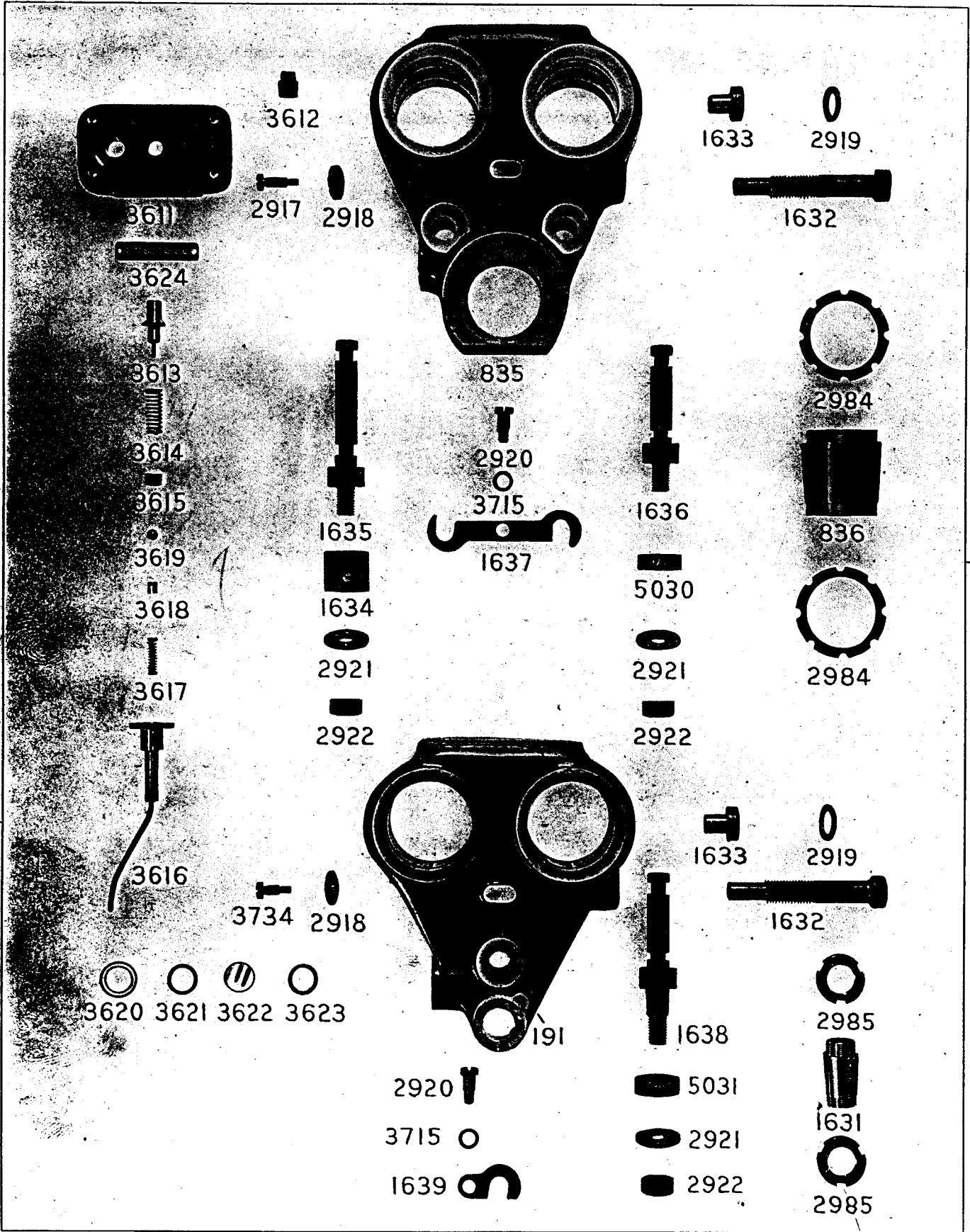
When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Electrical Controls

2992	Coolant Pump Switch
3301	Solenoid Lever Link
3302	Solenoid Link Pin, Lower
3314	Clutch Solenoid
3315	Solenoid Bracket
3413	Electrical Control Button
3430	Wiring Harness (State whether for Knee or Stand)
3506	Spindle Direction Plate
†4073	Spindle Jog Switch Bracket
*4074	Spindle Jog Plunger
*4076	Spindle Jog Plunger Spring
4079	Spindle Jog Switch
4951	Spindle Reverse Switch
4958	Transformer
5075	Fast Travel Switch
5573	Spindle Jog Plate
5643	Fast Travel Switch Lever
5644	Fast Travel Switch Holder
5645	Table Motor Conduit
5646	Knee Conduit
5656	Solenoid Overload Relay
5680	Spindle Motor Starter
5681	Table Motor Starter

†Bracket shown at right is for Vertical Machine;
that at left is for Universal and Plain Machines.

*Vertical Machine only



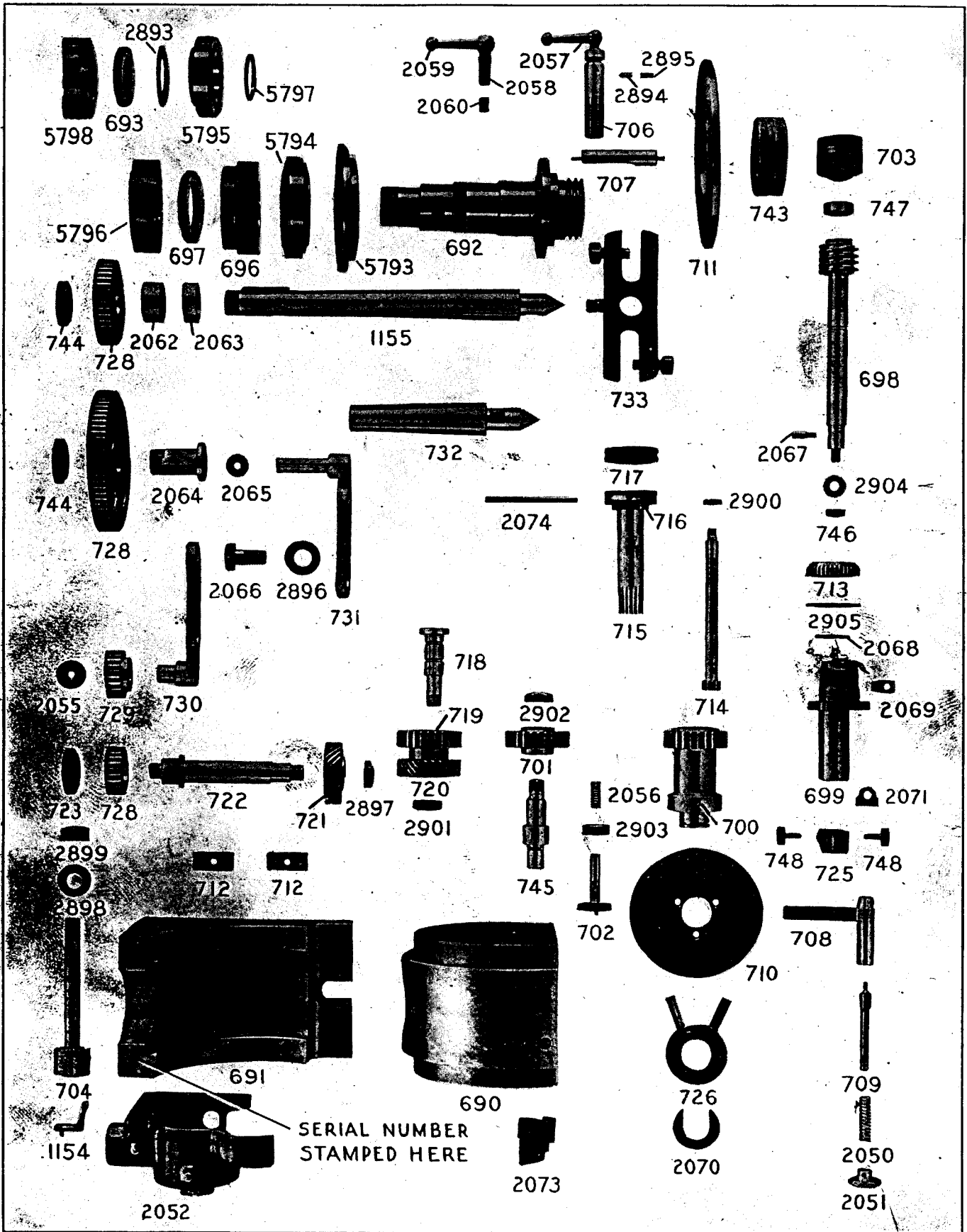
Arbor Yokes

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Arbor Yokes

*191	Arbor Yoke, Outer
*835	Arbor Yoke, Inner
836	Arbor Yoke (Inner) Bushing
1631	Arbor Yoke (Outer) Bushing
1632	Arbor Yoke Clamp Screw
1633	Arm Clamping Stud
1634	Arm Support Spacer Collar, Long
1635	Arm Support Clamp Bolt, Long
1636	Arm Support Clamp Bolt, Short
1637	Arm Support Clamp Bolt Plate, Double
1638	Arm Support Clamp Bolt
1639	Arm Support Clamp Bolt Plate, Single
2917	Clamping Washer (Small) Screw, Long
2918	Yoke Clamping Washer, Small
2919	Yoke Clamping Washer, Large
2920	Arm Support Clamp Plate Screw
2921	Arm Support Bolt Washer
2922	Arm Support Bolt Nut
2984	Arbor Yoke (Inner) Bushing Nut
2985	Arbor Yoke (Outer) Bushing Nut
3611	Arbor Yoke Oil Well Cover
3612	Arbor Yoke Reservoir Plug
3613	Arbor Yoke Oil Valve Plunger
3614	Arbor Yoke Oil Valve Plunger Spring
3615	Arbor Yoke Oil Valve Seat
3616	Arbor Yoke Oil Valve Body
3617	Arbor Yoke Oil Valve Spring
3618	Arbor Yoke Spring Plunger
3619	Arbor Yoke Oil Valve Steel Ball
3620	Sight Feed Glass Holder
3621	Washer, Fiber
3622	Glass Disk
3623	Washer, Cork
3624	Arbor Yoke Oil Notice Plate
3715	Clamp Plate Screw Washer
3734	Clamping Washer (Small) Screw, Short
5030	Arm Support Spacer Collar, Short
5031	Arm Support Spacer Collar

*Serial number of machine stamped on this part

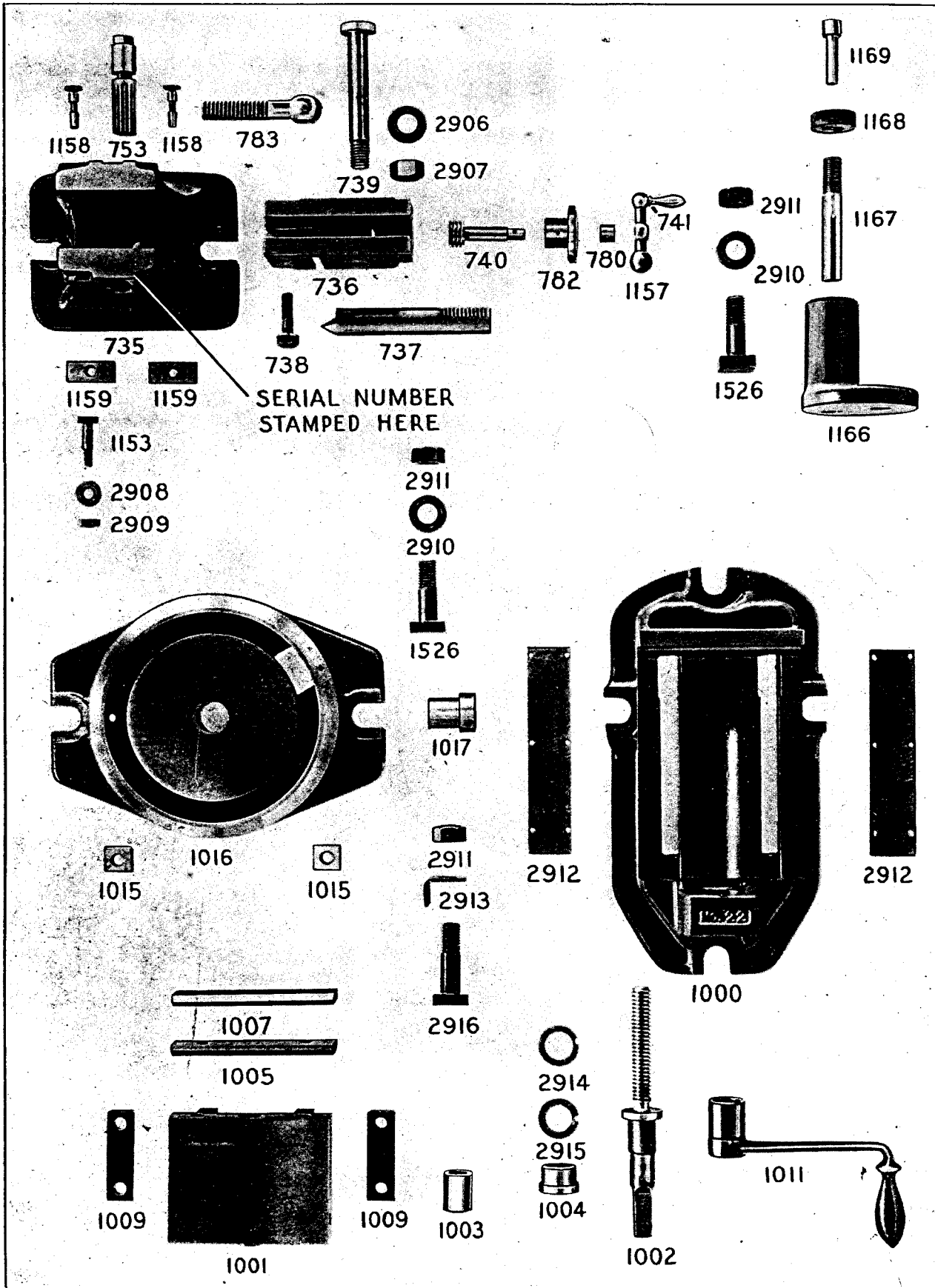


Headstock
Universal Spiral Index Centers

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Headstock
Universal Spiral Index Centers

690	Headstock Swivel	747	Worm Thrust Bearing
691	Headstock Base	748	Index Crank Adjusting Screw
692	Headstock Spindle	1154	Headstock Index Finger
693	Headstock Spindle Rear Nut	1155	Differential Indexing Center
696	Index Wormwheel	2050	Index Crank Spring
697	Index Wormwheel Nut	2051	Index Crank Knob
698	Worm Shaft	2052	Spiral Gear Guard
699	Worm Shaft Bushing	2055	Reverse Gear Washer
700	Index Plate Sleeve	2056	Index Stop Pin Spring
701	Intermediate Gear	2057	Spindle Stop Pin Pinion Handle
702	Index Stop Pin	2058	Spindle Clamp Screw
703	Worm Shaft Adjusting Screw	2059	Spindle Clamp Screw Handle
704	Swivel Clamp Bolt (State Upper or Lower)	2060	Spindle Clamp Screw Plug
706	Spindle Stop Pin Pinion	2062	Indexing Center Collar
707	Spindle Stop Pin	2063	Indexing Center Adjusting Collar
708	Index Crank	2064	Intermediate Gear Bushing
709	Index Crank Plunger Pin	2065	Intermediate Gear Stud Washer
710	Index Plate, Small (State No. of Holes)	2066	Intermediate & Reverse Gear Plate Screw
711	Index Plate, Large	2067	Worm Shaft Stud
712	Headstock Base Tongue	2068	Worm Shaft Thrust Washer
713	Worm Shaft Bushing Nut	2069	Worm Shaft Bushing Stop
714	Worm Shaft Bushing Pinion	2070	Sector Spring
715	Worm Shaft Bushing Nut Pinion	2071	Index Crank Clamp
716	Worm Shaft Bushing Nut Pinion Knob	2073	Spur Gear Guard
717	Worm Shaft Bushing Pinion Knob	2074	Wire Pin Wrench
718	Intermediate & Spiral Gear Stud	2893	Headstock Spindle Rear Thrust Washer
719	Intermediate Stud Gear	2894	Stop Pin Pinion Lock Plunger
720	Spiral Gear, Driven	2895	Stop Pin Pinion Lock Spring
721	Spiral Gear, Driver	2896	Gear Plate Screw Washer
722	Spiral Gear Shaft	2897	Spiral Gear Shaft Nut, Right
723	Spiral Gear Shaft Nut, Left	2898	Clamp Bolt Washer
725	Index Crank Collar	2899	Clamp Bolt Nut
726	Index Sector	2900	Worm Shaft Bushing Pinion Nut
728	Headstock Change Gear (State No. of Teeth)	2901	Intermediate & Spiral Gear Stud Nut
729	Reverse Gear	2902	Intermediate Gear Stud Nut
730	Reverse Gear Plate	2903	Index Stop Pin Collar
731	Intermediate Gear Plate	2904	Worm Shaft Washer
732	Headstock Center	2905	Worm Shaft Bushing Washer
733	Work Driver	5793	Front Bearing Dust Guard
743	Spindle Thread Guard	5794	Spindle Bearing, Front
744	Change Gear Nut	5795	Spindle Bearing, Rear
745	Intermediate Gear Stud	5796	Spindle Clamp Bushing
746	Worm Shaft Nut	5797	Rear Bearing Spacer Washer
		5798	Swivel Bushing, Rear

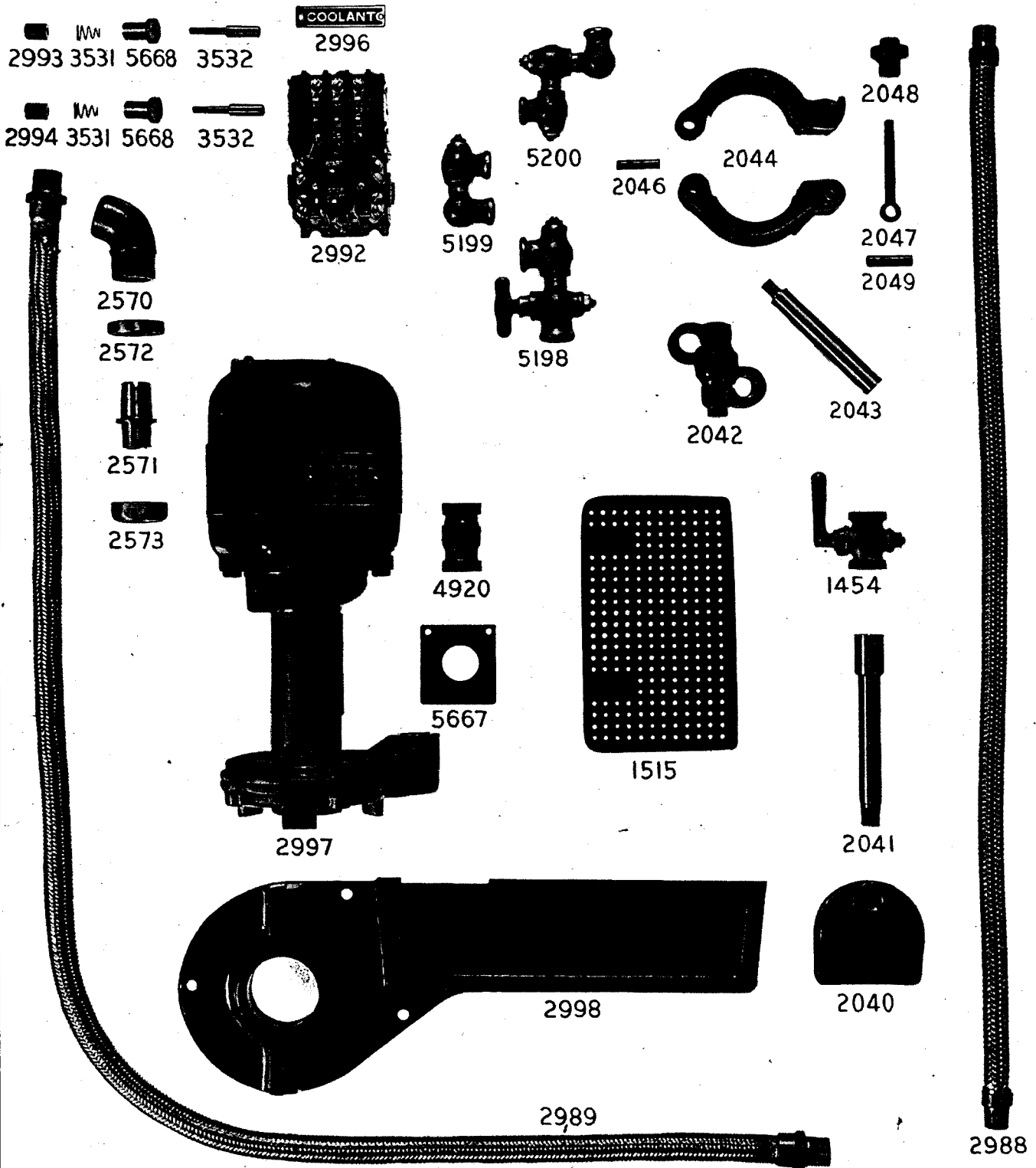


Footstock, Center Rest, Vises

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

Footstock, Center Rest, Vises

735	Footstock Base	1017	Swivel Pin
736	Footstock Adjusting Block	1153	Footstock Adjusting Block Guide Bolt
737	Footstock Center	1157	Footstock Center Ball Crank
738	Footstock Center Clamp Bolt	1158	Footstock Taper Pin
739	Footstock Clamp Bolt	1159	Footstock Tongue
740	Footstock Center Adjusting Worm	1166	Center Rest Stand
741	Footstock Center Ball Crank Handle	1167	Center Rest Shell
753	Footstock Pinion	1168	Center Rest Shell Nut
780	Footstock Center Adjusting Worm Bushing	1169	Center Rest Piston
782	Footstock Center Adjusting Worm Bearing	1526	Clamp Bolt
783	Footstock Rack Bolt	2906	Footstock Clamp Bolt Washer
1000	Vise Bed	2907	Footstock Clamp Bolt Nut
1001	Vise Slide	2908	Guide Bolt Washer
1002	Vise Screw	2909	Guide Bolt Nut
1003	Vise Screw Nut	2910	Clamp Bolt Washer
1004	Vise Screw Collar	2911	Clamp Bolt Nut
1005	Vise Jaw, Loose	2912	Bed Guard
1007	Vise Jaw, Fixed	2913	Swivel Base Washer
1009	Vise Strap	2914	Vise Screw Thrust Washer, Small
1011	Crank	2915	Vise Screw Thrust Washer, Large
1015	Swivel Base Tongue	2916	Swivel Base Clamp Bolt
1016	Swivel Base		



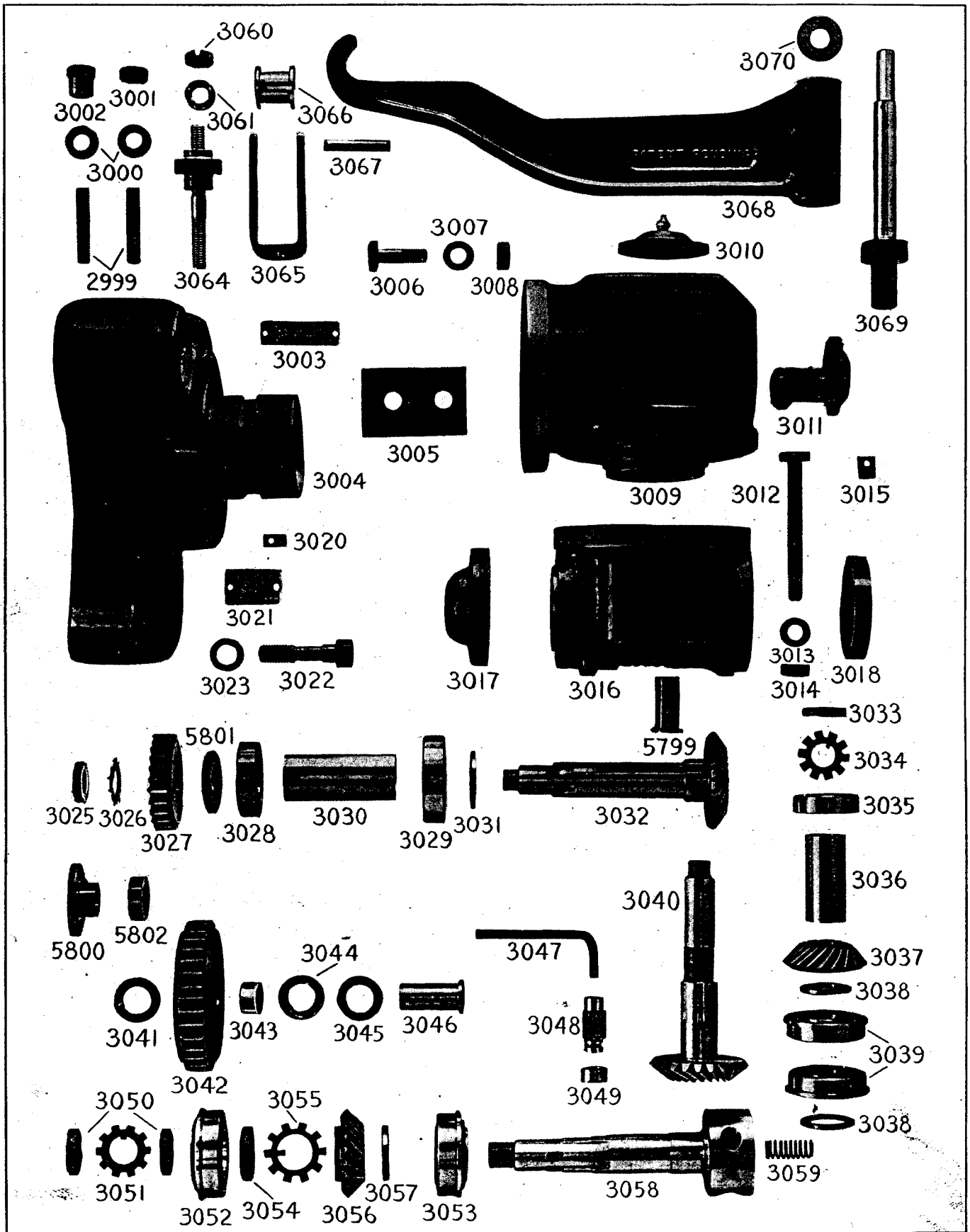
Coolant System
Additional Equipment

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

**Coolant System
Additional Equipment**

1454	Coolant Valve
1515	Table Coolant Strainer
2040	Distributor
2041	Distributor Pipe
2042	Distributor Pipe Swivel
2043	Distributor Stud
2044	Distributor Bracket
2046	Distributor Bracket Fulcrum
2047	Swing Bolt
2048	Nut
2049	Swing Bolt Fulcrum
2570	Flexible Tube Swivel, Lower
2571	Flexible Tube Swivel Sleeve
2572	Flexible Tube Swivel Check Nut
2573	Flexible Tube Swivel Adjustment Nut
2988	Distributor Flexible Tube
2989	Table Flexible Tube
2992	Coolant Switch
2993	Switch Button, Black
2994	Switch Button, Red
2996	Coolant Pump Push Button Plate
*2997	Motor Driven Centrifugal Pump
2998	Centrifugal Pump Support
3531	Switch Button Extension Spring
3532	Switch Button Extension
4920	Coolant Piping Check Valve
5198	Revolving Cock
5199	Swing Joint
5200	Universal Swing Joint
5667	Coolant Pipe Hole Plate
5668	Push Button Sleeve

*See also "Repair Parts for Brown & Sharpe Pumps"



No. 0 Universal Milling Attachment and No. 0 Attachment Crane
Additional Equipment

When ordering parts, state the size, style and serial number of the machine in addition to the part number and name.

**No. 0 Universal Milling Attachment
Additional Equipment**

2999	Swivel Bracket Stud	3040	Spindle Driving Gear
3000	Swivel Bracket Stud Washer	3041	Attachment Driving Gear Washer
3001	Swivel Bracket Stud Nut, Front	3042	Attachment Driving Gear
3002	Swivel Bracket Stud Nut, Rear	3043	Attachment Driving Gear Bushing
3003	Oiling Notice Plate	3044	Attachment Gear Stud Washer, Bronze
3004	Swivel Bracket	3045	Attachment Gear Stud Washer, Steel
3005	Swivel Bracket Shim	3046	Attachment Driving Gear Stud
3006	Horizontal Swivel Bolt	3047	Spindle Cam Wrench
3007	Horizontal Swivel Bolt Washer	3048	Spindle Cam
3008	Horizontal Swivel Bolt Nut	3049	Spindle Bushing
3009	Horizontal Swivel	3050	Attachment Spindle Nut
3010	Horizontal Swivel Cap	3051	Attachment Spindle Lockwasher
3011	Spindle Driving Gear Cap	3052	Spindle Roller Bearing, Rear
3012	Vertical Swivel Clamp Bolt	3053	Spindle Roller Bearing, Front
3013	Vertical Swivel Clamp Bolt Washer	3054	Spindle Pinion Nut
3014	Vertical Swivel Clamp Bolt Nut	3055	Spindle Pinion Lockwasher
3015	Horizontal Swivel Pointer	3056	Spindle Pinion
*3016	Vertical Swivel	3057	Spindle Pinion Washer
3017	Spindle Cap, Rear	3058	Attachment Spindle
3018	Spindle Cap, Front	3059	Spindle Adapter Spring
3020	Swivel Bracket Pointer	5799	Vertical Swivel Oiling Bushing
3021	Speed Ratio Plate	5800	Attachment Shear Collar
3022	Attachment Clamp Bolt	5801	Attachment Gear Thrust Washer
3023	Attachment Clamp Bolt Washer	5802	Attachment Gear (Driven) Bushing
3025	Intermediate Driving Gear Nut		
3026	Intermediate Driving Gear Lockwasher		
3027	Attachment Gear, Driven		
3028	Intermediate Gear Ball Bearing, Rear		
3029	Intermediate Gear Ball Bearing, Front		
3030	Intermediate Driving Gear Sleeve		
3031	Intermediate Driving Gear Washer		
3032	Intermediate Driving Gear	3060	Attachment Support Stud Nut
3033	Spindle Driving Gear Nut	3061	Attachment Support Stud Washer
3034	Spindle Driving Gear Lockwasher	3064	Attachment Support Stud
3035	Spindle Gear Ball Bearing, Upper	3065	Attachment Support
3036	Spindle Driving Gear Sleeve	3066	Attachment Support Roller
3037	Spindle Driving Gear Pinion	3067	Attachment Support Roller Stud
3038	Spindle Driving Gear Washer	*3068	Crane Arm
3039	Spindle Gear Ball Bearing, Lower	3069	Crane Arm Stud
		3070	Crane Arm Stud Washer

**No. 0 Attachment Crane
Additional Equipment**

*Serial number of equipment stamped on this part